Rules and Regulations

CONTENTS

PART A

RULES FOR THE SURVEY AND CONSTRUCTION OF SHIPS (GENERAL RULES)

Rules for the Survey and Construction of Ships (General Rules)

APPLICATION

1 The survey and construction of steel ships to be registered in accordance with the Regulations for the Classification and Registry of Ships are to be as prescribed in the Rules.

2 Ships are also to comply with the requirements of their Flag Administration in addition to the Rules of Sing-Lloyd (referred to as "SILO" in the Rules).

3 SILO may also make special requirements as instructed by the Flag Administration or the instructions set forth by the port authority in which whose territory the ships are trading.

DEFINITIONS

The definitions of terms, which appear in the Rules, are as specified in this Chapter, unless otherwise specified elsewhere.

1 Length of Ship

Length of ship *(L)* is the distance in *metres* on the designed maximum load line, from the fore side of stem to the aft side of rudder post in case of a ship with rudder post, or to the axis of rudder stock in case of a ship without rudder post. However, in case of a ship with cruiser stern, *L* is as defined above or 96% of the total length on the designed maximum load line, whichever is the greater.

2 Length for Freeboard

The length of ship for freeboard *(Lf) is* 96% of the length in *metres* measured from the fore side of stem to the aft side of aft end shell plate on a waterline at 85% of the least moulded depth measured from the top of keel, or the length in *metres* measured from the fore side of stem to the axis of rudder stock on that waterline, whichever is the greater. However, where the stem contour is concave above the waterline at 85% of the least moulded depth, the forward terminal of this length is to be taken at the vertical projection to this waterline of the aftermost point of the stem contour. The waterline on which this length is measured is to be parallel to the load line.

3 Breadth of Ship

The breadth of ship (B) is the horizontal distance in *metres* from outside of frame to outside of frame measured at the broadest part of the hull.

4 Breadth for Freeboard

The breadth of ship for freeboard *(Bf) is* the maximum horizontal distance in *metres* from outside of frame to outside of frame measured at the middle of *Lf.*

5 Depth of Ship

The depth of ship (D) is the vertical distance in *metres* from the top of keel to the top of freeboard deck beam at side measured at the middle of *L,* In case where water -tight bulkheads extend to a deck above the freeboard deck and are recorded in the Register Book as effective up to that deck, the depth is to be measured to the bulkhead deck.

6 Depth for Strength Computation

The depth of ship for strength computation (Ds) is the vertical distance in *metres* from the top of keel to the top of beam at side of the superstructure deck where the superstructure deck is strength deck, or the freeboard deck for other cases at the middle of *L.* Where the deck does not cover midship, the depth is to be measured at the imaginary deck line which is extended to the middle of *L* along the strength deck line.

7 Speed of Ship

Speed of ship (V) is the designed speed in *knots* which the ship with clean bottom can attain at the maximum continuous output on calm sea in loaded condition corresponding to the designed maximum load line (referred to as "the full load condition" in the Rules).

8 Midship Part of Ship

The midship part of ship is the part for *0.4L* amidships unless otherwise specified.

9 End Parts of Ship

The end parts of ship are the parts for *0.1L* from each end of the ship.

10 Load Line and Designed Maximum Load Line

(1) Load line is the water line corresponding to each freeboard assigned.

(2) Designed maximum load line is the water line corresponding to the full load condition.

11 Load Draught and Designed Maximum Load Draught

(1) Load draught is the vertical distance in *metres* from the top of keel plate to the load line.

(2) Designed maximum load draught (d) is the vertical distance in *metres* from the top of keel plate to the designed maximum load line measured at the middle of L_{BP}.

12 Full Load Displacement

Full load displacement (is the moulded displacement in *tons* corresponding to the full load condition.)

13 Block Coefficient

Block coefficient (Cb) is the coefficient given by dividing the volume corresponding to W by *LBd.*

14 Freeboard Deck

(1) The freeboard deck is normally the uppermost continuous deck. However, in cases where openings without permanent closing appliances exist on the exposed part of the uppermost continuous deck or where openings without permanent watertight closing appliances exist on the side of the ship below that deck, the freeboard deck is the continuous deck below that deck.

(2) In a ship having a discontinuous freeboard deck, the lowest line of the exposed deck and the continuation of that line parallel to the upper part of the deck is taken as the freeboard deck.

(3) For multi decks ships, the freeboard deck may be the lower deck. In this case the lower deck is to be continuous at least between the machinery space and peak bulkheads and continuous athwartships. Where the lower deck is stepped, the lowest line of the deck and the continuation of that line parallel to upper part of the deck is taken as freeboard deck.

15 Bulkhead Deck

The bulkhead deck is the highest deck to which the watertight transverse bulkheads extend.

16 Strength Deck

The strength deck at a part of ship's length is the upper most deck at that part to which the shell plates extend. However, in way of superstructures, except sunken superstructures, not exceeding *0.15L* in length, the strength deck is the deck just below the superstructure deck. The deck just below the superstructure deck may be taken as the strength deck even in way of the superstructure exceeding *0.15L* in length.

17 Raised Deck

The raised deck is the sunken superstructure deck below which no deck is provided.

18 Superstructure

The superstructure is the decked structure on the freeboard deck, extending from side to side of the ship or having its side walls at the position not further than *0.04Bf* from the side of ship.

19 Enclosed Superstructure

The enclosed superstructure is the superstructure complying with the following conditions:

(1) Access openings in the end bulkheads of the superstructure are provided with doors

(2) All other openings in side or end bulkheads of the superstructure are provided with weathertight means of closing.

(3) Access means, which are available at all times where bulkhead openings are closed, are provided for the crew to reach machinery and other working spaces.

20 Approved Working Pressure of Boiler and Pressure Vessel

The approved working pressure of a boiler or a pressure vessel is the maximum pressure at its drum intended by the manufacturer or user, and is not to exceed the mini -mum value among the allowable pressures of various parts determined in accordance with the requirements in Chapter 9 and 10, Part D.

21 Nominal Pressure of Boiler with Superheater

The nominal pressure of a boiler with superheater is the maximum steam pressure at superheater outlet intended by the manufacturer under which the safety valve of superheater is set.

Note: Engines, pipes, etc. connected with a boiler or a pressure vessel are to be designed so as to endure the pressure not less than the nominal pressure (the approved working pressure in case of a boiler or a pressure vessel without superheater).

22 Maximum Continuous Output of Engine

Maximum continuous output of engine is the maximum output at which the engine can run safely and continuously in the designed condition (which is of the full load running condition for a main engine).

23 Number of Maximum Continuous Revolutions

The number of maximum continuous revolutions is the number of revolutions at the maximum continuous output.

Note: The strength calculations of engines are to be based upon the maximum continuous output and the number of maximum continuous revolutions.

24 Propeller Shaft Kind 1 and Propeller Shaft Kind 2

1 Propeller shaft Kind I is a propeller shaft which is effectively protected against corrosion by sea water with a means approved by the Sing-Lloyd or which is made of corrosion resistant materials approved by the Sing-Lloyd. In this case, such shafts which comply with the following (1), (2) or (3) are categorized in propeller shaft Kind IA, propeller shaft Kind *IB* or propeller shaft Kind IC respectively.

(1) Propeller shaft Kind IA is a propeller shaft with a keyed propeller attachment, with a keyless propeller attachment or having a coupling flange at the after end and to which water lubricated stern tube bearing is adopted.

(2) Propeller shaft Kind *IB* is a propeller shaft with a keyed propeller attachment, with a keyless propeller attachment or having a coupling flange at the after end and to which oil lubricated stern tube bearing is adopted except for the shafts complying with (3).

(3) Propeller shaft Kind IC is a propeller shaft satisfying the conditions in (2) and the has a monitoring system including temperatures and pressure of the lubricating oil.

25 Stern Tube Shaft

Stern tube shaft is an intermediate shaft which lies in a stern tube.

26 Stern Tube Shaft Kind I and Stern Tube Shaft Kind 2

(1) Stern tube shaft Kind I is a stern tube shaft which is effectively protected against corrosion by sea water with a means approved by Sing-Lloyd or which is made of corrosion resistant materials approved by Sing-Lloyd. In this case, such shaft to which the water lubricated bearing is adopted is categorized in stern tube shaft Kind IA and such shaft to which the oil lubricated bearing is adopted is categorized in stern tube shaft Kind IB.

(2) Stern tube shaft Kind 2 is a stern tube shaft other than those specified in Para 1.

27 Deadweight Tonnage

Deadweight tonnage (is the difference in *tons* between full load displacement and light weight)

28 Light Weight

The Light Weight (is the displacement in *tons* excluding cargoes, fuel oil, lubricating oil, ballast and fresh water in tanks, stored goods, and passengers and crew and their effects).

29 Maximum Astern Speed

Maximum astern speed of ship is the designed speed in *knots* which the ship with clean bottom can attain at the maximum astern output on calm sea in the full load condition.

30 Dead Ship Condition

Dead ship condition is the condition under which the main propulsion plant, boilers and auxiliaries are not in operation due to the absence of power.

31 Machinery Space of Category A

Machinery spaces of category A are those spaces and trunks to such spaces which contain:

(1) internal combustion machinery used for main propulsion ; or

(2) internal combustion machinery used for purposes other than main propulsion where such machinery has in the aggregate a total power output of not less than 375 kW, or

(3) any oil-fired boiler (including inert gas generators) or oil fuel unit (including incinerators)

32 Machinery Space

Machinery spaces are all machinery spaces of category A and all other spaces containing propelling machinery, boilers, oil fuel units, steam and internal combustion engines, generators and major electrical machinery, oil filling stations, refrigerating, stabilizing, ventilation and air conditioning machinery, and similar spaces, and trunks to such spaces.

33 Cargo Space

Cargo spaces are all spaces used for cargo (including cargo oil tanks) and trunks to such spaces.

34 Cargo Area

Cargo area is a part of the ship that contains cargo tanks, slop tanks and cargo pump rooms including pump rooms, cofferdams, ballast and void spaces adjacent to cargo tanks and also deck areas through out the entire length and breadth of the part of ship over the above -mentioned spaces.

35 Accommodation Space

Accommodation spaces are those spaces used for public spaces, corridors, lavatories, cabins, offices, hospitals, pantries containing no cooking appliances and similar spaces.

36 Public Space

Public spaces are those portions of the accommodation which are used for halls, dining rooms, lounges and similar permanently enclosed spaces.

37 Service Space

Service spaces are those spaces used for galleys, pantries containing cooking appliances, lockers, mail, store rooms, workshops other than those forming part of the machinery spaces, and similar spaces and trunks to such spaces.

38 Passenger Ship

A passenger ship is a ship which carries more than twelve passengers where a passenger is every person other than:

(1) the master and the members of the crew or other per sons employed or engaged in any capacity on board a ship on the business of that ship ; and

(2) a child under one year of age.

39 Cargo Ship

A cargo ship is any ship which is not a passenger ship.

40 Tanker

A tanker is a cargo ship constructed or adapted for the carriage in bulk of liquid cargoes of a flammable nature except ships carrying liquefied gases in bulk and ships carrying dangerous chemicals in bulk. Tanker can be categorized into the following:

(1) tanker ($< 60^0$C) is a ship intended for the carriage in bulk of crude oil and petroleum products having a flash point of 60^0C and below, Reid vapour pressure being below atmospheric pressure.

(2) tanker ($> 60^0$C) is a ship intended for the carriage in bulk of crude oil and petroleum products having a flash point of 60^0C and above.

41 Ship Carrying Liquefied Gases in Bulk

A ship carrying liquefied gases in bulk is a cargo ship constructed or adapted and used for the carriage in bulk of liquefied gases.

42 Ship Carrying Dangerous Chemicals in Bulk

A ship carrying dangerous chemicals in bulk is a cargo ship constructed or adapted and used for the carriage in bulk of dangerous chemicals.

43 Ship Engaged in Fishing

A fishing vessel is a vessel used directly for catching and processing the fish (fish or other living resources of the sea)

44 Special Purpose Ship

A special purpose ship is a self propelled ship are meant for research, expeditionary, hydrographic, training ships and other ships which are engaged in the processing of living resources of the sea and not engaged in catching.

45 Tug

A tug is a ship specially intended for the towage and pushing of other ships and floating facilities.

46 Barge

A barge is a non self propelled cargo vessel unmanned and designed for transportation through towing or pushing by specific vessels such as tugs.

47 Supply Vessel

Supply vessel is a vessel designed for the carriage of supplies and cargoes to the mobile and fixed offshore units and fitted generally with a forward superstructure and an after weather cargo deck for carriage of supplies and cargoes.

PART B

PERIODICAL SURVEYS

CHAPTER 1
CLASS SURVEYS - GENERAL

1 Surveys

1.1 Classification Surveys

All ships including steel barges and passenger ships intended to be classed with SILO are subjected to Classification Surveys in accordance with the relevant requirements in Chapter 2, 10 and 11.

Classification Surveys comprise of the following Initial Surveys.

i. Classification Survey during Construction
ii. Classification Survey of Ships Not Built under Survey

1.2 Class Maintenance Surveys

Class Maintenance Surveys consist of the following:

i. Periodical Surveys
ii. Planned Machinery Surveys
iii. Occasional Surveys

At each of these surveys, tests or inspections are to be carried out to verify that hull, machinery, equipment, firefighting equipment, etc, are in good order.

i. Periodical Surveys

Annual Survey	Refer Part B Chapter 3
Intermediate Survey	Refer Part B Chapter 4
Special Survey	Refer Part B Chapter 5
Docking Survey	Refer Part B Chapter 6
Boiler Survey	Refer Part B Chapter 7
Propeller Shaft And Stern Tube Shaft Survey	Refer Part B Chapter 8

ii. Planned Machinery Surveys

Continuous Machinery Survey (CMS)	Systematic inspections of machinery and equipment, so that each survey interval for all CMS items does not exceed five years. Refer Part B Chapter 9
Planned Machinery Maintenance Scheme (PMS)	Inspections of machinery and equipment specified in according to the machinery maintenance scheme approved by SILO

iii. Occasional Surveys

The surveys consist of inspections of hull, machinery and equipment including damaged part and of works for repairs, modifications or conversions, which are carried out separately from (i) and (ii) above. The scope of the surveys and their procedures are determined by SILO depending on the purpose of the survey.

1.3 Intervals of Periodical Surveys and Planned Machinery Surveys

Annual	Within three months before or after each anniversary date
Intermediate	2nd or 3rd Annual Survey after the Classification Survey during Construction or a Special Survey.
Special	1. Within 3 months before the date of expiry of the Classification Certificate. 2. Commenced at the 4th Annual Survey and be completed within 3 months before expiry date of the Classification Certificate.
Docking	1. Concurrently with Special Surveys. 2. Within 36 months from the date of completion of the Classification Survey or the previous Docking Survey.
Boiler	1. Concurrently with Special Surveys. 2. Within 36 months from the date of completion of the Classification Survey or the previous Boiler Survey.
Propeller Shaft and Stern Tube Shaft	Ordinary Survey of the propeller shaft and stern tube shaft are to be carried out as specified below: (a) Ordinary Survey of Propeller shafts Kind I is to be carried out within 5 years from the date of completion of the Classification Survey or the previous Ordinary Survey. (b) Ordinary Survey for ships fitted with oil -lubricated stern tube bearings, may be postponed for not more than 3 years or 5 years from the date of completion of Partial Survey provided that the Partial Survey is carried out respectively at the time prescribed in (a) above. (c) The propeller shafts Kind I adopting the preventive maintenance system in accordance with the requirements 8.1.3, need not be withdrawn at the Ordinary Surveys. The shafts are to be withdrawn for inspection at the times required on the basis of the results of the preventive maintenance. (d) Ordinary Surveys of Propeller shafts Kind 2 or stern tube shafts Kind 2 in this Chapter are to be carried out as prescribed in i) and ii). i) Concurrently with Special Surveys ii) Within 36 months from the date of completion of the Classification Survey or the previous Ordinary Surveys However, where the part of the construction of the shaft in the stern tube bearing corresponds to the shaft Kind I and the construction of the shaft between the stern tube and the shaft bracket bearing corresponds to the shaft Kind 2, the shaft may be surveyed at the intervals prescribed in (a),

	provided that inspection required for the part corresponding to the shaft Kind 2 is carried out at the times prescribed in i) and ii).

2 Planned Machinery Surveys are to be carried out as specified below in (1) through (3)

a) In the Continuous Machinery Survey, each survey item or part is to be examined at the interval not exceeding 5 years.

b) In the Planned Machinery Maintenance Scheme, each survey item or part is to be examined according to the survey schedule table specified in 9.1.3 and at the opportunity of the general inspection including review of the maintenance records which is to be carried out every year.

c) In the Preventive Machinery Maintenance Scheme, each survey item or part is to be examined according to the survey schedule table specified in 9.1.4, and at the opportunity of the general inspection including review of the maintenance and condition monitoring records as well as operation tests which are to be carried out every year.

3 The classed ships are to be subject to Occasional Surveys when they fall under one of the conditions of (1) through (5) below. Periodical Surveys can substitute for the Occasional Surveys where recommendations for carrying out the Occasional Surveys are cleared at the Survey.

(1) When main parts of hull, machinery or important equipment or fittings which have been surveyed by SILO, have been damaged, or are to be repaired or altered.

(2) When load lines are to be changed or to be newly marked.

(3) When an alteration affecting her stability is made.

(4) When the Survey is requested by the owner.

(5) Whenever the survey is considered necessary by SILO

1.4 Periodical Surveys carried out in advance

1.4.1 Special Surveys may be carried out in advance of the due dates of the Special Survey upon application by the Owner.

1.4.2 Annual Surveys and Intermediate Surveys may be carried out in advance of the due dates of each Survey upon application by the Owner. In this case, one or more additional Periodical Surveys are to be carried out in accordance with the provisions specified otherwise by SILO.

1.4.3 In case where an Periodical Survey other than an Annual Survey or an Intermediate Survey is carried out in advance at the due time of the Annual Survey or Intermediate Survey, the following requirements may be applicable.

a) Where an Intermediate Survey or a Special Survey is carried out in advance at the due time of the Annual Survey, the Annual Survey may be dispensed with.

b) Where a Special Survey is carried out in advance at the due time of the Intermediate Survey, the Intermediate Survey may be dispensed with.

1.5 Postponement of Periodical Surveys

Special Surveys, Docking Surveys, Boiler Surveys and Ordinary Surveys for Propeller shafts Kind 2 may be postponed as specified in (1) or (2) below subject to the approval by SILO in advance. However, no postponement is to be permitted on the period of 36 months between any two Docking Surveys, Boiler Surveys and Ordinary Surveys for Propeller shafts Kind 2 respectively.

1.5.1 Maximum 3 months for the purpose of allowing the ship to complete its voyage to the port in which it is to be surveyed.

1.5.2 Maximum 1 month for the ship engaged on short voyages.

1.6 Waiver / Additional Requirements

1.6.1 At the Periodical Surveys and Planned Machinery Surveys, the Surveyor may impose additional requirements specified in Chapters 3 through 9 of this Part having regard to the size, service engaged, construction, age, history, results of previous surveys and actual condition of the ship.

1.6.2 When the results of a Periodical Survey suggest the likelihood of heavy corrosion, defects etc., and the Surveyor considers it necessary, close-up surveys, pressure tests or thickness measurements are to be carried out. Thickness measurements procedures and submission of gauging results are to be in accordance with the requirements of 5.2.6-1.

1.6.3 For tanks and cargo holds where effective coatings are found to be in a good condition, the extent of internal inspection, close -up surveys or gauging requirements specified in Chapters 3 through 9 of this Part may be specially considered at the discretion of the Surveyor.

1.6.4 Continuous Hull Surveys

For ships other than oil tankers, bulk carriers and ships carrying dangerous chemicals in bulk where approved by SILO, at the request of an owner, internal inspections, thickness measurements and pressure tests of tanks and compartments to be carried out at Special Surveys may be dispensed with at the discretion of the Surveyor provided that those inspections and tests have been carried out successively by the relevant Special Surveys (hereinafter, referred to as "Continuous Hull Survey”). If the inspection during Continuous Hull Surveys reveals any defects, the Surveyor may require further tanks and compartments to be examined precisely. SILO may, where considered necessary, require the Continuous Hull Survey to be carried out by a method other than specified above.

1.6.5 Where inspections have been carried out during the period between the 2nd and the 3rd Annual Surveys according to the requirements for Intermediate Surveys, said inspections to be carried out as Intermediate Surveys may be omitted at the discretion of the Surveyor.

1.7 Bulk carriers

1.7.1 For ships with single side skin construction, the additional requirements of damage stability, transverse watertight corrugated bulkhead and allowable hold loading on double bottom are to be complied when the ship reaches 10 years of age. Ships older than 10 years would have complied at the first Intermediate or Special Survey after 1 July 2003.

In the assessment for compliance, the thickness measurement as deemed appropriate by SILO is to be carried out.

1.7.2 For ships defined in Para (1), the thickness measurements as deemed appropriate by SILO are to be carried out for the vertical corrugated watertight bulkhead abaft the foremost hold at Special Surveys in addition to those according to Table B5.12, in order to verify the continuously complying with Para (1)

1.7.3 For ships which are required to carry out the annual thickness measurement for the vertical corrugated watertight bulkhead abaft the foremost hold as a result of previous measurement and the surveyor's recommendation, it shall be carried out in addition to Table B3.6.

1.7.4 For ships defined in Para (1), the following surveys are to be carried out at periodical surveys in addition to the surveys required in this chapter.

a) At annual surveys, the internal inspection of spaces and tanks, close up surveys and thickness measurement are to be carried out in accordance with the requirement of an Intermediate Survey for the foremost hold.

b) Function tests such as bilge well high level alarms and hold water ingress alarms are to be carried out in addition to those required in 3.2.3, 4.2.3 and 5.2.3 at periodical surveys.

1.8 Ships Laid-up

1.8.1 Ships laid-up are not subject to Class Maintenance Surveys. However, the laid up has to be approved by SILO

1.8.2 When ships are about to re-enter service, a Periodical Survey equivalent to the coming Periodical Survey and any overdue CMS items are to be carried out. However if the coming Periodical Survey is a Special Survey, it shall correspond to the age of the ship.

1.9 Machinery Verification Runs

If significant repairs are carried out to main or auxiliary machinery or steering gear, a sea trial or a dock trial may be required at the discretion of the attending surveyor.

2 Ships, Installations, Apparatus, etc. for Special Purposes

2.1 Incinerators of Waste Oil and Waste Substance

Where incinerators of waste oil and waste substance are installed on board, they are to be examined to the satisfaction of the Surveyor.

2.2 Surveys of Special Ships

If SILO judges that the requirements in this Part are impractical to due to the special nature of ship's design, services and operating mode, SILO shall notify the attending surveyor of the scope and extent of the survey

3 Definitions

Ballast tank	Tank which is being used solely for water ballast or a tank which is used for both cargo and ballast will be treated as a Ballast Tank when substantial corrosion has been found in that tank
Close-up	Survey where the details of structural components are within the close visual inspection range of the Surveyor.
Longitudinal members in the transverse section	Include all longitudinal members such as plating, longitudinal and girders at the deck side, bottom, inner bottom and longitudinal bulkheads in the transverse section
Representative tanks	Are those which are expected to reflect the condition of other tanks of similar types and service and with similar corrosion prevention systems. When selecting representative tanks, it should consider the service and repair history on board and identifiable critical and or suspect areas.
Substantial corrosion	Corrosion pattern indicates a wastage in excess of 75% of allowable margins, but within acceptable limits.
Suspect areas	Are locations showing substantial corrosion and/or are considered by the Surveyor to be prone to rapid wastage
Corrosion prevention system	a) A full hard coating supplemented by anodes or b) A full hard coating.
Coating condition is defined as follows:- 1. Good 2. Fair 3. Poor	1. Minor spot rusting. 2. Local breakdown at edges of stiffeners and weld connections and/or light rusting over 20% or more of areas under consideration, but less than as defined for poor condition. 3. General breakdown of coating over 20%or more of areas or hard scale at 10% or more of areas.
Cargo length area	Includes all cargo holds and adjacent areas including fuel tanks, cofferdams, ballast tanks and void spaces.
Oil	Petroleum including crude oil, heavy fuel oil, lubricating oil, light oil kerosene, gas oil, and others prescribed by the relevant laws and regulations.
Oil tankers	Are ships constructed or adapted for the carriage of oil in bulk and include chemical carriers intended to carry oil in bulk and combination carriers which are designed to carry either oil or solid cargoes in bulk, such as ore/oil carriers and ore/bulk/oil carriers.
Bulk carrier	Are ships constructed or converted with a single deck, top-side tanks and hopper side tanks in cargo area and intended primarily to carry dry cargoes in bulk, or ships constructed or converted with a single deck, two longitudinal bulkheads and a double bottom throughout the cargo area and intended for the carriage of ore cargoes in the center holds only; and includes combination carriers which are designed to carry either oil or solid cargoes in bulk, such as ore/oil carriers and ore/bulk/oil carriers
Ships carrying timber cargoes	Cargo ships with timber load lines markings or primarily carrying log cargoes.

Anniversary Date	Is the day corresponding to the expiry date of the Classification Certificate.

4 Preparation for Surveys

4.1 Notification

It is the responsibility of the owners to notify the Surveyor or Survey Offices in advance to ensure that the surveys are carried out without disruption.

4.2 Preparation for Surveys

4.2.1 Owners or their representatives shall assume the responsibilities in the preparations for surveys and are to include provisions for easy and safe access, gas freeing, ventilations, lightings, and cleanliness for the execution of the survey.

4.2.2 In oil tankers, bulk carriers and ships carrying dangerous chemicals in bulk, an applicant is to submit a Survey Programme identifying the survey items as part of preparation for the Special Survey.

4.2.3 The presence of a responsible owner's representative during the survey.

4.3 Suspension of Surveys

Surveys may be suspended where essential preparations have not been made or the Surveyor considers that the safety for execution of the survey is not ensured.

4.4 Repairs

When repairs are considered to be necessary, the owner shall obtain the Surveyor's verification after carrying out the necessary repairs.

4.5 Procedure for Tests, Wear and Tear

Speed Trial	Speed trial is to be carried out, where alterations or repairs which might affect ship's speed have been made. Sea or Dock trial of ship or machinery may be required at the discretion of the surveyor.
Inclining Test	Inclining test is to be carried out, where alterations or repairs which may affect ship's stability. Further inclining test may be required where deemed necessary by the Surveyor.
Repairs for Wear and Tear	Where the thicknesses of materials of hull structure, scantlings of equipment, etc. become less than the stipulated wear and tear limits, these are to be renewed either with the original scantlings at the time of construction or the scantlings deemed appropriate by SILO. Where, however, the original scantlings were larger than the required ones, or where deemed appropriate by SILO, these requirements may be amended taking into account the location, extent, kind, etc. of the wear and tear.

CHAPTER 2
CLASSIFICATION SURVEY

1 Classification Survey during Construction

1.1 General

In the Classification Survey during construction, the hull and equipment, machinery, fire protection and detection, means of escape, fire extinction, electrical installation, stability and load lines are to be examined in detail in order to ascertain that they meet the relevant requirements in the Rules.

1.2 Submission of Plans and Documents for Approval

1.2.1. When it is intended to build a ship to the classification with SILO, the following plans and documents are to be submitted for the approval by SILO before the work is commenced. Plan and documents may be subject to inspection by SILO prior to the submission of an application.

(1) Hull

No.	Plans/Documents	Remarks
1	General arrangement	Details to be included.
2	Midship Section	Athwartship sections at the hold and machinery space, and also in way of the wing tank if fitted designed at maximum load draught
3	Stem, Stern Frame, Propeller Post and Rudder	Drawings and data
4	Construction profile	Showing arrangement of watertight bulkheads, the load draught, sizes of brackets and transverse sections of the ship at 0.1 *L* and 0.2 *L* from both ends of the ship
5	Deck plans	Indicating arrangement and construction of hatchways, hatch beams, etc.
6	Single bottoms and double bottoms	Including bilge hopper tanks if applicable
7	Watertight and oil-tight bulkheads	Indicating the highest position of tank and positions of tops of overflow pipes
8	Superstructure end bulkhead	With details of closing appliances of openings on the bulkheads
9	Members to resist panting in both peaks and their vicinity	Drawings and data
10	Pillars and deck girders	Drawings and data
11	Shell expansion	Dimensions and arrangements of freeing ports and draught at the ballast condition for ships are to be indicated in this plan.
12	Shaft tunnels	To indicate watertight positions
13	Seating of boilers, engines, thrust and plummer blocks, dynamos and other important auxiliary engines	Indicating horse powers, heights and weights of main engines, and arrangements of holding down bolts
14	Machinery casings	Including insulations

15	Long deckhouses, if fitted	Drawings and data
16	Masts, mast houses and winch platforms	Drawings and data
17	Pumping arrangements	Indicating capacity of each tank, water or oil
18	Plans showing the height of timber deck cargo and arrangements of lashing and fixing.	For ships marked with the timber load lines or ships which are provided with arrangements for lashing and fixing for timber loading on deck.
19	Fire protection construction	To indicate materials used in the construction of superstructures, bulkheads, decks, deckhouses, trunks, stairways, deck coverings, etc. and arrangements of closing appliances of openings and means of escape
20	Plans showing escape routes	Details are to be included
21	Plans showing fire extinguishing arrangement	Fire extinguishing arrangement, numbers and types of fire pumps, hydrants, hoses, etc.
22	Plans showing arrangement for access	Access for peak tanks, deep tanks, cofferdam, cargo holds having large bilge hopper.
23	Navigation bridge visibility	Plans and data where the length of ship for freeboard length is 45 m or over

(2) Machinery

1	Engine Room arrangement	Machinery arrangement of machinery space, diagram for internal communication systems including diagram for engineers' alarm systems
2	Main and auxiliary engines including their attachments	Drawings and data in relation to the kind of engine
3	Power transmission gears, shafting and propellers	Drawings and data
4	Boilers and pressure vessels	Drawings and data
5	Auxiliary machinery and piping	Plans, drawings, specifications and data reference
6	Steering gear	Plans and data
7	Automatic and remote controls	Plans and data reference
8	Spare parts	List of spare parts
9	Electrical installations	Plans and data

(3) Stowage installations and cargo tank construction for liquefied gases carried in bulk

1	Manufacturing specifications for cargo tanks, insulations and secondary barriers	Including welding procedures, inspection and testing procedures for welding and cargo tanks, properties of insulation materials and secondary barriers and their processing manual and working standards
2	Details of cargo tank construction	Drawings and data
3	Arrangement of cargo tank accessories	Including details of fittings inside the tanks
4	Details of cargo tank supports	To indicate deck portions through which cargo tanks penetrate, and their sealing devices
5	Details of secondary barriers	Drawings and data

6	Specifications and standards of materials	To include insulations used for cargo piping system in connection with design pressure and or temperature
7	Specifications and standards of materials.	For cargo tanks, insulations, secondary barriers and cargo tank supports
8	Layout and details of attachment for insulations	Drawings and data
9	Constructions of cargo pumps, cargo compressors and their prime movers	Specification of the pumps, compressors and prime movers to be included
10	Piping diagrams of cargo and instrument	Drawings and data
11	Constructions of refrigeration systems	Piping diagrams of refrigerant for refrigeration systems
12	Bilge arrangements and ventilation system	For hold spaces or inter barrier spaces, cargo pump room, cargo compressor room, and cargo control room
13	Arrangement of sensors	For gas detectors, temperature indicators, pressure gauges
14	Diagrams of inert gas lines	To include details of pressure adjusting devices, where hold spaces or inter barrier spaces are filled by inert gases
15	Details of pressure relief device and drainage systems	To handle leakage of liquefied cargo in hold spaces or inter barrier spaces
16	Sectional assembly	Details of nozzles, fitting arrangement and details of fittings for various pressure vessels
17	Details of valves	For special purpose, cargo hoses, expansion joints, filters, etc. for cargo piping system
18	Piping diagram, constructions and specification	For equipment that uses cargo as the fuel
19	Electric wiring plans	To include a table of electrical equipments in dangerous spaces
20	Earthing connection	Drawings of earth connection for cargo tanks, piping, machinery equipment.
21	Plans showing dangerous spaces	Drawings and data
22	Plans showing arrangements for personnel protection	The arrangement, numbers and types of protective equipment, safety equipment, stretcher and medical first aid equipment, respiratory protection for emergency escape purpose, decontamination shower, eye-wash and shelter.

(4) Stowage installations and cargo tank construction for dangerous chemicals carried in bulk

1	Manufacturing specifications for independent cargo tanks	Including materials to be used, welding procedures and inspection and testing procedures for weld and cargo tanks
2	Details of cargo tank construction	Thickness, material, welding requirement are to be specified
3	Arrangements of cargo tank accessories	Details of fittings inside the tanks to be submitted.

4	Details of independent cargo tank supports	Deck portions through which cargo tanks penetrate and their sealing devices when provided
5	Coating or lining procedure of inside of the cargo tanks	Corrosion test results of coating or lining may be required when necessary
6	Plans showing arrangement and the methods of attachment of the insulation	Working procedure is to be included
7	For Cargo Cooling Plans	Relevant information are to be submitted depending upon the cargo storage plan and the type of cargo tank construction
8	Cargo pump	Construction plan including list of materials to be used and their specifications
9	Piping arrangement in cargo tank area	Detail drawings are required
10	Cargo tank ventilation arrangement	To show the constructional details of the ventilation system
11	Ventilation Plans	Of cargo pump rooms, cofferdams, double bottoms and others
12	Diagram of monitoring and measurement system	For cargo level, cargo temperature and others and the detail construction of their equipment
13	Control system for cargo temperatures	Drawings and data
14	Details of environmental control system	The processes involving inerting, padding, drying or ventilation and the piping diagram and the construction of their equipment
15	Instruments for cargo vapor detection	All essential wiring and devices specification and plans
16	Electrical wiring plans	A table of electrical equipment used in dangerous spaces is to be submitted
17	Earth connections	Arrangement of earth connections for cargo tanks, pipe lines, machinery and equipment, only when flammable cargoes are intended to be loaded
18	Plans showing dangerous spaces	Detail drawings are to be submitted
19	Plans showing arrangement for personnel protection	The arrangement, numbers and types of protective equipment, safety equipment, stretcher and medical first-aid equipment and the arrangement of decontamination and an eye-wash

(5) Other plans and documents which are deemed necessary by SILO

1	The plans mentioned in (1)	Are to indicate in detail the quality of materials used, scantlings and arrangements of structural members, their attachments, clearance between the bottom of boilers and the top of floors, and other particulars necessary for inspection of proposed constructions
2	A stability information booklet	Is to be submitted for approval by SILO
3	For ships to be provided with the loading manual	The loading manual including the conditions for loading and other necessary information.

4	For ships to be provided with a loading computer.	Lines provided with offset table, light load hydrostatic curves, tank capacity plan finished plan, and the results of inclining tests are to be submitted to SILO.
5	Waiver of Plans and Documents	Submission of the plans and documents may be omitted in accordance with the requirements stipulated otherwise by SILO, in case where a ship or machinery is intended to be built at the same manufacturer's work based on the plans and documents which have been approved for other ships.
6	For ships carrying liquefied gases in bulk	An operation manual is to be submitted for approval by SILO. For ships carrying dangerous chemicals in bulk, an operation manual is to be submitted for approval by SILO
7	For ships to be provided with the damage control plan	The damage control plan is to be submitted for approval by SILO
8	For ships to be provided with the emergency towing	Drawings indicating a location of emergency towing arrangements provided and reinforced part of hull in way of emergency towing arrangements are to be submitted for approval by SILO.
9	For ships to be provided with the operating and maintenance manual for the door and inner	The operation and maintenance manual is to be submitted for approval by SILO.

1.3 Submission of Other Plans and Documents (for new building)

1	Plans and documents in 2.1.2 are to be submitted	Drawings and data
2	Specifications for hull and machinery	Complete list and the manufacturers' instructions
3	Calculation sheets	minimum athwart ship section modulus in way of the midship
4	Corrosion prevention scheme	Full protection plans including the specifications
5	For exceptional loading conditions	plans showing the particulars of the cargo intended to be carried and its distribution

(6) Where the requirements of Load Line are applicable:

1	General arrangement	Drawings and data
2	Midship section	Drawings and data
3	Construction profile or structural arrangement	Drawings and data
4	Deck plans	Showing the freeboard, superstructure and decks members in hatchways
5	Superstructure end bulkheads	Drawings and data
6	Lines	Drawings and data

7	Hydrostatic curves	indicating the displacement and the change of displacement per cm immersion at each draught up to the freeboard deck
8	Plans showing the height of timber deck cargo and the arrangements of lashing and fixing	For ships that are to be marked with the timber load lines

(7) For storage installation and cargo tank construction for liquefied gases carried in bulk:

1	Principal basic design and technical reports of cargo containment systems	Drawings and data
2	Data of test method and its result	where model test is carried out.
3	Data for notch toughness, corrosiveness, physical and mechanical	To indicate materials and welded parts at the minimum design temperature and room temperature where new materials or welding methods are adopted for constructing the cargo tanks, secondary barriers, insulations and others
4	Data of design loads for tanks, supports and fixtures	Drawings and data
5	Calculation sheets of cargo tanks and supports	Drawings and data
6	Data of the test analysis and the results	Where model tests were carried out to demonstrate the strength and operation of cargo tanks, insulations, secondary barriers, cargo tank supports
7	Calculation records of heat transfer on the main parts of cargo tank under various condition of loading	Where considered necessary by SILO
8	Calculation records of the thermal stress on the main parts of cargo tank	For temperature distribution
9	Calculation records of temperature distribution on hull structure	As deemed necessary by SILO
10	Specifications of cargo handling systems	Drawings and data
11	Composition and physical properties of cargoes	To include saturated vapour pressure diagram within the necessary temperature range
12	Calculation records of relieving capacity for pressure relief valves of cargo tank	To include calculation of the back pressure in cargo vent system
13	Calculation records for capacity of refrigeration systems	Drawings and data
14	Cargo piping arrangement	Drawings and data
15	Calculation sheets of filling limits for cargo tanks	Drawings and data
16	Manholes and access	Arrangements of access manholes in cargo tank area and the guide for access through these manholes

17	Calculation for ship survival capability	Drawings and data
18	Equipment for personnel protection	Drawings and data

(8) For storage installation and cargo tank construction for dangerous chemicals in bulk:

1	Chemical list	Lists showing chemical and physical properties and other special properties of the all cargoes intended to be loaded
2	Loading plans	For dangerous chemicals and other chemicals to be loaded simultaneously with these dangerous chemicals
3	Guide of reactivity hazard defined by reactivity with other chemicals, water or the chemical itself	To include polymerization and the heating or cooling media. The chemicals not intended to be loaded simultaneously with the dangerous chemicals may be excluded from these guide
4	Data of reactivity hazard	Between intended cargoes and coating or lining in cargo tanks and of piping and equipment that may come into contact with cargo liquid or vapour
5	Corrosion resistance material	Data of suitability of corrosion resistance materials of the cargoes having corrosive properties
6	Strength Calculation	Strength calculation of each cargo tanks and, where deemed necessary, thermal stress calculation
7	Capacity calculation of heating system.	Drawings and data
8	Other Plans and documents	Depending upon the cargo storage plan and the type of cargo tank construction when the cargoes are required to be cooled
9	Access	Arrangements of access manholes in cargo tank area and the guide for access through these manholes
10	Calculation for ship survival capability	Drawings and data
11	Equipment for personnel protection	Drawings and data
12	For ships to be provided with the emergency towing, operation manual of emergency towing arrangements.	Submission of other plans and documents may be required where deemed necessary by SILO

1.4 Presence of Surveyor

The presence of the Surveyor is required at the following stages of the work in relation to hull and equipment

1.4.1 When the material tests are carried out.

1.4.2 When the materials or parts manufactured away from the site are being applied to the ship concerned.

1.4.3 When welding tests are being conducted.

1.4.4 When designated by SILO during shop work or sub assembly.

1.4.5 When each block is assembled.

1.4.6 When hydrostatic tests, watertight tests and non-destructive tests are carried out.
1.4.7 When hull is completed.

1.4.8 When operation tests are carried out on closing appliances of openings, remote control devices, steering gears, anchoring and mooring arrangements, emergency towing arrangements, piping, etc.

1.4.9 When installing of rudder, profiling of keel line, measurement of principal dimensions, measurement of deflection of hull, etc. are carried out.

1.4.10 When a loading computer is installed on board.

1.4.11 When the ships are marked with the load lines.
1.4.12 When sea trials are carried out.

1.4.13 When stability experiments are carried out.

1.4.14 For ships to be provided with the emergency towing arrangements when emergency towing arrangements are installed on board

1.4.15 When installing of fire extinguishing arrangement, and when the operation test are carried out.

1.4.16 When deemed necessary by SILO.

2 The presence of the Surveyor is required at the following stages of the work in relation to machinery :

(1) When the tests of materials of main parts of machinery prescribed in Part K are carried out.

(2) Main parts of machinery
(a) When the tests to the respective kind of machinery are carried out.

(b) When the materials are applied to the parts and the parts are installed on board.

(c) When machining of the main parts is finished and, if necessary, at a proper time during machining.

(d) In case of welded construction, before welding is commenced and when it is completed.

(e) When shop trials are carried out.

(3) When important machinery is installed on board.

(4) When operation tests are carried out on remote control devices of closing appliances, remote control devices for machinery and gears, automatic control devices, steering gear, mooring arrangements, piping, etc.

(5) When sea trials are carried out.

(6) When deemed necessary by SILO.

1.5 Hydrostatic and Watertight Tests

In the Classification Survey during construction, hydrostatic tests, watertight tests, etc. are to be carried out in accordance with the following

No.	Hull and equipment	Machinery	Ships carrying liquefied gases carried in bulk and ships carrying dangerous chemicals in bulk
1	Hydrostatic tests or watertight tests are to be carried out after all work in connection with water tightness are completed but before painting.	Hydrostatic, leakage or airtight tests are to be carried out in relation to the kind of machinery.	For ships carrying liquefied gases in bulk and ships carrying dangerous chemicals in bulk by • hydrostatic tests, • leakage or • airtight tests..
2	A part or all of the hose tests may be dispensed with at the discretion of SILO.		
3	Watertight tests may be replaced by airtight tests at the discretion of SILO.		

2 Classification Survey of Ships Not Built Under Survey (Class Entry Survey)

2.1 General

2.1.1 In the Classification Survey of ships not built under SILO survey, the actual scantlings of main parts of the ship are to be measured in addition to such inspection of the hull and equipment, machinery, fire protection and detection, means of escape, fire extinction, electrical installations, stability and load lines as required for the Special Survey corresponding to the ship's age in order to ascertain that they meet the relevant requirements in the Rules.

2.1.2 For ships subject to Classification Survey of ships not built under SILO survey, plans and documents necessary for registration to SILO are to be submitted according to the relevant requirements in 2.1.2 and 2.1.3.

2.1.3 For ships that are provided with loading manual, the conditions for loading and other necessary information are to be submitted for approval by SILO.

2.1.4 For ships carrying liquefied gases in bulk and ships carrying dangerous chemicals in bulk an operation manual is to be submitted for approval by SILO.

2.1.5 For ships that requires damage control plan, the plan is to be submitted for approval by SILO.

Table B2.1 Hydrostatic Tests			
No.	**Tanks, Spaces**	**Type of tests and pressure/head**	**Remarks**
1	Double bottom	Hydrostatic test with a head of water to the top of air pipe	Where tanks are used for the carriage of the same kind of oil in both sides of centre girder need not be tested.
2	Deep tanks	Hydrostatic test with a head of water to the load waterline, to top of overflow pipe, to the level of 2.45 m above the tank top, or to the level of 2/3 D from the tank top, whichever is the greatest	
3	Cargo tanks and cofferdams of oil tankers	Hydrostatic test with a head of water to the level of 2.45 m above the deck at side forming the crown of the tank or to the level of 0.6 m above the top of hatch, whichever is the greater.	Hydrostatic test for each tank and cofferdam is to be carried out under the water head required in this table when ship is afloat.
4	After peaks and stern tube compartments	Hydrostatic test with a head of water to the load water above load waterline, hose waterline. For portions test with a pressure of water not less than 0.2 *MPa* in the hose.	Where they are used as tanks, tests are as specified in column No.2.
5	Forepeaks	Hydrostatic test with a head of water to the load waterline or to the waterline corresponding to the draught of 2/3 D, whichever is the greater. For portions above this greater waterline, hose test with a pressure of water not less than 0.2 MPa.	Where they are used as tanks, tests are as specified in column No.2.
6	Chain lockers located abaft the collision bulkhead	Hydrostatic test with a head of water to the top of chain lockers.	
7	Shell Plating	For shell plating corresponding to those of column No.1 through No.6, to be as specified in each corresponding column.	
8	Watertight decks	Hose test with a pressure of water not less than 0.2 *MPa* in the hose.	For decks corresponding to those of column No.2 through No.6, to be as specified in each corresponding column.
9	Watertight bulkheads and recesses		The boundary of deep tanks or peak tanks as specified in each corresponding column.

10	Shaft tunnels and other watertight tunnels		The boundary as specified in each corresponding column
11	Hatchways with weather-tight steel covers		To be tested in closed position
12	Double plate rudders	Hydrostatic test with a head of 1.5D or 2d, whichever is the smaller, or airtight test with a pressure of 0.05 MPa	

2.1.6 For ships to be provided with the emergency towing arrangements **,** drawings indicating a location of emergency towing arrangements provided and reinforced part of hull in way of emergency towing arrangements are to be submitted for approval by SILO.

2.1.7 For ships to be provided with the operating and maintenance manual for the door and inner door, the operating and maintenance manual is to be submitted for approval by SILO.

2.2 Hydrostatic and Watertight Tests

In the Classification Survey prescribed in 2.2.1, sea trials are to be carried out after hydrostatic tests and water-tight tests carried out in accordance with the requirements in the following (1) through (3), machinery to be made in good order, working pressure of boilers to be determined, safety valves to be adjusted and accumulation test of boilers to be carried out. Except hydrostatic tests of boilers and pressure vessels of which important parts have been newly repaired, main steam pipes, and air tanks of which interior cannot be inspected, and tests for gas leakage of refrigerating machinery on board, tests and trials may be dispensed with at the discretion of SILO.

2.2.1 Double bottoms tanks, fore and aft peak tanks, cofferdams and chain lockers located aft of the collision bulkhead, watertight bulkheads and shaft tunnels are to be tested as specified in Table B 2.1.

2.2.2 Hydrostatic, leakage or airtight tests are to be carried out as specified in each chapter of Part D in relation to the kind of machinery.

2.2.3 For ships carrying liquefied gases in bulk, hydrostatic, leakage and airtight tests are to be carried out in addition to the test specified in (1) and (2). For ships carrying dangerous chemicals in bulk, leakage and airtight tests stipulated otherwise are to be carried out.

3 Sea Trials and Stability Experiments

3.1 Sea Trials

3.1.1 In the Classification Survey of all ships, sea trials specified in following (a) to (j) are to be carried out in full load condition, in the calmest possible sea and weather condition and at the deep unrestricted water. However, where sea trials cannot be carried out in full load condition, sea trials may be carried out in an appropriate loaded condition.

a) Speed test

b) Astern test

c) Steering test and the change over test from the main to auxiliary steering gears

d) Turning test. The turning test of an individual ship may be dispensed with, provided that sufficient data are available from the turning test of a sister ship and subject to the special approval by SILO.

e) Confirmation of no abnormality for the operating condition of machinery and behaviors of the ship during the trials

f) Operation test of windlasses

g) Operation test of automatic and remote control systems for main propulsion machinery or the controllable pitch propellers, boilers and electric generating sets

h) The accumulation test of boilers

i) Measurement of the torsional vibration for the shafting systems

j) Other tests if deemed necessary by SILO

3.1.2 The results of the tests during sea trial are to be submitted to SILO.

3.1.3 In the case of classification Survey of ships not built under SILO survey, the above tests may be dispensed with, provided that sufficient data on the previous tests are available and no alteration affecting the sea trial tests have been made after the previous tests.

3.2 Stability Experiments

3.2.1 In the Classification Survey, inclining experiments of a ship are to be carried out upon completion of the ship. A stability information booklet, which is to be prepared on the basis of the particulars of stability determined by the results of stability experiments and to be approved by SILO, is to be provided on board.

3.2.2 For ships not built under SILO survey, inclining experiments may be dispensed with, provided that sufficient information based on previous stability experiments is available and neither alternation nor repair affecting the stability has been made after the previous experiments.

3.2.3 The inclining experiments of an individual ship may be dispensed with, provided that available stability data are obtained from the stability experiments of a sister ship or other adequate means and a special approval is given by SILO.

4 Loading Tests

4.1 Ships carrying Liquefied Gases in Bulk and Dangerous Chemicals in Bulk

4.1.1 Where it is required that a test is to be carried out under a condition having the intended cargoes actually loaded in the cargo tank, the test may be carried out at the first loading after completion of the classification survey. In this case, this test is to be carried out as an occasional survey in the presence of the Surveyor.

4.1.2 For ships not built under SILO survey with enough service records, all or a part of the tests may be dispensed with at the discretion of SILO

5 Alterations

5.1 Inspections of Altered Parts

When any alterations to hull, machinery or equipment, which affect or may affect classification are intended to be made, requirements for Classification Survey during Construction are to apply to the ship.

CHAPTER 3
ANNUAL SURVEY

1 General

1.1 Special Requirements

The survey as comprehensive as Special Survey may be required when considered necessary by SILO taking into account the service and repair history of the ship or damages to similar ships or tanks and spaces.

1.2 Survey for Combination Carriers

At Annual Surveys for combination carriers such as ore/oil carriers and ore/bulk/oil carriers, the surveys are to be carried out in accordance with the relevant requirements in this Chapter, considering the ship's equipment, structural configuration and past operational experience.

2 Annual Surveys for Hull, Equipment, Fire Extinction and Fittings

Inspection of Plans and Documents	At Annual Surveys, inspections of control of plans and documents listed in Table B3.1 are to be carried out.
General Inspection	At Annual Surveys, inspections of hull, equipment, fire extinction and fittings listed in Table B3.2 are to be carried out.
Operation Test	At Annual Surveys, operation tests listed in Table B3.3 are to be carried out
Internal Inspections of Spaces and Tanks	At Annual Surveys, internal inspections listed in Table B3.4 are to be carried out
Close-up Surveys	At Annual Surveys, close-up surveys listed in Table B3.5 are to be carried out.
Thickness Measurements	At Annual Surveys, thickness measurements listed in Table B3.6 are to be carried out. As to the gauging equipment and thickness measurement report, the provisions of 5.2.6-1 are to be applied correspondingly as well.
Pressure Test	At Annual Surveys for oil tankers and ships carrying dangerous chemicals in bulk, pressure test is to be carried out when deemed necessary by the Surveyor

Table 1.3.3.1 Inspection of Plans and Documents

Items	Inspection
1. Loading Manual	For ships to be provided with the manual on board confirmation as to whether the manual is kept on board is to be made.
2. Stability Information Booklet	Confirmation as to whether the booklet is kept on board is to be made.
3. Damage Control Plan	For ships to be provided with the damage control plan on board to confirm that the approved plan is kept on board

4. Fire Control Plan	Checking whether the fire control plan is exhibited and those stored in watertight containers.
5. Operating and Maintenance Manual for the bow door and inner door and notice board which indicates the operating procedure of them	For ships to be provided with the manual and notice board onboard in accordance with the requirements in Chapter 23, Part C, and Chapter 21, Part CS; checking whether the manual is kept on board is to be made. Checking whether the board is provided is to be made.
6. Instruction Manuals for the Inert Gas System	For ships to be provided with the manual on board in accordance with the requirements of 5.5.2, Part R, checking whether the manual is kept on board is to be made.

Table B 3.2 General Inspection	
Items	**Inspection**
1. Shell plating	General condition of outside of the hull above the load waterline is to be examined.
2. Weather deck plating	
3. Openings on deck and outside of the hull	General condition of coamings and closing appliances of hatchways on exposed deck and within unenclosed superstructures and side port, cargo port and side scuttles below the freeboard or superstructure deck is to be examined.
4. Casings of engine room	General condition of exposed engine casings and their openings, skylights of boiler room and engine room and their closing appliances is to be examined.
5. Ventilators	General condition of coamings and closing appliances of ventilators to spaces below the freeboard deck or the deck of enclosed superstructures is to be examined.
6. Air pipes	General condition of air pipes on weather deck and their closing appliances is to be examined.
7. Watertight bulkhead and superstructure end bulkhead	General condition of watertight doors, penetrations and stop valves on watertight bulkheads and closing appliances of openings on superstructure end bulkheads is to be examined.
8. Load line marks	The indication of deck line and load line are to be checked.
9. Bulwark	General condition of bulwarks and shutters of freeing ports in bulwarks or guard rails is to be examined.
10. Means of access	General condition of permanent gangways or other means of access is to be examined.
11. Scuppers, inlets, other discharge pipes and valves	General condition of scuppers, inlets, other discharge pipes and valves is to be examined as far as practicable.
12. Securing arrangement for on deck timber	General condition of securing arrangement for on - deck timber including eye plates, lashing wires, etc. is to be examined, in case where the arrangement has been approved by SILO.

13. Anchoring and mooring arrangement	Anchoring and mooring arrangement including their accessories are to be examined as far as can be seen.
14. Fire extinguishing arrangement	General condition of fire extinguishing arrangements is to be examined and checking whether fixed fire extinguishing system, semi-portable or portable fire extinguishers and fireman's outfits are maintained in good order is to be made.
15. Fire protection arrangement and means of escape	Checking that no alteration has been made to these arrangements is to be made.
16. Sails and their accessories	Sails and their accessories are to be examined in the condition of being put in place and ready for unfolding.
17. Emergency towing arrangement	General condition of the ETA is to be examined
18. Loading computer	To examine the print-outs to ensure compliance with the stability data
Additional Requirements for Tankers and Ships Carrying Dangerous Chemicals in bulk	
19 Piping - General condition of cargo oil, fuel oil, ballast, vent pipes including vent masts and headers, inert gas pipes and all other piping in pump room and on weather decks is to be examined	
Additional requirement for bulk carriers over 15 years of age. 11	
20 Piping in the cargo holds. All piping and penetrations in cargo holds, including overboard piping, are to be examined.	

Table B3.3 Operation Tests	
Items	**Tests**
I Weathertight hatch covers	Hose test listed in Table B2.1 (when deemed necessary by the Surveyor) Random checking of the satisfactory operation of mechanically operated hatch covers
2 Closing appliances of watertight door on watertight bulkheads and openings on superstructure end bulkheads	Checking whether the appliances work in good order is to be made as deemed necessary by the Surveyor.
3 Appliances related to fire protection and escape	Checking whether the appliances work in good order is to be carried out.
4 Fire detection system and fire alarm system including manually operated call points	Checking whether the systems work in good order, including failure alarm of the system, is to be made.
5 Fire pumps including emergency fire pump, piping, hydrants, hoses, nozzles etc.	Operation test of the fire fighting system composed of fire pump, hydrants, etc. is to be carried out. For ships having operating system for periodically unattended machinery space, operation test of remote control system or automatic operation system of one pump is to be carried out.
6 Fixed deck foam system	Checking whether the system works in good order
7 Ventilation system	Checking whether fans work in good order is to be carried out.

Table B3.2.

3 Annual Surveys for Machinery

3.1 General Inspections

3.1.1 At Annual Surveys for Machinery, general inspection of the whole machinery in the engine room and the following inspections (1) through (3) are to be carried out

a) It is to be ascertained that the main propulsion machinery, power transmission machinery, shafting systems, prime movers other than main propulsion machinery, boilers, thermal oil heaters, incinerators, pressure vessels, auxiliaries, piping systems, control systems, electrical installations and switchboards are placed in good order.

b) Engine room, boiler spaces and means of escape are in good order

c) For ships adopting the preventive maintenance system a general inspection of the system and review of monitoring parameter's record of the system are to be carried out

3.1.2 At Annual Surveys for Machinery of tankers, the pump foundation, ventilation system in the cargo pump rooms and electrical installations in the hazardous areas

3.2 Operation Tests

3.2.1 At Annual Surveys for Machinery, operation tests for the systems and devices listed in Table B3.7 are to be carried out

3.2.2 At Annual Surveys for tankers and ships carrying dangerous chemicals in bulk, in addition to the requirements specified in Table B3.7, the installations and devices specified in Table B3.8 are subjected to operation testing.

CHAPTER 4
INTERMEDIATE SURVEY

4 Special Requirements for Ships Carrying Liquefied Gases in Bulk

4.1 General

In addition to the requirements of 3.2 and 3.3, requirements of 3.4 apply to Annual Survey of ships carrying liquefied gases in bulk. Inspections of inert cargo tanks or spaces may be omitted at the discretion of the Surveyor.

4.2 Inspections

At Annual Surveys for ships carrying liquefied gases in bulk, structures and equipment of the spaces specified in Table B3.9 are to be generally examined.

Inspection of Plans and Documents	At Intermediate Surveys, inspections of control of plans and documents specified in 3.2.1 are to be carried out.
General Inspection	At Intermediate Surveys, inspections of hull, equipment, fire-extinction and fittings specified in 3.2.2 are to be carried out. In addition, conditions of spare parts for fire-extinguishing systems are to be generally examined.
Operation Test	At Intermediate Surveys, operation tests listed in Table B4.1 are to be carried out.
Internal Inspections of Spaces and Tanks	At Intermediate Surveys, internal inspections listed in Table B4.2 are to be carried out.
Close-up Surveys	At Intermediate Surveys, close -up surveys listed in Table B4.3 are to be carried out.
Thickness Measurements	At Intermediate Surveys, thickness measurements which consist of those listed in Table B4.4 are to be carried out. As to the gauging equipment and thickness measurement report, the provisions of 5.2.6-1. are to be applied correspondingly as well.
Pressure Test	At Intermediate Surveys for oil tankers and ships carrying dangerous chemicals in bulk, pressure test is to be carried out subject to the satisfaction to the Surveyor when deemed necessary by the Surveyor as a consequence of the general inspection required in 4.2.2.

4.3 Intermediate Surveys for Machinery

4.3.1 General Inspections

At Intermediate Survey for Machinery, in addition to the general inspections specified in 3.3.1, the inspections specified in Table B4.5 are to be carried out. For each ship adopting the preventive maintenance system for propulsion shafting system in accordance with the requirements 8.1.3, general inspection of the shafting system and review of all condition monitoring data available on board the ship on the system are to be carried out in order to ascertain that the system is well maintained.

4.3.2 Operation Tests

At Intermediate Surveys for Machinery, the operation tests specified in 3.3.2 are to be carried out.

4.4 Special Requirements for Ships Carrying Liquefied Gases in Bulk

4.4.1 General

In addition to the requirements of 4.2 and 4.3, requirements of 4.4 apply to Intermediate Surveys for ships carrying liquefied gases in bulk. Inspections of inert cargo tanks or spaces may be omitted at the discretion of the Surveyor.

4.4.2 Inspections

At Intermediate Surveys for ships carrying liquefied gases in bulk, inspections of spaces, structures and equipment specified in Table B4.6 are to be carried out. The survey may be expanded to include operation tests, operation tests, open -up inspections, etc. where deemed necessary by the Surveyor.

Table B4.1 Operation Test	
Items	**Tests**
Equipment or installations of items I and 3 through 7 in Table B3.3	Tests for each items specified in Table B3.3 are to be carried out.
Doors on watertight bulkheads and closing appliances on superstructure end bulkheads	Checking whether doors and closing appliances work in order is to be made.
Drainage, mooring and anchoring arrangements and their accessories	Checking whether arrangements work in order is to be made. The checking may be dispensed with at the discretion of the Surveyor.
Fixed dry chemical powder fire fighting system	Checking whether piping is maintained in good condition is made by delivering air. Checking whether a monitor and a hose work in order is to be made. Checking whether the remote control system and the related automatic valve work in order is to be made. Checking of quantity of starting or pressuring gases is to be made.
Water spray system	Checking whether the system works in order is to be made by delivering water. Checking of quantity of delivered water may be dispensed with.
Carbon dioxide, halon and dry chemical powder extinguishing medium	Checking the quantity of media
Fixed carbon dioxide and fixed halon fire fighting system	Checking whether piping are maintained in good condition is made by delivering air. Checking whether an alarm of systems works in order is to be made.
Fixed foam fire fighting system and fixed high expansion foam fire fighting system	Check that the pipes are maintained in good condition.
Fixed pressure water spraying fire fighting system	Checking whether the system works in order is to be made by delivering water.

	Checking whether the pump of the system works in order is to be made.
Automatic sprinkler system	Checking whether the delivery alarm and the pump works in order is to be made while fire detecting system is working.
Closing appliances of openings related to fire fighting in way of cargo holds	Checking whether closing appliances work in order is to be made

4.5 Special Requirements for Ships Carrying Dangerous Chemicals in Bulk

4.5.1 General

In addition to the requirements of 4.2 and 4.3, requirements of 4.5 apply to Intermediate Surveys of ships carrying dangerous chemicals in bulk.

4.5.2 Inspections

At Intermediate Surveys of ships carrying dangerous chemicals in bulk, inspections of spaces, structures and equipment specified in Table B4.7 are to be carried out in addition to inspections required in 3.5.2. The survey may be expanded to include operation tests, operation tests, open up inspections, etc. where deemed necessary by the Surveyor.

Table B4.2(2) Internal Inspections of Spaces and Tanks	
Items	Inspections
Requirements for Bulk Carriers	
Engine room and boiler	An internal inspection is to be carried out
Ballast tanks	An inspection of areas found suspect in way of ballast tanks at the previous Special Survey is to be carried out. For ships over 5 years and up to 10 years of age, an internal inspection of representative ballast tanks and combined cargo/ballast tanks, if any, is to be carried out. Where poor coating condition, corrosion or other defects are found in a ballast tank or where a protective coating has not been applied from the time of construction, the inspection is to be extended to other ballast tanks of the same type. For ships over 10 years of age, an internal inspection of all ballast tanks and all combined cargo/ballast tanks, if any, is to be carried out. If such inspections reveal no visible structural defects, the inspection may be limited to a verification that the protective coating remains effective. For ballast tanks where a protective coating is found in poor condition, and it is not renewed or where a protective coating has not been applied, excluding double bottom tanks, an internal inspection is to be carried out at annual intervals. For double bottom ballast tanks with the condition as specified, where considered necessary by the Surveyor, an internal inspection is to be carried out at annual intervals.
Cargo holds	For ships over 5 years of age, an internal inspection of all cargo holds is to be carried out

Requirements for Ships Carrying Timber Cargoes	
Engine room and boiler room	An internal inspection is to be carried out
Ballast tanks	Same as those for cargo ships
Cargo holds	For ships over 5 years of age, an internal inspection of all cargo holds is to be carried out.

Table B4.3 Close-up Surveys	
Items	Inspections
Oil Tankers and Ships Carrying Dangerous Chemicals in bulk over 10 Years of age	
Structural members in ballast tanks	Close -up surveys are to be carried out for ballast tanks to the same extent as previous special survey.
Structural members in cargo tanks	Close -up surveys are to be carried out for at least two combined cargo/ballast tanks, if any, to the same extent as previous Special Survey. Close-up surveys to only one combined tank are to be accepted where there is no more combined tank. In this case, requirements for cargo tanks apply to combined cargo/ballast tanks. Close-up surveys of at least one cargo tank are to be carried out to the same extent as previous special survey after the third Special Survey.

Table B4.4 Thickness measurements	
Items	Note
Requirements for Cargo Ships over 5 *years* of age except those specified in the followings	
Structural members in ballast tanks	The thickness measurement is to be carried out to evaluate the condition of areas found suspect at the previous Special Survey. Where considered necessary by the Surveyor as a result of the survey specified in Table B4.2, the thickness measurement is to be carried out at the discretion of the Surveyor, where poor coating condition, corrosion or other defects are found in a ballast tank or where a protective coating has not been applied from the time of construction. Where substantial corrosion is found, additional thickness measurements are to be carried out according to the provision of 5.2.6-2.
Requirements for Oil Tankers and Ships Carrying Dangerous Chemicals in bulk over 5 *years* of age	
Cargo oil, fuel oil, ballast tanks vent pipes, vent heads, masts and headers, inert gas pipes and all other pipes in pump room and on weather decks	When deemed necessary by the Surveyor as a consequence of the inspection specified in 4.2.2, thickness measurements are to be carried out.
Structural members in ballast tanks	The Thickness Measurement is to be carried out to evaluate the condition of area found suspect at the previous Special Survey.

	Where considered necessary by the Surveyor as a result of the survey specified in Table B4.2, the thickness measurement is to be carried out at the discretion of the Surveyor, where poor coating condition, corrosion or other defects are found in a ballast tank or where a protective coating has not been applied from the time of construction. If the results of such thickness measurements indicate that substantial corrosion is found, the extent of thickness measurements is to be increased in accordance with the provision of 5.2.6-3
Structural members in cargo tanks	The Thickness Measurement is to be carried out to evaluate the condition of areas found suspect at the previous Special Survey. If the results of such thickness measurements indicate that substantial corrosion is found, the extent of thickness measurements is to be increased in accordance with the provision of 5.2.6-3
Requirements for the bulk carriers over 5 *years* of age	
structural members in ballast tanks	Where considered necessary by the Surveyor as a result of the survey specified in Table B4.2, the thickness measurement is to be carried out at the discretion of the Surveyor, where poor coating condition, corrosion or other defects are found in a ballast tank or where a protective coating has not been applied from the time of construction The thickness measurements are to be carried out to evaluate the condition of areas found suspect at the previous Special Survey. If the results of such thickness measurements indicate that substantial corrosion is found, the extent of thickness measurements is to be increased in accordance with the provision of 5.2.6-4.
Structural members in cargo holds - Structural members subject to close-up survey	The thickness measurement is to be carried out to determine both general and local corrosion levels at areas subject to close-up survey. The thickness measurement may be dispensed with provided the Surveyor is satisfied by the close-up survey, that there is no structural diminution and the protective coating where fitted were remains effective. The thickness measurements are to be carried out to evaluate the condition of areas found suspect at the previous Special Survey. If the results of such thickness measurements indicate that substantial corrosion is found, the extent of thickness measurements is to be increased in accordance with the provision of 5.2.6-4.
Requirements for Ships Carrying Timber Cargoes over 5 *years* of age	

Structural members in cargo holds - Structural members subject to close-up survey	The thickness measurement of structural members subject to close-up survey in all cargo holds is to be carried out. The thickness measurement is to be carried out to the same extent as previous Special Survey. The thickness measurement may be dispensed with provided the Surveyor is satisfied by the close-up survey, that there is no structural diminution and the protective coating where fitted were remains effective

Table B4.5 Additional Requirements at Intermediate Surveys

Items	Inspections
Electrical installations	For tankers, electrical installations in the hazardous areas are to be generally examined and their insulation resistance is to be measured. However, where a proper record of measurement is maintained and deemed appropriate by the Surveyor, consideration may be given to accepting recent readings.
Refrigerating Machinery	The general condition of the safety devices are to be examined.

Table B4.6 Special Requirements for Ships Carrying Liquefied Gases in bulk

Items	Inspections
Piping of fixed gas detecting instruments	General inspection is to be carried out.
Pressure relief valves with non-metallic membranes	If the cargo tanks are equipped with relief valves with non-metallic membranes in the main or pilot valves, it is to be confirmed that such non -metallic membranes are maintained in good condition.
Electrical installation	Operation test of interlock devices is to be carried out. Insulation resistance test of electric circuits in gas dangerous spaces or areas is to be carried out. This test may be omitted at the discretion of the Surveyor, if the insulation resistance is verified by the records of the recent test is carried out by the crew.
Earthing	Earthing between hull structures and the cargo tanks is to be examined visually as far as accessible.
Drainage system for leaked cargo	Operation test of drainage system for leaked cargo in inter barrier spaces and hold spaces is to be carried out.
Fire fighting system in enclosed gas dangerous spaces	Fixed piping is to be tested by air. Operation test of alarming devices for emergency escape is to be carried out.
Personnel Protection	Where air compressor is provided for safety equipment, operation tests of air compressor are to be carried out.

Table B4.7 Special Requirements for Ships Carrying Dangerous Chemicals in bulk

Items	Inspections
Electrical installations	Operation test of interlock devices is to be carried out. Insulation resistance test of electric circuits in gas dangerous spaces or areas is to be carried out. This test may be omitted at the discretion of the Surveyor, if the insulation resistance is verified by the records of the recent test is carried out by the crew.
Earthing	Earthing between hull structures and the cargo tanks is to be examined visually as far as accessible.
Fire fighting system in enclosed gas dangerous spaces	Fixed piping is to be tested by air. Operation test of alarming devices for emergency escape is to be carried out.
Personnel Protection	Where air compressor is provided for safety equipment, operation tests of air compressor are to be carried out.

CHAPTER 5
SPECIAL SURVEY

1 General

1.1 Inspections to be carried out at the Commencement or Completion of Special Surveys

1.1.1 In case where the Special Survey is commenced in accordance with the requirements in 1.1.3-10(b), the Thickness Measurement required in 5.2.6 is to be carried out at the commencement of the Survey to facilitate planning repairs, as far as practicable.

1.1.2 In case where the Special Survey is completed in accordance with the requirements in 1.1.3-1(3)(b), inspections required in 3.2.2, 3.2.3, 3.3.1 and 3.3.2 are at least to be carried out at the completion of the Special Survey. Where considered necessary by the Surveyor as a result of these inspections, inspections may be expanded to include those which have already been carried out.

1.2 Survey for Combination carriers

At Special Surveys for combination carriers such as ore/oil carriers and ore/bulk/oil carriers, the surveys are to be carried out in accordance with the relevant requirements in this Chapter, considering into the ship's equipment, structural configuration and past operational experience.

2 Special Surveys for Hull, Equipment, Fire extinction and Fittings

2.1 Inspection of Plans and Documents

At Special Surveys, inspections of control of plans and documents specified in 3.2.1 are to be carried out.

2.2 General Inspection

2.2.1 At Special Surveys, inspections of hull, equipment, fire-extinction and fittings specified in 4.2.2 are to be carried out carefully.

2.2.2 At Special Surveys for tankers and ships carrying dangerous chemicals in bulk, in addition to -1, cargo piping, vent piping, purging piping, gas free piping, inert gas piping and all other piping systems within all cargo tanks, all tanks and spaces bounding cargo tanks such as ballast tanks, pump rooms, pipe tunnels, cofferdams and void spaces and on weather decks are to be examined.

2.2.3. In Special Surveys for bulk carriers, in addition to -1, all piping systems within all cargo tanks and ballast tanks, pump rooms, pipe tunnels, cofferdams and void spaces bounding cargo tanks and on the weather deck are to be examined.

2.3 Operation Test

2.3.1 At Special Surveys, operation tests specified in 4.2.3 are to be carried out, and in addition to such operation tests, it is to be confirmed that the loading instrument required in 34.1.1 and 34.3.2, Part C works in order. In applying the requirements for operation tests specified in 4.2.3, the operation test for mechanically operated hatch covers specified in item I in

Table B4.1 is to be carried out for all mechanically operated hatch covers, and it is not allowed to dispense with operation tests for mooring and anchoring arrangements specified in item 3 in Table B4.1.

2.3.2 Where considered necessary by the Surveyor, an execution of the inclining test and an alteration of the stability information may be required.

2.4 Internal Inspections of Spaces and Tanks

2.4.1 At Special Surveys, paying due attention to (1) through (7) below, inspections of structures and fittings such as piping, etc. in tanks and spaces are to be carried out carefully.

a) Structural members, piping, hatch covers, etc. sensitive to corrosion in the cargo holds where highly-corrosive cargoes to steel such as logs, salt, coal, sulfide ore, etc. have been loaded.

b) Portions sensitive to wearing down by heat such as plating under boilers

c) Structurally discontinuous portions such as corners of hatchway openings on deck, openings including side scuttles, cargo port, etc.

d) Condition of coating and corrosion prevention system if applied

e) Condition of striking plates under sounding pipes

f) Condition of cement or deck composition, if fitted

g) Locations on which defects such as cracking, buckling, corrosion, etc. have been found in similar ships or similar structures

2.4.2 At Special Surveys, paying attention to -1 above, internal inspections of tanks or spaces listed in Table B5.1

Table B5.1 Internal inspections of tanks and spaces

Special Survey	Tanks and spaces subject to an inspection	Note
Special Survey for ships up to 5 *years* of age (Special Survey No.1)	Cargo holds Cofferdam Water tanks (tanks used for fresh or sea water) Fuel oil tanks other than those of double bottom Cargo tanks (other than those of tanker, ships carrying liquefied gases in bulk and ships carrying dangerous chemicals in bulk) Machinery spaces and other spaces	An internal inspection of the deep fuel oil tanks except both peak tanks may be omitted provided the Surveyor is satisfied with the condition of tanks after the external inspection of the tanks. For ballast tanks where a protective coating is found in poor condition, and it is not renewed or where a protective coating has not been applied, excluding double bottom tanks, an internal inspection is to be carried out at annual intervals.

		For double bottom ballast tanks with the condition as specified, where considered necessary by the Surveyor, an internal inspection is to be carried out at annual intervals.
Special Survey for ships over 5 years and up to 10 years of age (Special Survey No.2)	Tanks and spaces subject to an inspection carried out at Special Survey No.1 Fuel oil tanks in double bottom	Fuel oil tanks excluding both peak tanks need not all be examined internally, provided, after an external inspection and from an internal inspection of each one double bottom tank forward and aft and of one selected deep tank, the Surveyor is satisfied with the condition of the tanks.
Special Survey for ships over 10 *years* of age (Special Survey No.3 and subsequent Special Survey)	Tanks and spaces subject to an inspection carried out at Special Survey No.2 Lubricating oil tanks are to be carried out. In case where postponement of the Special Survey for a ship is granted in accordance with the requirements in 1.1.5, a kind of the Special Survey to be applied to the ship is to be determined based on the original expiry date of the Classification Certificate of the ship.	Fuel oil tanks excluding both peak tanks need not all be examined internally, provided, after an external inspection and from an internal inspection of each one double bottom tank amidship, forward and aft and of a half numbers of deep tanks, the Surveyor is satisfied with the condition of the tanks. Lubricating oil tanks need not be examined internally, provided, after an external inspection, the Surveyor is satisfied with the condition of the tanks. However, it is not allowed to dispense with the internal inspection of fuel oil tanks and lubricating oil tanks for ships over 15 *years* of age.

2.4.3 At Special Surveys for tankers and ships carrying dangerous chemicals in bulk, in addition to -1 and -2 above, an internal inspection of tanks and spaces listed in Table B5.2 is to be carried out.

2.4.4 At Special Surveys for bulk carriers, in addition to -1 and -2 above, an internal inspection of tanks and spaces listed in Table B5.3 is to be carried out.

2.5 Close-up Surveys

2.5.1 At Special Surveys, a Close-up Survey is to be carried out for portions shown in (1) and (2) below:

a) Lower parts of shell frames, tank side brackets and lower parts of transverse bulkheads

a) Lower parts (located on inner bottom plating) of airpipes, sounding pipes, etc.

2.5.2 At Special Surveys for oil tankers and ships carrying dangerous chemical in bulk, notwithstanding the provision of -1 above, a Close-up Survey is to be carried out for structural members and so forth listed in Table B5.4.

2.5.3 At Special Surveys for bulk carriers, notwithstanding the provision of -1 above, a Close-up Survey is to be carried out for structural members and so forth listed in Table B5.5**.** For ore carriers, a Close-up Survey for the structural members in wing ballast tanks and wing void spaces is to be carried out in accordance with requirements for those in Table B5.4 instead of in Table B5.5.

2.6 Thickness Measurements

2.6.1 At Special Surveys, thickness measurement is to be carried out in accordance with (1) through (3) below.

a) Thickness measurement is to be carried out using an appropriate ultrasonic gauging machines or other approved means. The accuracy of the equipment is to be proven to the Surveyor as required.

b) Thickness measurement is to be carried out within 12 *months* prior to completion of the survey in question under the supervision of the Surveyor. However, thickness measurements carried out not under the supervision of the Surveyor may be accepted provided that the firm approved by Sing-Lloyd under the **"Rules for Approval of Manufacturers and Service Suppliers"** which is separately specified carries out thickness measurements within 12 *months* prior to completion of the survey in question. The Surveyor may re-check the measurements as deemed necessary to ensure acceptable accuracy.

Table B5.2 Additional requirements of internal inspections for tankers and ships carrying dangerous chemical in Bulk

Special Surveys	Tanks and spaces subject to an inspection	Notes

All Special Surveys	All cargo tanks	For oil tankers, combined cargo/ballast tanks, if any, are to be examined carefully taking account of ballast history and the extent of the corrosion prevention system provided. For oil tankers, condition of the inner surface of the bottom plating is to be examined in order to ascertain that the there is no excessive pitting of the plating. For oil tankers, bell mouths of the cargo suction pipes are to be removed to enable inspection of the shell plating and bulkheads in that vicinity as considered necessary by the Surveyor.
	All tanks and spaces adjacent to cargo tanks (ballast tanks, pump rooms, pipe tunnels, cofferdams and void spaces)	For oil tankers and ships carrying dangerous chemicals in bulk, an internal inspection of ballast tanks is to be carried out at annual intervals, where a protective coating is found in poor condition, and it is not renewed or where a protective coating has not been applied to the tanks. An internal inspection of pump room is to be carried out carefully paying attention to the sealing arrangements of all penetrations of bulkheads, ventilating arrangements, foundations and gland seals of pumps.

Table B5.3 Additional Requirements of internal inspections for Bulk Carriers

Special Surveys	Tanks and spaces subject to an inspection	Notes
All Special Surveys	All cargo holds All tanks and spaces adjacent to cargo holds (ballast tanks, pipe tunnels, cofferdams and void spaces)	Combined cargo/ballast tanks, if any, are to be examined taking account of ballast history and the extent of the corrosion prevention system provided. For ballast tanks where a protective coating is found in poor condition, and it is not renewed or where a protective coating has not been applied, excluding double bottom tanks, an internal inspection is to be carried out at annual intervals. For double bottom ballast tanks with the condition as specified, where considered necessary by the Surveyor, an internal inspection is to be carried out at annual intervals. Ballast tanks converted to void spaces are to be examined applying the provisions for ballast tanks correspondingly.

c) A thickness measurement record is to be prepared and submitted to Sing-Lloyd.

2.6.2 At Special Surveys, a thickness measurement is to be carried out according to -1 above for structural members and so forth listed in **Table B5.6.** Where substantial corrosion is found in the results of such thickness measurements, the thickness measurement is to be extended to all the structural members listed in Table B5.7, of which the subtitle corresponds to substantially corroded members.

2.6.3 At Special Surveys for oil tankers and ships carrying dangerous chemicals in bulk, notwithstanding to the provision of -2 above, a thickness measurement is to be carried out for structural members and so forth listed in **Table B5.8** according to -1 above. Stainless steel hull structure and piping except for clad steel may be exempted from thickness measurements when deemed appropriate by Sing-Lloyd. Where substantial corrosion is found in

Table B5.4 Requirements of Close-up Surveys for Oil tankers and Ships Carrying Dangerous Chemicals in bulk

Special Survey	Structural members subject to the Close-up survey
Special Survey for ships up to 5 years of age (Special Survey No. 1)	a) One Web Frame Ring in a ballast wing tank, if any, or a cargo wing tank used primarily for water ballast or a ballast wing tank or ballast double hull tank*' b) One Deck Transverse - in a cargo tank or on deck c) One Transverse Bulkhead in a ballast tank d) One Transverse Bulkhead in a cargo wing tank e) One Transverse Bulkhead in a cargo center tank
Special Survey for ships over 5 years and up to 10 years of age (Special Survey No.2)	a) All Web Frame Ring in a ballast wing tank, if any, or a cargo wing tank used primarily for water ballast or a ballast wing tank or ballast double hull tank*' b) One Deck Transverse in or on each of the remaining ballast tanks, if any c) One Deck Transverse in or on a cargo wing tank d) One Deck Transverse in or on two cargo center tanks e) Both Transverse Bulkheads - in a ballast wing tank, if any, or a cargo wing tank used primarily for water ballast or a ballast wing tank or ballast double hull tank*' f) One Transverse Bulkhead in each remaining ballast tank g) One Transverse Bulkhead in a cargo wing tank h) One Transverse Bulkhead in two cargo center tanks i) All Plating and Internal Structure - in a ballast wing tank or ballast double hull tank*' (Only for ships carrying dangerous chemicals in bulk

Special Survey for ships over 10 years and up to 15 years of age (Special Survey No.3)	For oil tankers; a) All Web Frame Rings in all ballast tanks b) All Web Frame Rings in a cargo wing tank c) One Web Frame Ring in each remaining cargo wing tank d) All Transverse Bulkheads - in all cargo and ballast tanks e) One Deck and Bottom Transverse - in each cargo center tank f) As considered necessary by the Surveyor For ships carrying dangerous chemicals in bulk; g) All Plating and Internal Structure in all ballast tanks h) All Plating and Internal Structure in a cargo wing tank i) One Transverse Section in each remaining cargo tank j) All Transverse Bulkheads in all cargo tanks
Special Survey for ships over 15 years of age (Special Survey No.4 and subsequent Special Surveys)	As Special Survey No.3. Additional transverses included as deemed necessary by the Surveyor.

Note
Abbreviations in this table mean

a) Complete transverse web frame ring including adjacent structural members such as shell plating, longitudinal stiffeners, brackets, etc.

b) Deck transverse including adjacent deck structural members such as shell plating, longitudinal stiffeners, brackets, etc.

c) Transverse bulkhead complete including girder system and adjacent structural members such as brackets, stiffeners, etc.

d) Transverse bulkhead lower part including girder system and adjacent structural members such as brackets, stiffeners, etc.

e) Deck and bottom transverse including adjacent structural members such as deck plating, bottom plating, longitudinal stiffeners, etc.

f) Additional complete transverse web frame ring

g) Complete tank - including all tank boundaries and internal structure, and external structure on deck in way of the tank

i) Double hull tank - including double bottom tank and side tank even though these tanks are separate.

The results of such thickness measurements, the thickness measurement is to be extended to all the structural members listed in the table among Table B5.9 through Table B5.12, of which the subtitle corresponds to substantially corroded members.

2.6.4 At Special Surveys for Bulk Carriers, notwithstanding the provision of -2 above, a thickness measurement is to be carried according to -1 above out for structural members and so forth listed in Table B5.13. Where substantial corrosion is found in the results of such thickness measurements, the thickness measurement is to be expanded to all the structural members listed in the table among

Table B5.5 Requirements of Close-up Surveys for Bulk Carriers

Special Survey	Structural members subject to Close-up survey
Special Survey for ships up to 5 years of age (Special Survey No. 1)	1. All shell frames in all cargo holds including their end attachments 2. Two selected transverse bulkheads and lower part of remaining transverse bulkheads (including stiffeners and girders) 3. One transverse web with associated plating and longitudinal in two representative ballast tanks of each type (topside, bilge hopper or side tank). 4. Air pipes and sounding pipes in cargo holds: in way of tank top 5. All cargo hold hatch covers and coaming
Special Survey for ships over 5 years and up to 10 years of age (Special Survey No.2)	1. All shell frames in all cargo holds including their end attachments 2. One transverse bulkhead and lower part of another transverse bulkhead in each cargo hold (including stiffeners and girders) 3. About half of transverse webs with associated plating and longitudinal, and upper and lower parts of each bulkhead in a representative ballast tanks of each type (topside, bilge hopper or side tank) 4. One transverse web with associated plating and longitudinal in remaining ballast tanks 5. Both forward and aft bulkhead (including stiffeners and girders) in one side ballast tank 6. All cargo hold hatch covers and hatch coaming 7. Selected area of deck plating inside line of hatch openings between cargo hatches 8. Air pipes and sounding pipes in cargo holds: in way of tank top
Special Survey for ships over 10 years and up to 15 years of age (Special Survey No.3)	1. All shell frames in all cargo holds including their end attachments 2. All transverse bulkheads (including stiffeners and girders) in all cargo holds 3. All transverse webs with associated plating and longitudinals in each ballast tank (topside, bilge hopper or side tank) 4. All transverse bulkheads (including stiffeners and girders) in all ballast tanks 5. All cargo hold hatch covers and hatch coamings

	6. All deck plating inside line of hatch openings between cargo hold hatches 7. Air pipes and sounding pipes in cargo holds: in way of tank top
Special Survey for ships over 15 years of age (Special Survey No.4 and subsequent Special Surveys)	1. As Special Survey No.3

Note:
Close-up Surveys of transverse bulkheads are to be carried out at least at four levels as specified as follows

a) Immediately above the inner bottom and immediately above the line of gussets (if fitted) and shedders for ships without lower stool.

b) Immediately above and below the lower stool shelf plate (for those ships fitted with lower stools), and immediately above the line of the shedder plates.

c) About mid height of the bulkhead.

d) Immediately below the upper deck plating and immediately adjacent to the upper wing tank, and immediately below the upper stool shelf plate for those ships fitted with upper stools, or immediately below the topside tanks.

Table B5.14 through Table B5.18, of which the subtitle corresponds to substantially corroded members.

2.7 Pressure Tests

2.7.1 At Special Surveys, a pressure test of tanks is to be carried out as below.

a) A pressure test as below:

i) For tanks: the pressure corresponding to the maximum head that can be experienced in service
ii) For piping: the working pressure

b) A pressure test of tanks may be carried out when the ship is afloat, provided that an internal inspection of bottom is also carried out.

c) At Special Surveys for ships having many water tanks and oil tanks, some water tanks or oil tanks may be exempted from a pressure test where deemed appropriate by the Surveyor taking account of present ship's condition, ship's age and an interval from the previous testing.

2.7.2 At Special Surveys for cargo ships, a pressure test is to be carried out according to -1 above for tanks listed in Table B5.19.

2.7.3 At Special Surveys for tankers and ships carrying dangerous chemicals in bulk, notwithstanding the provision of -2 above, a pressure test is to be carried out for tanks and piping systems as specified below:

Table B5.6 Requirements for Thickness Measurements for Cargo Ships

Special Survey	Structural members and so forth subject to thickness measurement
Special Survey for ships up to *5* years of age (Special Survey No. 1)	1. Suspect area 2. In cargo holds where high -corrosive cargoes to steel such as logs, salt, coal, sulfide ore, etc. have been loaded, lower parts of web (most thin parts of web in case of built-up type frame) and their end brackets of three hold frames at least at forward, middle and aft parts of each cargo hold on both sides and one lowest strake and strakes in way of tween decks of all watertight transverse bulkheads in cargo spaces together with internals in way 3. Both ends and middle part including face plate of one transverse ring or corresponding main structural members in one each tank selected arbitrary from the top side tanks, bilge hopper tanks and deep tanks used as the permanent ballast tanks
Special Survey for ships over *5* years and up to 10 years of age (Special Survey No.2)	1. Suspect area 2. Following portions of structural members within *0.5L* amidships; (1) Each plate in one section of the strength deck plating for the full beam of the ship (2) Each strength deck plate in way of water ballast tanks, if any (3) Each strength deck plate on or underneath which log cargoes or other cargoes being prone to accelerate corrosion have been carried 3. In cargo holds specified in 2. of the column of S.S.No.1, lower and upper parts of web (most thin parts of web in case of built -up type frame) and their end brackets of appropriate number of hold frames (total to be 1/3 at least of whole number frames in each cargo hold) at forward, middle and aft parts of each cargo hold on both sides and all lowest strake and strakes in way of tween decks of all watertight transverse bulkheads in cargo spaces together with internals in way 4. In cargo holds other than 3. above, structural members specified in 2. of the column of S.S.No.1 5. Both ends and middle part of each hatch side and end coaming (plating and stiffeners)

	6. Both ends and middle part (including face plate) of approximately half the number of transverse rings or corresponding main structural members and at least one plate of upper and lower ends of each bulkhead in each one selected tank from the top side tanks, bilge hopper tanks and deep tanks used as the permanent ballast tanks 7. Both ends and middle part of one transverse ring or corresponding main structural members (including face plate) in all remaining top side tanks, bilge hopper tanks and deep tanks used as the permanent ballast tanks except those specified in 6. above
Special Survey for ships over 10 years and up to *15* years of age (Special Survey No.3)	1. Suspect area 2. Following portions of structural members; (1) Each strength deck plate within *0.5L* amidships (2) Each plate and member in two transverse sections within *0.5L* amidships. For ship less than 100 m in length, the number of transverse sections may, however, be reduced to one. (3) One selected wind and water strake in way of cargo spaces outside *0.5L* amidships on each side 3. In all cargo holds, lower and upper parts of web (most thin parts of web in case of built-up type frame) and their end brackets of appropriate number of hold frames (total to be 1/3 at least of whole number frames in each cargo hold) at forward, middle and aft parts of each cargo hold on both sides and all lowest strake and strakes in way of tween decks of all watertight transverse bulkheads in cargo spaces together with internals in way 4. Both ends and middle part of each hatch side and end coaming (plating and stiffeners) 5. All cargo hold hatch covers (plating and stiffeners) 6. Both ends and middle part (including face plate) of about a half the number of transverse rings or corresponding main structural members and each plate at upper and lower parts of each bulkhead in all top side tanks, bilge hopper tanks and deep tanks used as the permanent ballast tanks

Table B5.6 (2) Requirements for Thickness Measurements for Cargo Ships	
Special Survey	Structural members and so forth Subject to thickness measurement
Special Survey for ships over 15 *years* and up to 20 *years* of age (Special Survey No.4)	1. Suspect area 2. Following portions of structural members (1) All exposed main deck plate full length (2) Each plate and member in three transverse sections within 0.5L amidships. For ships less than 100 *m* in length, the number of transverse sections may, however, be reduced to two. (3) Representative exposed superstructure deck plating (poop, bridge and forecastle deck) (4) All wind and water strakes, port and starboard, full length (5) All keel plate full length. Also, additional bottom plates in way of cofferdams, machinery spaces and aft end of tanks 3. Structural members specified in 3. to 6. in the column of S.S.No.3
Special Survey for ships over 20 *years* of age (Special Survey No.5 and subsequent Special Surveys)	1. Suspect area 2. Each plate and member in three transverse sections within 0.5L amidships 3. Structural members specified in 2. (except 2.(2)) and 3. in the column of S.S.No.4

Table B5.7 Requirements of Additional Thickness Measurements for Cargo Ships with substantial corrosion		
Structural Member Extent of Measurement		Pattern of Measurement
1. Plating	Suspect area and adjacent plates	5 point pattern over I *square metre*
2. Girders	Suspect area	5 point pattern over I *square metre*
3. Stiffeners	Suspect area	3 measurements in line across web - 3 measurements on flange

(1) Tanks listed in Table B5.20
(2) Piping systems specified in 5.2.2-2

4 At Special Survey for Bulk Carriers, notwithstanding the provision of -2 above, a pressure test is to be carried out according to -1 above for tanks listed in Table B5.21.

3 Special Surveys for Machinery

3.1 General Inspections

At Special Surveys for Machinery, in addition to the general inspection specified in 3.3.1, the surveys specified in Table B5.22 are to be carried out. For each ship adopting the preventive maintenance system for propulsion shafting system in accordance with the requirements 8.1.3, general inspection of the shafting system and review of all condition monitoring data available on board the ship on the system are to be carried out in order to ascertain that the system is well maintained.

3.2 Operation Tests and Pressure Tests

At Special Surveys for Machinery, in addition to the operation test specified in 3.3.2, the operation tests specified in Table B5.23 are to be carried out.

4 Special Requirements for Ships Carrying Liquefied Gases in Bulk

4.1 General

In addition to the requirements of 5.2 and 5.3, requirements of 5.4 apply to Special Surveys of ships carrying liquefied gases in bulk.

4.2 Inspections

At Special Surveys for ships carrying liquefied gases in bulk, inspections specified in 4.4.2 and inspections of spaces, structures and equipment specified in Table B5.24 are to be carried out.

5 Special Requirements for Ships Carrying Dangerous Chemicals in Bulk

5.1 General

In addition to the requirements of 5.2 and 5.3, requirements of 5.5 apply to Special Surveys of ships carrying dangerous chemicals in bulk.

5.2 Inspections

At Special Surveys for ships carrying dangerous chemicals in bulk, inspections specified in 4.5.2 and inspections of spaces, structures and equipment specified in Table B5.25 are to be carried out.

Table B5.8 Requirements of Thickness Measurements for Oil Tankers and Ships Carrying Dangerous Chemicals in Bulk

Special Survey	Structural members and so forth subject to thickness measurement
Special Survey for ships up to 5 years of age (Special Survey No. 1)	1. Suspect area 2. Each deck plating in one transverse section in way of a ballast tank, if any, or a cargo tank used primarily for water ballast within the cargo area 3. Structural members subject to close -up survey for general assessment and recording of corrosion pattern 4. Cargo oil, fuel oil, ballast, vent pipes including vent masts and headers, inert gas pipes and all other piping in pump room and on weather decks, when deemed necessary by the Surveyor as a consequence of general inspections specified in 5.2.2

Special Survey for ships over 5 years and up to 10 years of age (Special Survey No.2)	1. Suspect area 2. Within the cargo area (1) Each deck plate (2) One transverse section 3. Structural members subject to close -up survey for general assessment and recording of corrosion pattern 4. Selected wind and water strakes outside 0.5L amidship. 5. Cargo oil, fuel oil, ballast, vent pipes including vent masts and headers, inert gas pipes and all other piping in pump room and on weather decks, when deemed necessary by the Surveyor as a consequence of general inspections specified in 5.2.2
Special Survey for ships over 10 years and up to 15 years of age (Special Survey No.3)	1. Suspect area 2. Within the cargo area (1) Each deck plating (2) Two transverse sections 3. Structural members subject to close-up survey for general assessment and recording of corrosion pattern 4. Selected wind and water strakes outside the cargo area 5. All wind and water strakes within the cargo area 6. Cargo oil, fuel oil, ballast, vent pipes including vent masts and headers, inert gas pipes and all other piping in pump room and on weather decks, when deemed necessary by the Surveyor as a consequence of general inspections specified in 5.2.2
Special Survey for ships over 15 years of age (Special Survey No.4 and subsequent Special Surveys)	1. Suspect area 2. Within the cargo area (1) Each deck plate (2) Three transverse sections (3) Each bottom plate 3. Structural members subject to close-up survey for general assessment and recording of corrosion pattern 4. Selected wind and water strakes outside the cargo area 5. All wind and water strakes within the cargo area 6. Cargo oil, fuel oil, ballast, vent pipes including vent masts and headers, inert gas pipes and all other piping in pump room and on weather decks, when deemed necessary by the Surveyor as a consequence of general inspections specified in 5.2.2

Table B5.9 Requirements of Thickness Measurements for Oil Tankers and Ships Carrying Dangerous Chemicals in bulk (Bottom Structure)

Structural member	Extent of Measurement	Pattern of Measurement
1. Bottom plating	Minimum of 3 bays across tank, including aft bay. Measurements around and under all bell mouths. Suspect plate and adjacent plate, if any	5 point pattern for each panel between longitudinal and webs 5 point pattern for each panel between longitudinal over I *m* length
2. Inner bottom and bottom longitudinal	Minimum of 3 longitudinal in each bay where bottom plating measured.	3 measurements in line across flange and 3 measurements on vertical web.
3. Bottom girders and brackets including longitudinal girders and transverse floors	At fore and aft transverse bulkhead bracket toes and in centre of tanks. Suspect plate	Vertical line of single measurements on web plating with one measurement between each panel stiffener, or a minimum of three measurements. Two measurements across face flat. 5 point pattern on girder/bulkhead Brackets 5 point pattern over about I m^2
4. Bottom transverse webs	3 webs in bays where bottom plating measured, with measurements at both ends and middle.	5 point pattern over 2 *square metre* area. Single measurements on face flat.
5. Panel stiffening	Where fitted.	Single measurement
6. Watertight bulkheads (WT Floors) (if any)	a) lower 1/3 of tank b) upper 2/3 of tank	a) 5 point pattern over about I in' b) 5 point pattern alternate plates over I m^2 of plating
7. Web Frames (if any)	Suspect plate	5 point pattern

Table B5.10 Requirements of Thickness Measurements for Oil Tankers and Ships Carrying Dangerous Chemicals in Bulk (Deck Structure)

Structural member	Extent of Measurement	Pattern of Measurement
1. Deck plating	Two bands across tank	Minimum of three measurements per plate per band
2. Deck longitudinal	Minimum of 3 longitudinal in each of two bays	3 measurements in line vertically on webs, and 2 measurements on flange (if fitted)
3. Deck girders and brackets	At fore and aft transverse bulkhead, bracket toes and in centre of tanks	Vertical line of single measurements on web plating with in measurement between each panel stiffener, or a minimum of three measurements. Two measurements across face flat. 5 point pattern on girder/bulkhead brackets
4. Deck transverse webs	Minimum of two webs with measurements at middle and both ends of span	5 point pattern over about 2 *square metre* areas. Single measurement on flat surface

5. Panel stiffening	Where available	Single measurement

Table B5.11 Requirements of Thickness Measurements for Oil Tankers and Ships Carrying Dangerous Chemicals in Bulk (Shell and Longitudinal Bulkheads)

Structural member	Extent of Measurement	Pattern of Measurement
1. Deckhead and bottom strakes, and strakes in way of stringer platform	Plating between each pair of longitudinal in a minimum of 3 bays	Single measurement
2. All other strakes	Plating between every 3rd pair of Longitudinal in same 3 bays	Single measurement
3. Longitudinal deck head and bottom strakes	Each longitudinal in same 3 bays	3 measurements across web and 1 measurement of flange
4. Longitudinal -all others	Every third longitudinals in same 3 bays	3 measurements across web and 1 measurement of flange
5. Longitudinals - bracket	Minimum of three at top, middle and bottom of tank in same 3 bays	5 point pattern over area of bracket
6. Web frames and cross ties	3 webs with minimum of three locations on each web, including in way of cross tie connections	5 point pattern over about 2 *square metre* area, plus single measurement on web frame and cross tie face flats

Table B5.12 Requirements of Thickness Measurements for Oil Tankers and Ships Carrying Dangerous Chemicals in bulk (Transverse Bulkheads and Swash Bulkheads)

Structural member	Extent of Measurement	Pattern of Measurement
1. Deck head and bottom strakes, and strakes in way of stringer platform	Plating between pair of stiffeners at three locations - approx. 1/4, 1/2 and 3/4 width of tank	5 point pattern between stiffeners over I *metre* length
2. All other strakes	Plating between pair of stiffeners at middle location	Single measurement
3. Strakes in corrugated bulkheads	Plating for each change of scantling at centre of panel and at flange of fabricated connection	5 point pattern over about I *square* metre of plating
4. Stiffeners	Minimum of three typical stiffeners	For web, 5 point pattern over span between bracket connections (2 measurements across web at each bracket connection, and one at centre of span). For flange, single measurement at each bracket toe and at centre of span.
5. Brackets	Minimum of three at top, middle and bottom of tank	5 point pattern over area of bracket

6. Deep webs and girders	Measurements at toe of racket and centre of span	For web, 5 point pattern over about 1 *square metre.* 3 measurements across face flat.
7. Stringer platforms	All stringers with measurements at both ends and middle	D point pattern over I *square metre* of area plus single measurements near bracket toes and on face flats

Table B5.13 Requirements of Thickness Measurements for Bulk Carriers	
Special Surveys	Structural members and so forth subject to thickness measurement
Special Survey for ships up to 5 *years* of age (Special Survey No.1)	1. Suspect area 2. At least following structural members for general assessment and recording of corrosion pattern (1) Lower parts of webs and lower end brackets of each three hold frames at a fore/middle/aft part of both sides in each cargo hold (2) At least one plate of lowest strake of each transverse bulkhead (3) Other structural members subject to close-up survey
Special Survey for ships over 5 *years* and up to 10 *years* of age (Special Survey No.2)	1. Suspect area 2. Structural members within the cargo length area • Two transverse sections of deck plating, outside line of cargo hatch openings • All deck plating, where log cargoes or other cargoes being prone to accelerate corrosion are loaded 3. At least following structural members for general assessment corrosion pattern • Lower and upper parts of web and end brackets of sufficient number (at least 1/3 of total number) of frames at a fore/middle/aft part of both sides in each cargo hold • All parts of one transverse bulkhead and lowest strake of the other in each cargo hold • Other structural members subject to close-up survey 4. All cargo hold hatch coamings (plating and stiffeners) 5. Selected cargo hold hatch covers (plating and stiffeners) 6. Selected areas of deck plating inside line of openings between cargo hold hatches 7. Wind and water strakes in way of the transverse sections specified in para 2 above

Special Survey for ships over 10 *years* and up to 15 *years* of age (Special Survey No.3)	1. Suspect area 2. Structural members within the cargo length area • Each deck plating outside line of cargo hatch openings • Two transverse sections, one in the amidship area, outside line of cargo hatch openings 3.Following structural members for general assessment and corrosion pattern: • Hold frames: same as S.S. No.2 • All transverse bulkheads in all cargo holds • Other structural members subject to close-up survey 4. All cargo hold hatch covers and coamings (plating & stiffeners) 5. All deck plating inside line of openings between cargo hold hatch 6. All wind and water strakes within the cargo length area 7. Selected wind and water strakes outside the cargo length area
Special Survey for ships over 15 *years* of age (Special Survey No.4 and subsequent Special Surveys)	1. Suspect area 2. Structural members within cargo length area • Each deck plating outside line of cargo hatch openings • Three transverse sections, one in the • amidship area, outside line of cargo hatch openings • Each bottom plate 3. Structural members specified in 3. to 7. for S.S. No.3

Table B5.14 Requirements of Additional Thickness Measurements for Bulk Carriers (Shell Plating)

Structural member	Extent of Measurement	Pattern of Measurement
1. Bottom and Side Shell Plating	a. Suspect plate, plus four adjacent plates b. See other tables for particulars on gauging in way tanks and cargo holds	a. 5 point pattern for each panel between longitudinal
2. Bottom/Side Shell Longitudinal	Minimum of three longitudinal in way of suspect areas	3 measurements in line across web 3 measurements on flange

Table B5.15 Requirements of Additional Thickness Measurements for Bulk Carriers (17ransverse Bulkheads in Cargo Holds)

Structural Members	Extent of Measurement	Pattern of Measurement
I Lower Stool	a Transverse band within 25 mm of welded connection to inner bottom b Transverse band within 25 mm of welded connection to shelf plate	a 5 point between stiffeners over one metre length b As above
2 Transverse Bulkhead	a Transverse band at approximately mind height b Transverse band at part of bulkhead adjacent to upper deck or below up per stool shelf plate (for those ships fitted with tipper stool)	a 5point between stiffeners over I metre length b As above

Table B5.16 Requirements of Additional Thickness Measurements for Bulk Carriers (Deck Structure Including Cross Stripes, Main Cargo Hatchways, Hatch Covers, Coamings and Topside Tanks)		
Structural Member	Extent of Measurement	Pattern of Measurement
I Cross Deck Strip Plating	a Suspect cross deck strip plating	a 5 point pattern between underdeck stiffeners over I metre length
2 Underdeck Stiffeners	a Transverse members b Longitudinal member	a 5 point pattern at each end and mid span b 5 point pattern on both web and flange
3 Hatch Covers	a Skirt, each side and ends, 3 locations b 3 longitudinal bands, outboard strakes (2) and centerline strake (1)	a 5 point pattern at each location b 5 point measurement each band
4 Hatch Coamings	Each side and end of coaming, one band lower 1/3, one band upper 2/3 of coaming	5 point measurement each band i.e. end or side coaming
5 Topside Water Ballast Tanks	a Watertight transverse bulkheads i. lower 1/3 of bulkhead ii. upper 2/3 of bulkhead iii. stiffeners b 2 representative swash transverse bulkheads i. lower 1/3 of bulkhead ii. upper 2/3 of bulkhead iii. stiffeners c 3 representative bays of sloping plating i. lower 1/3 of tank ii. upper 2/3 of tank	i. 5 point pattern over I *sq.* metre of plating ii. 5 point pattern over I *sq.* metre of plating iii. 5 point pattern over I metre length
6 Main Deck Plating	Suspect plates and adjacent (4)	5 point pattern over I *sq.* metre of plating
7 Main Deck Longitudinals	Minimum of 3 longitudinal where plating measured	5 point pattern on both web and flange over I metre length
8 Web Frames / Transverse	Suspect plates	5 point pattern over I sq.

Table B5.17 Requirements of Additional Thickness Measurements for Bulk Carriers (Double Bottom and Hopper Structure)		
Structural member	Extent of Measurement	Pattern of Measurement
1 Inner Double Bottom Plating	Suspect plate plus all adjacent plates	5 point pattern for each panel between longitudinals over I *metre* length
2 Inner Double Bottom Longitudinals	3 longitudinals where plates measured	3 measurements in line across web and 3 measurements on flange

3 Longitudinal Girders or Transverse Floors	Suspect plates	5 point pattern over about I *sq. inctre*
4 Watertight Bulkheads (WT Floors)	a lower 1/3 of tank b upper 2/3 of tank	a 5 point pattern over I *sq. metre* of plating b 5 point pattern alternate plates over 1 sq. metre of plating
5 Web Frames	Suspect plates	5 point pattern over I *sq. metre* of plating
6 Bottom/side shell longitudinals	Minimum of 3 longitudinals in way of suspect areas	a. 3 measurements in line across web b. 3 measurements on flange

Table B5.18 Requirements of Additional Thickness Measurements for Bulk Carriers (Cargo Holds)

Structural member	Extent of Measurement	Pattern of Measurement
1. Side Shell Frames	Suspect frame and each adjacent	a. At each end and mid span: 5 point pattern of both web and flange
		b. 5 point pattern within 25 *mm of* welded attachment to both shell and lower slope plate

Table B5.19 Requirements of Pressure Tests for Cargo Ships

Special Survey	Tanks Subject to pressure tests
Special Survey for ships up to 5 years of age (Special Survey No. 1)	1. All water tanks including cargo holds used for ballast and all cargo tanks. Special consideration may be, however, given to limit testing of fresh water tanks to representative tanks provided that, after an internal and external inspection of the tanks, the Surveyor is satisfied with the condition of the tanks. 2. All fuel oil tanks and all lubrication oil tanks. Special consideration may be, however, given to limit testing of fuel oil tanks and lubrication oil tanks to representative tanks provided that, after an internal and external inspection of the tanks specified in 5.2.4-2**,** the Surveyor is satisfied with the condition of the tanks.
Special Survey for ships over 5 years and up to 10 years of age (Special Survey No.2)	1. Same requirements as Special Survey No. 1

Special Survey for ships over 10 years and up to 15 years of age (Special Survey No.3)	1. All water tanks including cargo holds used for ballast and all cargo tanks 2. All fuel oil tanks Special consideration may be, however, given to limit testing of double bottom tanks to representative tanks including one forward and one aft tank and of deep tanks to representative tanks provided that, after an internal and external inspection of the tanks specified in 5.2.4-2, the Surveyor is satisfied with the condition of the tanks. 3. All lubrication oil tanks Special consideration may be, however, given to limit testing of lubrication oil tanks to representative tanks provided that, after an internal and external inspection of the tanks specified in 5.2.4-2, the Surveyor is satisfied with the condition of the tanks.
Special Survey for ships over 15 years of age (Special Survey No.4 and subsequent Special Surveys)	1. All water tanks including cargo holds used for ballast, all cargo tanks, all fuel oil tanks and all lubrication oil tanks

Table B5.20 Requirements of Pressure Tests for Oil Tankers, etc.	
Special Survey for ships up to 5 years of age (Special Survey No. 1)	Tanks Subject to pressure tests 1. Cargo tank boundaries facing ballast tanks, void spaces, pipe tunnels, fuel oil tanks, pump rooms or cofferdams 2. For oil tankers, representative tanks for fresh water, fuel oil and lubrication oil within the cargo area 3. All water tanks Special consideration may be, however, given to limit testing of fresh water tanks other than tanks specified in 2. above to representative tanks provided that, after an internal and external inspection of the tanks, the Surveyor is satisfied with the condition of the tanks. 4. All fuel oil tanks and all lubrication oil tanks Special consideration may be, however, given to limit testing of fuel oil tanks and lubrication oil tanks other than tanks specified in 2. above to representative tanks provided that, after an internal and external inspection of the tanks specified in 5.2.4-2, the Surveyor is satisfied with the condition of the tanks.

Special Survey for ships over 5 years and up to 10 years of age (Special Survey No.2)	1. Cargo tank boundaries facing ballast tanks, void spaces, pipe tunnels, fuel oil tanks, pump rooms or cofferdams 2. All cargo tank bulkheads which form the boundaries of segregated cargoes 3. For oil tankers, representative tanks for fresh water, fuel oil and lubrication oil within the cargo area 4. All water tanks Special consideration may be, however, given to limit testing of fresh water tanks other than tanks specified in 3. above to representative tanks provided that, after an internal and external inspection of the tanks, the Surveyor is satisfied with the condition of the tanks. 5. All fuel oil tanks and all lubrication oil tanks Special consideration may be, however, given to limit testing of fuel oil tanks and lubrication oil tanks other than tanks specified in 3. above to representative tanks provided that, after an internal and external inspection of the tanks specified in 5.2.4-2, the Surveyor is satisfied with the condition of the tanks.
Special Survey for ships over 10 years and up to 15 years of age (Special Survey No.3)	1. All cargo tanks bulkheads 2. All water tanks 3. All fuel oil tanks Special consideration may be, however, given to limit testing of double bottom tanks to representative tanks including one forward and one aft tank and of deep tanks to representative tanks provided that, after an internal and external inspection of the tanks specified in 5.2.4-2, the Surveyor is satisfied with the condition of the tanks. 4. All lubrication oil tanks Special consideration may be, however, given to limit testing of lubrication oil tanks to representative tanks provided that, after an internal and external inspection of the tanks specified in 5.2.4-2, the Surveyor is satisfied with the condition of the tanks.
Special Survey for ships over 15 years of age (Special Survey No.4 and subsequent Special Surveys)	1. All cargo tank bulkheads 2. All water tanks, all fuel oil tanks and all lubrication oil tanks

Table B5.21 Requirements of Pressure Tests for Bulk Carriers	
Special Survey	Tanks Subject to pressure tests

Special Survey for ships up to 5 years of age (Special Survey No. 1)	1. All boundaries of ballast tanks, deep tanks and cargo holds used for ballast within the cargo length area 2. Representative tanks for fresh water, fuel oil and lubrication oil within the cargo length area 3. All water tanks Special consideration may be, however, given to limit testing of fresh water tanks other than tanks specified in 1. and 2. above to representative tanks provided that, after an internal and external inspection of the tanks, the Surveyor is satisfied with the condition of the tanks. 4. All fuel oil tanks and all lubrication oil tanks Special consideration may be, however, given to limit testing of fuel oil tanks and lubrication oil tanks other than tanks specified in 2. above to representative tanks provided that, after an internal and external inspection of the tanks specified in 5.2.4-2, the Surveyor is satisfied with the condition of the tanks.
Special Survey for ships over 5 years and up to 10 years of age (Special Survey No.2) Special Survey for ships over 10 years and up to 15 years of age (Special Survey No.3)	1. As Special Survey No. 1 1. All water tanks including cargo holds used for ballast 2. All fuel oil tanks Special consideration may be, however, given to limit testing of double bottom tanks to representative tanks including one forward and one aft tank and of deep tanks to representative tanks provided that, after an internal and external inspection of the tanks specified in 5.2.4-2, the Surveyor is satisfied with the condition of the tanks. 3. All lubrication oil tanks Special consideration may be, however, given to limit testing of lubrication oil tanks to representative tanks provided that, after an internal and external inspection of the tanks specified in 5.2.4-2, the Surveyor is satisfied with the condition of the tanks.
Special Survey for ships over 15 years of age (Special Survey No.4 and subsequent Special Surveys)	1. All water tanks including cargo holds used for ballast, all fuel oil tanks and all lubrication oil tanks

Table B5.22 Additional Requirements at Special Surveys for Machinery

Items	Inspections
I Diesel engines (main propulsion machinery and auxiliary machinery essential for main propulsion and for the manoeuvring and the safety)	(a) The essential part of the crankcase and cylinder jacket, the foundation bolts, the chock liners and the tie rod bolts are to be generally examined. (b) The doors of the crankcase and the explosion relief devices of the crankcase and scavenge space are to be generally examined. (c) The anti-vibration dampers, balancers, etc. are to be generally examined. (d) The crankshaft alignment is to be checked and , if necessary, placed in good order.

2 Electrical installations	(a) The switchboards (including those for emergency), distribution boards, cables, etc. are, as far as practicable, to be generally examined. (b) Insulation resistance of the generators and switchboards (the both including those for emergency use), the motors and the cables are to be tested to ensure that they are placed in good order, and to be adjusted if it is found not to comply with the requirements 2.18.1, Part H**.** However, where a proper record of measurement is maintained and deemed appropriate by the Surveyor, consideration may be given to accepting recent readings. (c) For tankers, ships carrying liquefied gases in bulk and ships carrying dangerous chemicals in bulk, electrical installations in the hazardous areas are to be generally examined and their insulation resistance is to be measured. However, where a proper record of measurement is maintained and deemed appropriate by the Surveyor, consideration may be given to accepting recent readings.
3 Refrigerating machinery	(a) The safety devices are to be generally examined to ascertain that they are placed in good order. (b) The machinery is to be examined in a working condition and ascertained that there is no leakage of refrigerant.
4 Spare parts and associated fittings	Spare parts and their associated fittings for machinery are to be examined.

Table B5.23 Additional Requirements at Special Surveys

Items	Inspections
1 Speed governors, generator circuit breakers, associated relays	The operation tests are to be carried out with all generators run under loaded condition, either separately or in parallel, as far as practicable.
2 Condensers, evaporators, receivers	For those used for *NH3 (R717)* as refrigerant, the parts exposed to the primary refrigerant are to be tested at a pressure of 90% of the design pressure (the pressure may be reduced down to 90% of the setting pressure of the relief valves. However, the pressure test may be replaced by other means as deemed appropriate by Sing-Lloyd.
3 All other machinery and its parts than -2 above	Pressure test is to be handled in accordance with the requirements 2.2.2(2) in case where deemed necessary by the Surveyor.
4 Lighting systems, communication and signaling systems, ventilating systems, other electrical equipment	Operation tests (including operation tests) of the interlocking devices for safety operation are to be carried out in case where deemed necessary by the Surveyor.

Table B5.24 Special Requirements for Ships Carrying Liquefied Gases in bulk

Items	Inspections
I Cargo tanks	Following inspections are to be carried out: (a) An internal inspection of all cargo tanks is to be carried out. (b) A visual inspection of insulation` or cargo tank surface if insulation is not fitted with is to be carried out. Special attention is to be paid to the part in way of chocks, supports, keys and other parts which consist of the foundation of insulation of tanks. Removal of insulation may be required where deemed necessary by the Surveyor. (c) Thickness measurement for cargo tank plate may be required where deemed necessary by the Surveyor. (d) Non-destructive test for independent tank of Type B is to be carried out in accordance with the approved program. This program is to be prepared according to the cargo tank design. Cargo tanks other than independent tank of Type B are to be examined by non –destructive test on welded connections of tank shell, main structural members and other parts liable to bear high stress*'. (e) All cargo tanks are to be leak -tested. However, the leak test of membrane tanks, semi-membrane tanks and independent tanks below deck may be omitted, if it is verified by the logbook or other proper means that gas detecting devices are in normal condition and no leak is recorded. (f) In case where there is any doubt on the integrity of any of the cargo tanks in the result of inspections of (a) through (e) above, the tank is to be tested under the pressure as specified below; For independent tank of Type C: Not less than 1.25 times maximum allowable design pressure of pressure relief valves (hereinafter referred to as *MARVS* in this chapter) For independent tank of Type A and B and integral tank: Proper pressure according to the cargo tank design (g) For independent tank of Type C, either of the following tests (i) or (ii) is to be carried out at the alternate Special Survey, such as 2, 4, 6 in addition to inspections (a) through (h). (i) Test under the pressure of 1.25 times *MARVS,* and thereafter, non -destructive test stipulated in (d) , or (ii) Non -destructive test according to the program prepared fir the cargo tank design.
2 Hold spaces and secondary barriers	Tank supporting and surrounding hull structures in hold spaces, secondary barriers and their insulation are to be visually examined. In case where there is any doubt about integrity of secondary barriers, the integrity is to be verified by pressure or vacuum test or other proper means. * 5
3 Venting system for cargo tanks	Pressure relief valves for cargo tanks are to be overhauled, readjusted, operation-tested and sealed. Pressure/vacuum relief devices and associated safety systems for inter barrier spaces and hold spaces are to be examined, overhauled and tested depending on their design.

4 Cargo and process piping	Inspections (a) and (b) are to be carried out. Removal of insulation may be required where deemed necessary by the Surveyor. (a) Where deemed necessary by the Surveyor; whole or a part of valves and associated fittings are to be overhauled, or pressure test under the pressure of 1.25 times *MARVS* is to be carried out and leak test for removed pipes is to be carried out after restored (b) Pressure relief valves are to be visually examined and whole or a part of these valves are to be overhauled, readjusted, operation tested and sealed.
5 Cargo handling equipment	Inspections and tests (a) through M are to be carried out. (a) Cargo pumps, cargo gas compressors and gas blowers, and their prime movers are to be over hauled and operation tests for safety devices are to be carried out. Overhaul of electric motors as prime movers may be dispensed with. (b) Heat exchangers, pressure vessels and evaporators are to be overhauled and pressure relief valves are to be operation tested. If an internal inspection of vessels is impracticable, a pressure test of vessels and a operation test of pressure relief valves are to be carried out.*' (c) Following tests (i) through (iii) are to be carried out for refrigerating equipment. (i) Overhaul of pumps and compressors and operation tests of pressure vessels such as condensers, evaporators, inter -coolers, oil separators and relief valves" (ii) Leak test of pressure vessels and heat exchangers under the pressure of not less than 90 % of the set pressure of relief valves (iii) Leak test of refrigerant piping system under the pressure of not less than 90 % of set pressure of relief valves

Note)

(* 1) For membrane and semi-membrane tanks and internal insulation tanks, the inspection and testing are to be carried out in accordance with programs specially prepared according to approved method for each tank system.

(* 2) If the visual inspection of insulation of tanks is impossible to do, surrounding structural members are to be examined for cold spots when the cargo tanks are cold. However, in case where integrity of cargo tanks and their insulation is verified by the cargo log book, the inspection of cold spots may be omitted.

(* 3) These are the parts liable to bear high stress cargo tank supports and anti-rolling/anti-pitching devices-web frames or stiffening rings-swash bulkhead boundaries-dome and sump connections to tank shell-foundations for pumps, towers, ladders, etc. -pipe connections

(* 4) If a special program does not exist, at least 10 % of the length of the welded connections in each of the highly stressed area such as the followings is to be tested. This test is to be carried out properly from inside and outside of the tank. Insulation is to be removed at the test, if necessary. - cargo tank supports and anti-rolling/anti-pitching devices -stiffening rings - Y -connections between tank shell and a longitudinal bulkhead of bilge tanks - swash bulkhead boundaries -dome and sump connections to tank shell -foundations for pumps, towers, ladders, etc. -pipe connections

(* 5) If the visual inspection of secondary barriers and their insulation for membrane tank method etc. is impossible to do, pressure or vacuum test approved in advance and inspection for cold spots are to be carried out. However, in case where integrity of insulation is verified by the log book etc., inspection for cold spots may be omitted.

(* 6) In case where Planned Machinery Surveys are applied, open-up inspections to be carried out at Special Surveys for each equipment may be replaced with visual inspections.

Table B5.25 Special Requirements for Ships Carrying Dangerous Chemicals in Bulk	
Items	Inspections
I Insulation of cargo tanks	Insulation of cargo tanks is to be carried our generally. Where deemed necessary by the Surveyor, removal of the insulation may be required.
2 Cargo tank supporting	Foundation of cargo tanks including supports, keys and anti-rolling/anti–pitching devices is to be carried out generally. Where deemed necessary by the Surveyor, removal of the insulation may be required.
3 Sealing arrangement for tanks	Sealing arrangement for tanks and tank covers penetrating decks are to be examined generally. Where deemed necessary by the Surveyor, removal of the insulation, covers etc. or operation test of the closing devices may be required.
4 Cargo pumps	Main parts of cargo pumps are to be opened up and examined.'

CHAPTER 6
DOCKING SURVEY

1 Docking Surveys

1.1 Surveys in dry dock or on slipway

At Docking Surveys, inspections listed in Table B6.1 are to be carried out in dry dock or on slipway after cleaning of outer shell.

1.2 In-water Surveys

In-water Surveys may be accepted in lieu of Surveys in dry dock or on slipway subject to the prior approval by the Sing-Lloyd. In any case, Surveys in dry dock or on slipway to be carried out at the time specified in 1.1.3-1(4)(a) are not to be replaced with In-water Surveys.

1.3 Others

For each ship adopting the preventive maintenance system for propulsion shafting system in accordance with the requirements 8.1.3, general inspection of the shafting system and review of all condition monitoring data available on board the ship on the system are to be carried out in order to ascertain that the system is well maintained.

Table B6.1 Requirements for Docking Surveys

Items	Inspections
Shell plating including keel plate, stem and stern frame	The structure in way of discontinuity, parts of the structure liable to be excessively corroded and openings in the shell are to be examined carefully. Grillage covers are to be removed where deemed necessary by the Surveyor.
Rudder	Rudder is to be lifted or removed. Pintles and gudgeons, etc. are to be examined. The rudder bearing clearance is to be measured. Lift or removal of the rudder may be omitted provided the Surveyor is satisfied with the condition of the rudder by measurement of the clearance.
Sea inlets and overboard discharges and their associated valves below freeboard deck	Sea inlets and overboard discharges are to be examined, and valves, cocks together with their fastenings to the hull are to be dismantled and examined. Dismantling of them may be dispensed with at the discretion of the Surveyor provided they were dismantled and examined in good order at the last Docking Survey.
After end of stern bush	The clearance between the propeller shaft or the stern tube shaft and the after bearing of the stern tube or the shaft bracket bearing or wear down of the bearing is to be measured.
Sealing devices for stern tube and shaft bracket bearing	The efficiency of oil gland is to be checked.
Propeller	Propellers are to be examined. In case where a controllable pitch propeller is fitted, the pitch control device is to be examined under working condition.

Valves and cocks on shell plating, sea chest or distance peace	Main parts of valves and cocks attached to shell plating, sea chests or distance pieces are to be opened up and examined. The bolts or studs fastening these mountings to the shell are to be examined. Overhaul may be dispensed with at the Surveyor's discretion.
Anchor, anchor chain, ropes, hawse pipe, chain locker and cable clenches	At the Docking Surveys carried out at the time specified in 1.1.3-1(4)(a), anchor and anchor chains are to be ranged and examined. At the Special Survey No.2 and subsequent Special Surveys, the diameter of anchor chain is to be measured. If the mean diameter of a link, at its most worn part, is reduced by 12% or more from its required nominal diameter, it is to be renewed.
Tanks and spaces	At Docking Surveys carried out at the time specified in 1.1.3-1(4)(a) or 1.1.4-5, the internal inspection and close-up survey to be carried out at the relevant Special Surveys or Intermediate Surveys are to be carried out as far as practicable.

PART C

CLASS GUIDANCE

CHAPTER 1
CLASS GUIDANCE – GENERAL

This Guidance provides details on the type of surveys and related requirements. Moreover it emphasizes the preparatory work and the essential documents. This Guidance also helps ship owners and ship managers to carry out the surveys expeditiously and as scheduled.

1. SURVEY APPLICATION

The applicant is to submit the form "APPLICATION FOR SURVEYS AND ISSUE OF CERTIFICATES" given in the appendix to the nearest local office of the Society listed in the "DIRECTORY".

2. PREPARATION FOR SURVEY

(1) The applicant is to refer to the attached tables which list the essential items required for each periodical survey with regard to internal examination, opening-up examination, test, measurement and confirmation examination. In principle, general condition examination and visual examination are not part of the Rules and Regulations.

(2) The applicant is recommended to have ship's crew or specialists check the condition of hull, machinery, equipment etc., and to arrange for repairs or renewals prior to the surveys, if necessary. By submitting the records of such checking and the records of maintenance by crew to the Surveyor, the extent of survey may be reduced at the discretion of the Surveyor.

(3) Prior to thickness measurement for hull structure members, the meeting between the owner’s representative, thickness measurement firm’s representative and surveyor(s) is to be held.

(4) The Special Survey may commence at the 4th Annual Survey after Classification Survey or previous Special Survey and to be completed by the 5th anniversary date. In this case, it is recommended that the hull thickness measurement is carried out, so far as practicable, at the 4th Annual Survey.

(5) At intermediate survey for oil tankers, chemical tankers and general cargo ships (more than 500 gross tonnage) of over 15 years of age and for bulk carriers of over 10 years of age, equivalent survey items as last Special Survey (except pressure tests of tanks) including Docking Survey is required. In case of bulk carriers of over 10 years and up to 15 years of age, In-Water Survey may be acceptable in lieu of Docking Survey required by Intermediate Survey. Intermediate Survey for those ships (except general cargo ships) may commence during the second Annual Survey or after and be completed at the time of the second or the third Annual Survey.

(6) For oil tankers, chemical tankers, bulk carriers (including ore carriers) engaged in international voyages, the survey program is to be submitted as a part of survey preparation for Special Survey, Intermediate Survey for oil tankers, chemical carriers of over 15 years of age and bulk carriers of over 10 years of age.

3. ATTENDANCE TO SURVEYS

The owners or their representatives, who are able to supervise the preparation for surveys, are requested to attend the surveys.

4. MAINTENANCE AND PRESENTATION OF DOCUMENTS

The following documents kept on board are to be presented to the attending Surveyor prior to the surveys.

(1) Certificates, etc.
- Certificate of Classification
- Registration Certificate
- Statutory Certificates

Cargo Ship Safety Construction Certificate
Cargo Ship Safety Equipment Certificate
Cargo Ship Safety Radio Certificate
International Load Line Certificate
International Oil Pollution Prevention Certificate
International Air Pollution Prevention Certificate
International Sewage Pollution Prevention Certificate
Anti Fouling System Certificate
IMO Fitness Certificate
- Condition Evaluation Report (Executive Hull Summary)
- Cargo Gear Booklet

(2) Survey record files for class survey record, for statutory record and for condition evaluation report of ships to which ESP has been applied

(3) Finished plans on hull, machinery and equipment, approved manuals and documents (Loading Manual, Stability Information, etc.)

(4) Service records/Maintenance records

- Hull thickness measurement record
- Periodical inspection table for automatic and remote control systems
- Insulation resistance test record
- Chief Engineer's report for Continuous Machinery Survey (CMS)

(5) Enhanced Survey Programme (ESP)

- Condition Evaluation Report (Executive Hull Summary)
- Main Structural Plans for Hull
- Cargo and Ballast History
- Repair History
- Thickness Measurement Reports
- Survey Programme
- Inspection Report by ship's members with reference to structural deterioration, bulkheads and piping, condition of coating and/or corrosion prevention system etc.
- Records of IGS and COW system (if applicable)

5. SURVEY ITEMS

(1) Regarding internal inspection, opening-up inspection, test, measurement, confirmation, etc. required for periodical surveys, the following listed tables are to be referred to, depending on the kind of surveys and type of ships.

Type of Surveys (for all ships' type)	***Table***
Special Survey, Intermediate Survey, Annual Survey	1
Docking Survey	2
Boiler Survey	3
Propeller Shaft and Stern Tube Survey	4

Type of Surveys (for ships' type)	*Table*
Tankers and Chemical Carriers	5
Gas Carriers	6
Chemical Carriers	7

(2) These tables contain only survey items which require internal examination, internal general examination, opening-up examination, test, measurement and/or confirmation examination, but not general condition examination or visual examination.

(3) Surveyor may request any examination in addition to those specified in the tables where he deems necessary.

(4) Surveyor may modify the extent and/or requirement of survey, taking into consideration the condition of the relevant part upon reviewing the service record or maintenance record.

(5) With regard to thickness measurement of structural members, please refer to Part F of Rules and Regulation. Longitudinal Strength of hull girder is reassessed on the basis of thickness measurements, and structural reinforcements may be required.

6. ENHANCED SURVEY PROGRAMME

(1) For Oil Tankers, Bulk Carriers (including Ore Carriers) and Chemical Tankers, internal inspection, close-up survey, thickness measurement and etc. are required additionally during the periodical surveys. In addition, for the above ship types (more than 20,000 DWT), starting with Special Survey No.3, all Special Survey and Intermediate Hull Survey should be carried out by at least two exclusive surveyors. For Bulk Carriers (more than 100,000 DWT) of single side skin construction, Intermediate Hull Survey between 10 and 15 years of age should be performed by two exclusive surveyors.

(2) For each Special Survey for Oil Tankers, Chemical Tankers and Bulk carriers, and for each Intermediate Survey for Oil Tankers & Chemical Tankers over 15 years of age and for Bulk Carriers over 10 years of age, a specific survey programme, identifying the outline of the survey such as internal examination, close-up survey, thickness measurement, etc., is required to be prepared and submitted in advance by the shipowners.

7. Requirements for General Dry Cargo Ships

"General Cargo Ships" are ships constructed or converted to carry solid cargoes other than:

- Bulk Carrier
- Container Carrier
- Ro-Ro Cargo Ships
- Car Carriers
- Refrigerated Cargo Ships
- Wood Chip Carrier and
- Cement Carriers

Table 1 Class Survey (AS, IS, SS)

ITEMS FOR SURVEY	AS	IS	SS
Internal Examination, Internal General Examination, Close Up Survey and Pressure Test for Hull Compartments and tanks (Excluding Installed Tanks)	I*1	I*1	I*1, P*1

-To make preparations for survey, such as cleaning of compartments, chipping and scaling, gas-freeing, sufficient lighting, nondestructive testing equipment and other items of preparation required for tests and examinations according to the purpose of survey. -To remove potential dangers such as improper arrangement of scaffoldings, poor lighting conditions, fire, explosion, electric shock, falling objects, harmful gases and oxygen deficiency -To prepare staging, cherry picker or rubber boats for close-up survey. -To consult with attending surveyor about survey items including thickness measurement preparation. ・Internal Examination and Pressure Test (Refer to **Table 1-1**) ・Close-up survey Oil Tankers and Chemical Carriers Bulk Carriers and Ore Carriers General Dry Cargo (including timber carriers) Ships other than the above			
THICKNESS GAUGING OF STRUCTURAL MEMBERS (**Part F of Rules and Regulations)**	M*3	M*2	M
MOORING ARRANGEMENT, ANCHORING ARRANGEMENT ・Measurement of diameter of anchor chain cables (to be conducted at DS coinciding with SS No.2 and subsequent.) ・Performance test of the arrangement	T	T	M/T
LOADING COMPUTER	T	T	T
AUTOMATIC AIR PIPE HEADS (Internal examination of the heads as required by attending surveyor) Special Survey No.1 : 1. Each one head for ballast tanks at P&S side located on exposed deck In the forward 0.25 L 2. Each one head for ballast tanks at P&S side located on exposed deck in the after 0.25 L Special Survey No.2 : 1. All heads located on exposed deck in the forward 0.25 L 2. At least 20% heads (preferably air pipes serving ballast tanks) located on exposed deck in the after 0.25 L Special Survey No.3 and subsequent Special Survey : All heads located on exposed deck	I	I	I
STEERING ARRANGEMENT (Control System, Alarm System, Rudder Indicator)	T	T	T
BILGE SYSTEM (Cargo Hold, Engine Room, Cargo Pump Room etc.)	T	T	T
Cargo Hatch Cover ・Hose test (if deemed necessary by the Surveyor) ・Mechanically operated steel hatch cover	I	I	T
Test of closing appliances (door for watertight bulkhead and superstructure end bulkhead)	T	T	T
Test of fire protection arrangement and means of escape	I	I	T
Plans & Documents ・Loading Manual ・Stability Information ・Damage Control Plan and Booklet ・Fire Control Plan ・Manual for the bow door and inner door and notice board ・Instruction Manual for the Inert Gas System ・Cargo Securing Manual (for Japanese Ships) ・The other plans and documents if required	I	I	I
General Examination	I	I	I

・Shell Plating and Weather Deck Plating ・Opening on deck and outside of the hull ・Casings of Engine Room ・Ventilators and Air Pipes ・Load Line Marks ・Bulwark ・Means of Access ・Scuppers, Inlets, Other Discharge Pipes and Valves ・Securing Arrangement for on-deck timber ・Anchoring and Mooring Arrangement ・Fire Protection Arrangement and Means of Escape ・Sails and their Accessories ・Emergency towing Arrangement ・Piping in the cargo holds (ship's age > 15 years)			
MAIN ENGINE, AUXILIARY ENGINE, PROPELLER SHAFTING, POWER TRANSMISSION SYSTEM, MONITORING DEVICE, CONTROL SYSTEM, ETC. ・Opening-up inspection (Planned Machinery Survey) (Note) In applying Planned Machinery Maintenance Scheme (PMS) or Preventive Machinery Maintenance Scheme (PMMS), refer to the approved Survey Schedule Table. In applying Continuous Machinery Survey (CMS), refer to "Explanatory Notes On Continuous Machinery Survey"	O	O	O
・Main engine, auxiliary engine for generator and for essential service a) Over speed protective device b) Automatic stop and alarm system by failure of supply of L.O. c) Steam shut-off devices in case of low main condenser vacuum d) Other safety devices (remote control emergency stop device, trip device by excessive vibration for steam turbine, etc.) ・Measurement of crank deflection of main engine ・Remote control of shut-off device for flammable oil tanks ・Remote control stop of F.O. pumps, cargo oil pumps, ventilators, boiler draft fans, ・Communication system ・Monitoring devices (pressure indicators, thermometers, ammeters, voltmeters and revolution meters) ・Automatic devices or remote control devices ・Pressure test of condensers and shells of receivers for refrigerating installation (may be dispensed with at the discretion of the Surveyor, except those using NH3 (R171) as refrigerant.) ・Leak test of refrigerant under working condition of refrigerating machinery	T	T	T
BOILER, THERMAL OIL HEATER, EXHAUST GAS ECONOMISER ・Performance test of safety device, alarm devices and pressure indicators including confirmation of calibration records for the pressure indicators	T	T	T
SPARE PARTS, TOOLS AND INSTRUMENTS	I	I	I
ELECTRICAL INSTALLATIONS ・Performance test of speed governors, circuit breakers and their associated relays (Running test under loaded condition either separately or in parallel)	T	T	T

・Performance test of communication system and emergency source of power ・ Insulation resistance measurement of generators, switchboards, motors and electric cables (may be dispensed with proper record is maintained) ・Insulation resistance measurement of electrical equipment in hazardous area of tankers and chemical carriers (may be dispensed with where proper record is maintained) ・Lighting, communication, signaling and ventilation systems and other electrical equipment including performance test of interlocking devices			
Type (foam extinguisher) / Standard Validity / Type (dry-chemical extinguisher) / Standard Validity Portable foam (9*l*) / 1 year (spare 2 years) / Portable dry-chemical / 5 years Moval foam (45*l*, 135*l*) / 1 year (spare 2 years) / Movable dry-chemical / 5 years Portable foam applicator (20*l*) / 3 years* (spare 3 years) / Fixed dry-chemical / valid so far as it is no moisturized Deck foam / 3 years* High expansion foam / 3 years* * : - IMO MSC / Circ.582 to be referred. (Validity may be extended for 1 years subject to verification of effectivenes by chemical analysis.) - Flag's special requirements, if any, to be referred.			

Table 1-1 Internal Examination and Pressure Test for Spaces and Tanks required at Periodical Surveys

IE : Internal Examination PT : Pressure Test SS : Special Survey IS : Intermediate Survey AS : Annual Survey

5 years → 10 years → 15 years → Over 15 years →

Surveys / Spaces, Tanks	IS	SS No.1		IS	SS No.2		IS	SS No.3		IS	AS General
	IE	IE	PT	IE	IE	PT	IE	IE	PT	IE	IE
Water Tanks (double bottom & deep tanks)	/	○	○ *1	○ *2	○	○ *1	○ *3 *E	○	○	○ *3 *E	○ *4 *5
Fuel Oil Tanks — double bottom tanks	/	/	△ *6	/	□ *7 *8	△ *6	/	□ *9 *10	△ *6 *7	/	/
Fuel Oil Tanks — deep tanks	/	□ *11	△ *6	/	□ *8 *12	△ *6	/	□ *10 *13	△ *6	/	/
Lubricated Oil Tanks	/	/	△ *6	/	/	△ *6	/	□	△ *6	/	/
Cargo Tanks (tankers and chemical carriers)	/	○	○ *14	/	○	○ *15	○ *7	○	○ *16	○ *E	/
Cargo Tanks (except tankers, gas carrier and chemical carriers)	/	○	△	/	○	△	/	○	○	/	/
Cargo Holds (other cargo ships)	/	○	/	/	○	/	○ *17	○	/	○ *7	/
Cargo Holds (general dry cargo ships)	/	○	/	○ *7	○	/	○	○	/	○ *E	○ *18
Cargo Holds (bulk carriers except double skin)	/	○	○ *19	○	○	○ *19	○ *E	○	○ *19	○ *E	○ *20
Cargo Holds (double skin bulk carriers)	/	○	○ *19	○	○	○ *19	○ *E	○	○ *19	○ *E	○ *21
Cargo Holds (lumber carriers)	/	○	/	○	○	/	○	○	/	○ *22 *E	○ *22
Void Space, Cofferdam, Rudder Trunk, etc.	/	○	/	/	○	/	○ *E	○	/	○ *E	/
Engine room, Pump Room, etc.	○	○	/	○	○	/	○	○	/	○	○

1. SS 1 : Special Survey for ships up to 5 years of age
   SS.2 : Special Survey for ships over 5 years and up to 10 years of age
   SS.3 : Special Survey for ships over 10 years and up to 15 years of age
   SS.4 and subsequent SS : Special Survey for ships over 20 years of age
2. Subsequent SS after SS4, Internal Examination and Pressure Test are to be carried out for all water, fuel oil, lubricating oil and cargo tanks.

○ : to be carried out.

□ : may be dispensed with subject to external examination.

△ : may be limited to representative tanks subject to external and internal examination

＊1	Fresh water tanks may be limited to representative tanks subject to external and internal examination. In case of oil tankers and bulk carriers, the tanks in cargo area to be included in representative tanks.
＊2	In addition to tanks of which the internal examination is required at annual intervals as the consequence of the last SS, representative sea water ballast tanks (at least, fore & aft peak tank and two deep tanks (in case of double hull tankers and double skin bulk carriers, three deep tanks) in cargo area to be examined. Where poor coating condition, corrosion or other defects are found, or a protective coating has not been applied from the time of construction, examination to be extended to other similar ballast tanks.
＊3	All sea water ballast tanks including combined cargo/ballast tanks.
＊4	For ships of over 5 years of age, tanks of which an internal examination is requested at annual intervals as a consequence of the last SS or IS to be examined.
＊5	For ships of over 15 years of age, all tanks adjacent to (with a common plane boundary) a cargo tank with heating coils to be examined. However, where coating was found to be in GOOD condition at the last IS or SS, this may be specially dispensed with.
＊6	For oil tankers and bulk carriers, tanks in cargo area to be included in representative tanks.
＊7	One forward and after compartment
＊8	One double bottom tank or deep tank in cargo area
＊9	At least each one tank (amidship, forward and aft)
＊10	Two tanks including deep tank in cargo area and One tank in engine room
＊11	At least both peak tanks
＊12	At least both peak tanks, and one selected tank
＊13	At least both peak tanks and half the numbers of deep tanks
＊14	Test for cargo tank boundaries facing spaces/tanks other than cargo tanks
＊15	Test for cargo tank boundaries of segregated cargoes in addition to areas indicated in ＊14
＊16	Test for all cargo tank bulkheads
＊17	At least one selected cargo hold
＊18	One forward and after cargo holds for ships of over 10 years of age, and all cargo holds for ships of over 15 years of age
＊19	For combined Cargo hold/Ballast tank, where substantial corrosion is found, requirements for ballast tanks to be applied to. No dispensation after SS4.
＊20	All cargo holds for ships of over 10 years of age
＊21	Two selected cargo holds for ships of over 10 years and up to 15 years of age All cargo holds for ships of over 15 years of age
＊22	All cargo holds for ships of over 5 years of age
＊ E	Same requirements as previous SS for oil tankers, chemical tankers and general dry cargo ships of 15 years of age and bulk carrier of 10 years of age. (except fuel oil tanks, lubrication oil tanks and pipe tunnels / cofferdams / void spaces not adjacent to cargo holds and cargo tanks)

Table 2 Class Survey (Docking Survey)

SURVEY ITEMS	
BOTTOM INSPECTION (IN DRYDOCK OR ON SLIPWAY) ・Inspection of rudder, shell plating ・Lifting or removing of rudder (Note) May be dispensed with provided the Surveyor is satisfied with the condition of the rudder bearings by measurement of the clearances. ・Pressure Test may be required as deemed necessary by the surveyor	I, M, T

・Measurement of clearance of rudder bearing ・Inspection of propeller ・Sea inlet and overboard discharge and their associated valves under freeboard deck ・Opening-up examination of sea valves (Note) May be dispensed with at the discretion of the Surveyor provided they were dismantled and examined at the last Docking Survey ・Clearance or wear down of stern tube ・Sealing device of stern tube bearing: Confirmation of efficiency of oil gland of sealing device ・Anchor, anchor chain, rope, hawse pipe, chain locker and chain stopper At Docking Survey carried out in connection with SS, anchor and anchor chain are to be ranged and examined. At SS No.2 and subsequent, measurement of diameter of anchor chain is to be carried out. ・Internal examination, close-up survey, thickness measurement of tank and spaces. (1) At least of the lower portions, which are considered to be the parts below light ballast water line, of the cargo holds/tanks and water ballast tanks at Docking Surveys in dry dock or on slipway carried out in conjunction with Special Surveys or at the time specified in the Rules (2) At Docking Surveys carried out at the time specified in the Rules as far as applicable. (Note) ・In principle, In-water survey may be accepted in lieu of Docking Survey other than that coincides with Special Survey for ships up to 15 years old according to the approved plans and documents. The approval of these plans and documents are performed by the survey office in charge of confirming the ship's facility suitable for In-water survey, and it is noted in the *Particulars of Ship* . ・No extension should be granted except along with the extension of SS for ships. However, in any case, it should not exceed 36 months from the previous docking	

X: General examination O: Opening-up examination M: Measurement I: Internal examination

Table 3 Class Survey (Boiler Survey)

SURVEY ITEMS	
BOILER, THERMAL OIL HEATER, EXHAUST GAS ECONOMIZER, ETC. ・Internal and external inspection ・Opening-up inspection of valves and cocks ・Performance test of safety devices ・Popping test of safety valves and confirmation of their setting pressure (including confirmation of the calibration record of pressure gauge) (Note) ・No extension should be granted except along with the extension of SS for Ships to which HSSC is applied. ・For boilers, preparation is to be made by discharging of boiler water, opening-up of smoke door, cleaning of water/fire side including furnace, overhauling of mountings/safety valves. ・For exhaust gas economizers, preparation is to be made by opening-up of smoke door, cleaning of exhaust gas side, overhauling of mountings/safety valves.	T,O,I

I: Internal examination O: Opening-up examination T: Performance test

Table 4 Class Survey (Propeller Shaft and Stern Tube Survey)

SURVEY ITEMS	
Ordinary Surveys ・Examination of propeller shaft, coupling bolt and stern tube ・Examination by "Magnetic Particle Method" on propeller fitting parts	O, I, M,P

・Clearances in stern tubes or wear down of stern bearings (before pulling out and after fitting)	
・Opening-up examination of stern tube sealing devices	
・In the case of CPP propellers, opening-up of pitch control gear and working parts and examination by "Magnetic Particle Method" of propeller blade fixing bolts	
・L.O. tank low level alarms, oil temperature measuring devices, L.O. piping and L.O. circulating pumps	
・Propeller force fitting for the shafts with keyless propeller attachment (Note) Propeller shaft with preventive maintenance system (PSCM) is to be dealt in accordance with the approved preventive maintenance manual.	
Partial Survey / Postponement Surveys(for the purpose of harmonizing PS with Docking survey) **(1) Postponement Survey [6 months for 1A/ 12 months for 1B, 1C]**	
・Examination of propeller shafts exposed in the engine room	
・Records of wear down/clearance in the stern bearings	
・Examination of maintenance records of the stern tube sealing devices	
・Confirmation that the main engines have been operated out of the barred speed range for torsional vibration	
・Examination of the sea water piping for water-lubricated stern tube bearings (1A)	
・Operation test of L.O. low level alarms, Oil temperature measuring device, L.O. piping and L.O. circulating pumps (1B/1C) **(2) Partial Survey of shafts of Kind 1B with oil-lubricated stern tube bearings [3 years postponement from the date of completion of the partial survey]**	
・Examination by "Magnetic Particle Method" on propeller fitting parts (may be dispensed with for those with keyless attachment and flange connection)	
・Clearances in stern tube or wear down of stern bearings	
・Opening-up examination of stern tube sealing device (may be dispensed with for keyless and flange type shafts)	
・L.O. tank low level alarms, oil temperature measuring devices, L.O. piping and L.O. circulating pumps **(3) Partial Survey of shafts Kind 1C [5 years postponement from the date of completion of the partial survey]**	
・All items required in (2) above	
・Checking "Record for Monitoring System of Stern Tube Bearing and Oil Sealing Devices"	

O: Opening-up examination
T: Performance test
M: Measurement
C: Confirmation examination

Table 5 Class Survey (Additional Requirements for Tankers)

SURVEY ITEMS	AS	IS	SS
Facilities Related to Tanker			
・Pump foundation and ventilation system in cargo pump room	I	I	I
・Cargo oil, fuel oil, ballast, vent pipes including vent masts and headers, inert gas pipes and all other pipings in cargo pump room and on weather decks		T	T
a) pressure test (For Intermediate Survey, when deemed necessary by the surveyor.)			
b) thickness measurement (When deemed necessary by the surveyor.)	I	I	I
・Earthing between hull structures and cargo tanks	T	T	T

・Electrical and mechanical remote operating and shut-off device for Cargo Oil Pump, Bilge Pump, Ballast Pump and Stripping Pump in pump room ・Bilge system in pump room ・Level gauging system of cargo tank ・Pressure gauge on cargo discharge line ・Inert gas system a) Inert gas blower, scrubber room ventilation system b) Deck water seal, non-return valve c) Remote control valve, Automatic control valve d) Interlocking system between soot blower and shut-off valve on gas supply line e) Measuring system, Alarm system, Safety device ・Fixed and portable gas detecting instruments and associated alarms ・Gauging devices for oxygen density ・Cargo oil piping and Ballast piping iwo COTs, compartments adjacent to COTs and weather decks ・Inert gas generator	T	T	T
Electrical Installation (dangerous space) ・Insulation resistance test (may be dispensed with where proper record is maintained)	M	M	M

Table 6 Class Survey (Additional Requirements for Ships Carrying Liquefied Gases)

SURVEY ITEMS	AS	IS	SS
CARGO CONTAINMENT SYSTEMS (For membrane and semi-membrane tanks, the examination and testing are to be carried out in accordance with an approved program for each tank system.) (Note) : Gas free/ventilation and removal of the insulation are to be prepared as required for conducting the following surveys. ・Internal examination of cargo tanks		I	I
・External examination of cargo tanks and their insulation (If the visual examination of insulation of tanks is impossible, the examination of cold spots is to be carried out. However, in case where integrity of cargo tanks and their insulation is verified by the cargo log book, the examination of cold spots may be dispensed with.) ・Thickness gauging on tank plates		M	M
・Non-destructive test (For independent tanks of Type B, the extent of non-destructive test is to be in accordance with an approved program.) ・Leak test on cargo tanks (For independent tanks below deck, the leak test may be dispensed with, in case where no leakage is verified by the cargo log book.) ・Pressure test on cargo tanks	I	T	T
・Additional requirements for independent tanks of Type C Either of the following test (1) or (2) is to be carried out at the alternate Special Surveys, such as 2nd, 4th, 6th...: (1) Pressure test and non-destructive test (2) Non-destructive test in accordance with an approved program ・Hold spaces and secondary barriers (If the integrity of secondary barriers is not verified by a visual examination, the integrity is to be verified by pressure or vacuum test or other appropriate means.)	I	T	T

・Sealing arrangement for tanks or tank covers penetrating decks ・Electrical bonding between independent cargo tanks and hull structure	I	T	T
VENTING SYSTEM OF CARGO CONTAINMENT SYSTEM ・Pressure/vacuum relief valves for cargo tanks ・Sealing of pressure relief valves (For pressure relief valves with non-metallic membranes in the main or pilot valves, such nonmetallic membranes are to be renewed at intervals not exceeding three years or the approved interval.) ・Pressure/Vacuum relief devices and associated safety systems for interbarrier/hold spaces	I	I	I
CARGO AND PROCESSING PIPING (Note) Removal of the insulation is to be prepared where considered necessary by the surveyor. ・Piping ・All or a part of the total number of valves and associated fittings ・All or a part of the total number of pressure relief valves ・Sealing of pressure relief valves ・Electrical bonding between hull structures and piping, and between pipe flanges			

SURVEY ITEMS	AS	IS	SS
CARGO HANDLING SYSTEMS*4 ・Emergency shut-off devices	**T**	**T**	**T**
・Cargo heat exchangers, vapourizers, pressure vessels ・Cargo pumps, cargo gas compressors, cargo gas blowers, their prime movers (Opening-up inspection of electric motors may be dispensed with.) ・Pipings and their insulations ・Automatic and manual stopping devices for cargo pumps and compressors	**I**	**T**	**T**
・Equipment relating to refrigerant a) Pumps and compressors b) Condensers, receiver, inter-coolers, oil separators and relief valves c) Leak test of pressure vessels and heat exchangers under the pressure of not less than 90 % of the set pressure of relief valves d) Leak test of refrigerant piping system under the pressure of not less than 90 % of set pressure of relief valves ・Drainage system for leaked cargo in interbarrier spaces and hold spaces	**I**	**T**	**T**
GAUGING DEVICES, GAS DETECTION INSTRUMENTS AND ASSOCIATED ALARMS ・Liquid level gauges, high level alarms and valves related to emergency shutdown system ・Temperature indication equipment and associated alarms ・Pressure gauges and associated alarms for cargo tanks, interbarrier spaces / hold spaces ・Fixed and portable gas detecting instruments and associated alarms ・O2 content meter	**T**	**T**	**T**
・Safety devices related to use of boil-off gas as fuel ENVIRONMENTAL CONTROL SYSTEM FOR HOLD SPACES	**I**	**T**	**T**

・Gas free and purging systems and gas collecting devices for cargo tanks ・Inert gas generating system, inert gas storage system, dry air installation, gases for compensating normal losses and drying agent ・Pressure control system for inert gas relevant system, means for preventing backflow of gases and monitoring system FIRE EXTINGUISHING ARRANGEMENT ・Test by delivering air for fixed piping and function test of alarms in enclose gas dangerous spaces ・Additional fireman's outfits for flammable cargoes, fire fighting systems for gas dangerous closed spaces and alarming devices for emergency escape ELECTRICAL INSTALLATION ・Interlocking devices ・Insulation resistance test of electric circuits in gas dangerous spaces (may be dispensed withwhere proper record is maintained)	**T**	**T**	**T**

SURVEY ITEMS	AS	IS	SS
PERSONEL PROTECTION ・Decontamination shower and eye wash (if required to be installed) ・Protection equipment, safety equipment, stretcher, medical first-aid equipment, respiratory protection for emergency escape purpose and shelter in emergency ・Air compressor (if provided for safety equipment) OTHERS a) Cross flooding equipment, watertight door, etc. which are provided in connection with the ship's stability in damaged condition, as far as accessible. b) Closing devices of windows, doors and other openings wheelhouse and of those on exposed walls of superstructures and deckhouses as required and arrangements for the air locks c) Venting systems including their spare fans or impellers for enclosed spaces and compartments in cargo area d) Fixed or portable trays or insulation for deck protection to be provided against cargo leakage e) Gas-tight bulkhead penetrations including gas-tight shaft sealings, as far as accessible f) Heating arrangements of structural hull steel, as far as accessible g) Type approved cargo hoses h) Earthing between hull structures and cargo pipes as far as accessible i) Bow or stern loading and unloading arrangements and their related installations emergency muster station and other equipment required for special cargoes j) Electrical installations in gas dangerous spaces or areas k) Cargo log book, operational records and manuals related to cargo containment system and cargo handling system l) The IMO Code for gas carriers or the Rules incorporating the provisions of the abovementioned Code	T,I	T,I	T,I

I: Internal examination O: Opening-up examination P: Pressure test X: General examination
T: Performance test M: Measurement C: Confirmation examination
*1 : Where considered necessary by the surveyor
*2 : At the first Annual Survey after the ship enters in service of carrying liquefied gases, where considered
necessary by the surveyor.
*3 : If internal examination of vessels is impracticable, pressure test of vessels and performance test of pressure
relief valves are to be carried out.

*4 : In the case where CMS is applied, the opening-up examination required at periodical surveys may be replaced by visual Inspection

Table 7 Class Survey (Additional Requirements for Ships Carrying Dangerous Chemicals in Bulk)

SURVEY ITEMS	AS	IS	SS
WEATHER DECK			
・Sampling arrangements for cargoes from heating and cooling lines	**I**	**I**	**I**
・Closing devices of windows, doors and other openings of wheelhouse and of those on exposed walls of superstructures and deckhouses as required			
・Pump discharge pressure gauges provided outside the pump rooms			
・Insulation of piping	**T**	**T**	**T**
・Thickness gauging on tank plates			
CARGO PUMP ROOM			
・Remote operating electrical and mechanical shutdown devices for cargo pumps and bilge system			
・Personnel rescue arrangements in cargo pump room			
・Equipment for cargo separation	**I**	**I,O**	**I,O**
・Ventilating system including spare fans or impellers for enclosed spaces and compartments in cargo area			
・System for flowback to land facilities of cargo liquid and its slop and vapour			
・Thickness gauging on tank plates			
・Cargo pumps			
・Pump foundation and ventilation system in cargo pump room			
CARGO TANKS AND ASSOCIATED EQUIPMENTS			
・Insulation of cargo containment (Removal of the insulation is required where considered necessary by the Surveyor.)	**T**	**T**	**T**
・Foundation of cargo containment, including supports, keys and anti-rolling/anti-pitching devices (Removal of the insulation is required where considered necessary by the Surveyor.)	**M**	**M**	**M**
・Sealing arrangement for tanks and tank covers penetrating decks (Removal of the insulation and covers or performance test of closing devices may be required)			
ENVIRONMENTAL CONTROL SYSTEM FOR CARGO CONTAINMENTS AND SURROUNDING SPACES			
・Equipment for inerting / padding / drying and gases for compensating normal losses and drying agents			
・Monitoring system for environmental control for vapour spaces in cargo containments and void spaces surrounding such cargo containments			
GAUGING, DETECTING AND ALARMING DEVICE			
・Liquid level gauges, high level alarms and valves associated with overflow control system			
・Gauging devices for liquid level, temperature, pressure, etc. of cargo containment system and associated alarms			
・Fixed and portable gas detecting instruments and the associated alarms			
・ O2 content meter			
BONDING (Electrical bonding between hull structures and cargo piping)			
ELECTRICAL INSTALLATION			

・Interlock devices ・Insulation resistance test of electrical circuits in gas dangerous spaces (may be dispensed by the Surveyor)			

SURVEY ITEMS	AS	IS	SS
FIRE FIGHTING ARRANGEMENT ・Air blow test of fixed piping in gas dangerous spaces and performance test of alarm system ・Additional fireman's outfits for flammable cargoes, fire fighting systems for gas dangerous closed spaces and alarming devices for emergency escape CARGO OIL PIPING AND BALLAST PIPING WITHIN ALL CARGO TANKS, ALL TANKS AND SPACES BOUNDING CARGO TANKS SUCH AS BALLAST TANKS, PUMP ROOMS, PIPE TUNNELS, COFFERDOAMS AND VOID SPACES AND ON WEATHER DECKS PERSONNEL PROTECTION ・Protection equipment ・Safety equipment ・Stretcher and medical first-aid equipment ・Decontamination shower and eye wash ・Respiratory protection for emergency escape purpose ・Air compressor (if provided for safety equipment) OTHERS a) Cross flooding equipment, watertight door, etc. which are provided in connection with the ship's stability in damaged condition, as far as accessible. b)Cargo sample storage arrangements c) Bow and stern loading / unloading arrangements d) Fixed or portable trays or insulation for deck protection to be provided against cargo leakage e) Identification marks of pipe lines including pumps and valves f) Drainage system from vent pipes g)Type approved cargo hoses h) Special arrangement in accordance with the special requirements for certain cargoes i) Heating and cooling arrangements for cargoes j) Electrical installations in gas dangerous spaces or areas k)Cargo log book, operational records and manuals related to cargo containment system and cargo handling system l) The IMO Code for chemical tankers or the Rules incorporating the provisions of the abovementioned Code	T	T,M	T,M

APPENDIX

<u>Guidance for Undergoing Change of Flag Survey</u>

This guidance provides the procedure due to the change in flags and the incoming and outgoing flags have authorized Sing-Lloyd to carry out statutory surveys / issue the statutory certificates.

1. Documents

Please submit the followings to any Sing-Lloyd offices:

(1) Survey application (and Audit application for SMC and/or ISPS)
(2) Copy of the Provisional Registration Certificate

(3) Copy of the Radio Station License
(4) Copy of the GMDSS Operator License

2. Preparations

1. To amend the port of registry and the new ship's name, if applicable on the followings:

(1) Both fore side shell and stern plate, lifeboats, liferaft container (also liferaft itself for certain flags), life buoys and lifejackets
(2) Fire control plan *1, Life saving plan, Muster list, General arrangement, Capacity plan, Damage Control Plan, etc.
(3) Shipboard Oil Pollution Emergency Plan (SOPEP) *2, Shipboard Marine Pollution Emergency Plan (SMPEP) *2, Oil Record Book *3, Loading Manual, etc.

2. Please conduct the necessary modifications and provide additional equipment imposed by the Flag State, if necessary. *4

3. Radio survey

Please arrange a radio inspector authorized by Sing-Lloyd to carry out the followings, and Initial survey of Safety Radio Certificate under the new flag State.

(1) Re-programming MMSI Number into MF/HF-DSC, VHF-DSC, Satellite EPIRB
(2) Re-programming Country code and ID Number into INMARSAT
(3) Re-programming MMSI, Call-Sign and Ship's Name (if altered) into AIS
(4) Re-programming Flag, Ship's Name and Classification (if altered) into VDR
(5) LRIT

Please arrange the followings at survey.

(6) Refitting New Call Sign board
(7) Shore base maintenance agreement
(8) Annual at-sea and shore-based maintenance report for EPIRB
(9) Annual at-sea maintenance report for VDR

4. Re-approval of documents

The following manuals and booklets will be re-approved by the surveyor.
(1) Loading Manual, Stability Information Booklet
(2) Shipboard Oil Pollution Emergency Plan (SOPEP), Shipboard Marine Pollution Emergency Plan (SMPEP)
(3) Cargo Securing Manual
(4) Grain Loading Booklet (Necessary documents: Application, Copy of provisional registration certificate) *5
(5) Cargo gear register and relevant certificates issued by Sing-Lloyd

5. Certificates issued by Sing-Lloyd Head Office

The following certificates will be issued by Sing-Lloyd Head Office:

(1) Tonnage Certificate*6
Please apply to Sing-Lloyd Head Office with the following documents for issuance of the Tonnage certificate.

(Necessary documents: Application, Copy of provisional registration certificate, General arrangement)
(2) Grain Loading Certificate *5

6. Scope of surveys and Special requirements of each flag State

Please contact the local survey office for information concerning surveys for Flag Change prior to the surveys.
The surveyor in charge will notify the scope of surveys and the special requirements imposed by the Flag State, if any.

7. Others

Please request the Exclusive Surveyors’ Office in advance should the following be required due to flag change:

・Dangerous Goods Fitness Certificate,

・BC Code Fitness Certificate,

・Survey report of crew's accommodation (ILO Convention),

・Statement of Compliance (MARPOL 73/78 Annex IV),

・Statement (MARPOL 73/78 Annex V),

・Carving and Marking Note (applicable to only some flag administrations)

PART D

CLASS NOTATIONS

CLASS NOTATIONS AND SYMBOLS

A. NOTATIONS

1 Unrestricted Service

Vessels which have been built to the satisfaction of Sing-Lloyd to the full requirements of the Rules, Guide, or to their equivalent, where approved by the Committee for unrestricted service at the assigned freeboards, will be classed and distinguished in the *Record* by the symbols ✠ **S1** indicating compliance with the hull requirements of the Rules and for self-propelled vessels ✠ **SMS** indicating compliance with the machinery requirements of the Rules.

2 Special Rules

Vessels which have been built to the satisfaction of the Surveyors to Sing-Lloyd to the requirements as contained in the Rules for special types of vessels and which are approved by the Committee for unrestricted ocean service at the assigned freeboards, will be classed and distinguished in the *Record* by the symbols ✠ **S1** followed by the appropriate notation, such as **Oil Carrier**, **Ore Carrier**, **Bulk Carrier**, **Ore or Oil Carrier**, **Oil or Bulk/Ore (OBO) Carrier**, **Liquefied Gas Carrier**, **Chemical Carrier**, **Passenger Vessel**, **Vehicle Carrier**, **Container Carrier, Towing Vessel**, **Refrigerated Cargo Carrier**.

3 Special Purpose Vessels

Vessels of special design, intended primarily for ferry service, for dredging, for fishing, etc., which have been built to the satisfaction of the Surveyors to the Bureau to arrangements and scantlings approved for the particular purpose, where approved by the Committee for a particular service at the assigned freeboards, will be classed and distinguished in the *Record* by the symbols ✠ **S1** followed by a notation of the trade for which special modifications to the Rules have been approved.

4 Geographical Limitations

Vessels which have been built to the satisfaction of the Surveyors to the Class to special modified requirements for a limited service, where approved by the Committee for that particular service, will be classed and distinguished in the *Record* by the symbols and notations as described in the Rules

5 Vessels Not Built Under Survey

Vessels which have not been built under survey to this Class, but which are submitted for classification, will be subjected to a special classification survey. Where found satisfactory and thereafter approved by the Committee, they will be classed and distinguished in the *Record* by the symbols and special notations as described in 1-1-3/1 to 1-1-3/7, but the mark À signifying survey during construction will be omitted.

6 Equipment Symbol

The symbol ✠ placed after the symbols of classification, thus: ✠ **S1** ✠, will signify that the equipment of anchors and chain cables of the vessel is in compliance with the requirements of the Rules or with requirements corresponding to the service limitation noted in the vessel's classification, which have been specially approved for the particular service.

7 ✠ SMS Notation

Machinery, and boilers if installed, which have been constructed and installed to the satisfaction of the Surveyors to the Bureau to the full requirements of the Rules, when found satisfactory after trial and approved by the Committee, will be classed and distinguished in the *Record* by the notation ✠ **SMS**.

8 SMS Notation

Machinery, and boilers if installed, which have not been constructed and installed under survey to this Bureau, but which are submitted for classification, will be subjected to a special classification survey. Where found satisfactory and thereafter approved by the Committee, they will be classed and distinguished in the *Record* by the notation **SMS**. The mark ✠ signifying survey during construction will be omitted.
9 Automatic Control Systems

Where, in addition to the individual unit controls, it is proposed to provide remote, centralized, or automatic control systems for propulsion units, essential auxiliaries, or for cargo handling, relevant data is to be submitted to permit the assessment of the effect of such systems on the safety of the vessel. All controls necessary for the safe operation of the vessel are to be proved to the Surveyor's satisfaction. The automatic and remote-control systems are to be in accordance with the applicable requirements of the relevant Rules or Guide.

10 Dynamic Loading Approach

Vessels which have been built to plans reviewed in accordance with an acceptable procedure and criteria for calculating and evaluating the behavior of hull structures under dynamic loading conditions, in addition to full compliance with other requirements of the Rules, will be classed and distinguished in the *Record* by the notation **SH-DLA** placed after the appropriate hull classification notation.

11 Spectral Fatigue Analysis

Where a spectral fatigue analysis is performed satisfactorily in accordance with an acceptable procedure and criteria, and the vessel is built in accordance with plans approved on the basis of the results of such analysis, the vessel will be distinguished in the *Record* by the notation **SFA (year)**. The notation, **SFA (year)**, denotes that the designated fatigue life value is equal to 20 years or greater. The **(year)** refers to the designated fatigue life equal to 20 years or more (in 5-year increments) as specified by the applicant.

12 Common Structural Rules for Tankers and Bulk Carriers

Vessels designed and built to the requirements IACS, "Common Structural Rules for Double Hull Oil Tankers", and, "Common Structural Rules for Single/Double Side Skin Bulk Carriers" will be identified in the *Record* by the notation **CSR.** These vessels are transferred into class and are not built under Sing-Lloyd's Rules and Regulations.

13 Ice Classes

Vessels to be distinguished in the *Record* by the notation **Ice Class** are to meet the requirements in the Rules applicable to the designated ice class.

14 PORT Notations

Where requested by the Owner, control and monitoring installations which are found to comply with the requirements *in Port* and which have been installed and tested under survey by the Surveyor will be assigned and distinguished in the *Record* with the class notation **PORT**.

B. SYMBOLS AND DESCRIPTION

1. SYMBOL: ✠

DESCRIPTION

The Iron Cross, ✠, symbol is assigned to vessels and offshore units for which the hull construction and/or the manufacture of its machinery and components and any associated required testing, as applicable, is carried out under Sing-Lloyd survey. For a vessel or offshore unit constructed under survey of another recognized Classification Society or Authority, the Iron Cross, ✠, symbol will be omitted from the hull and/or machinery classification notations.

2. SYMBOL**: ✠ S1**

DESCRIPTION

S1 is a classification symbol that**,** together with the Iron Cross ✠ symbol**,** indicates compliance with the Hull requirements of the Sing-Lloyd Rules or their equivalent for unrestricted ocean service and survey by Sing-Lloyd during construction of the vessel. The symbols ✠ **S1** may be followed by appropriate vessel type notation such as **Oil Carrier**, **Bulk Carrier**, **Fuel Oil Carrier**, **Ore Carrier**, **Passenger Vessel**, **Vehicle Carrier**, **Container Carrier**, **Towing Vessel**, **Refrigerated Cargo Carrier**, **Liquefied Gas Carrier**, etc. The Iron Cross ✠ symbol will be omitted for vessels that have not been built under survey by the Sing-Lloyd.

3. SYMBOL:✠ **S1 (Special Purpose)**

DESCRIPTION

The symbols ✠ S1 followed by a Notation of the trade for which specific arrangements and scantlings have been approved (i.e. Ferry Service, Dredging, Fishing, etc.) and to which the special purpose vessels have been built to the satisfaction of Sing-Lloyd

4. SYMBOL:✠ **S1 (Geographical Limitations)**

DESCRIPTION

The symbols ✠ S1 followed by a notation of the service limitations is to be assigned to vessels, which have been built to the satisfaction of Sing-Lloyd to specific requirements for restricted service, for the particular service. (e.g. **Singapore Off Port Limit**, **Gulf of Mexico**, **Philippine Inter-Island Service, Coastal Service Less than 25 Miles, etc.**)

5. SYMBOL:✠ **SMS**

DESCRIPTION

SMS is a classification notation that, together with the Iron Cross ✠ symbol, indicates that a vessel's machinery, boilers and systems have been constructed and installed in accordance with the requirements of the Sing-Lloyd Rules. The ✠ **SMS** notation is intended for new construction of Sing-Lloyd classed self-propelled vessels and offshore units.

6. SYMBOL: **SMS**

DESCRIPTION

The **SMS** notation, without the **I**ron Cross ✠ symbol, is assigned to self-propelled vessels and offshore units for which the machinery, boilers and systems have not been constructed and installed under survey by the Society, but are found satisfactory with regard to Sing-Lloyd requirements.

7. SYMBOL:✠ **ACC**

DESCRIPTION

Automatic **C**entralized **C**ontrol (**ACC**) – This notation is assigned to a vessel having the means to control and monitor the propulsion-machinery space from a continuously manned centralized control and monitoring station installed within or adjacent to, the propulsion machinery space. The Maltese Cross ✠ symbol signifies that the pertinent automatic or remote control and monitoring systems have been assembled, tested and installed under construction by Sing-Lloyd

8. SYMBOL:✠ **ACCU**

DESCRIPTION

Automatic **C**entralized **C**ontrol **U**nmanned (**ACCU**) – This notation is assigned to a vessel having the means to control and monitor the propulsion-machinery space from the navigation bridge and from a centralized control and monitoring station installed within or adjacent to, the propulsion machinery space. The **I**ron Cross ✠ symbol signifies that the pertinent automatic or remote control and monitoring systems have been assembled, tested and installed under survey by Sing-Lloyd.

9. SYMBOL:✠ **ABCU**

DESCRIPTION

Automatic **B**ridge **C**entralized **C**ontrol **U**nmanned (**ABCU**) – This notation is assigned to a self propelled vessel which is fitted with the required automation and remote monitoring and control systems to enable the propulsion machinery space to be periodically unattended (similar to an **ACCU** classed vessel) and the propulsion control to be effected primarily from the navigation bridge. The **I**ron Cross ✠ symbol signifies that the pertinent automatic or remote control and monitoring systems have been assembled, tested and installed under construction by Sing-Lloyd

10. SYMBOL:✠ **APS**

DESCRIPTION

This notation is assigned to a self-propelled vessel fitted with athwartship thrusters intended to assist in the maneuvering of the vessel. The **I**ron Cross ✠ symbol signifies that compliance with these Rules was verified by Sing-Lloyd during construction of the vessel. This includes survey of the machinery at the manufacturer's plant (where required), during installation on board the vessel; and during trials.

11. SYMBOL: **AT**

DESCRIPTION

Additional **T**hickness (**AT**) – This notation is assigned to all conventional type vessels and to floating production installations where the vessel incorporates additional plate thickness above the required scantlings. The notation will be followed by the description of the major hull girder component(s) that has the additional thickness. It will also include a number to indicate the magnitude of the additional thickness (rounded to the nearest 0.5 mm) that has been applied, i.e., **AT(DK+0.5)**.

12. SYMBOL: **CCO-HR(TEMP), CCO-HR(TEMP)+**

DESCRIPTION

These notations are assigned to a vessels complying with the requirements specified in the Sing-Lloyd *Guide for Vessels Operating in Low Temperature Environments*.

CCO-HR(TEMP) – This notation is assigned to a vessel designed, built and surveyed in accordance with requirements *for Vessels Operating in Low Temperature Environments* (which addresses the requirements for materials, welds and coatings, hull construction and equipment, vessel systems and machinery, safety systems and additional requirements for specific vessel types intended to operate in a low temperature environment. The design service temperature for which the vessel is designed is listed in the parentheses.

CCO-HR(TEMP)+ – This notation is assigned to a vessel designed, built and surveyed in accordance with requirements for **CCO-HR(TEMP)** along with placement of additional equipment onboard for the crew and specific low temperature environment training for the crew The design service temperature for which the vessel is designed is listed in the parentheses.

13. SYMBOL: **CPS**

DESCRIPTION

Coating **P**erformance **S**tandard (**CPS**) – This optional notation signifies that the protective coatings used on a vessel's tanks and void spaces comply with *the Class Notation Coating Performance Standard (CPS)*. The Guide illustrates the application of the criteria contained in the IMO Resolution MSC.215(82) Performance Standard for Protective Coatings for Dedicated
Seawater Ballast Tanks in All Types of Ships and Double-Side Skin Spaces of Bulk Carriers (IMO PSPC).

14. SYMBOL: **CRC**

DESCRIPTION

Crane **R**egister **C**ertificate (**CRC**) – This optional notation signifies that the vessel's crane(s) is designed and constructed in accordance with Sing-Lloyd *Guide for Lifting Appliances*. A Register of Lifting Appliances attesting to compliance with the requirements of the above Guide will be issued at the request of the Owner or builder upon satisfactory completion of plan review, in-plant survey, installation and testing of the crane to the satisfaction of the attending Surveyor.

15. SYMBOL:✠ **DPS-0**

DESCRIPTION

The **D**ynamic **P**ositioning **S**ystem notation **DPS-0** indicates that a self-propelled (or non-propelled) vessel is fitted with a system of thrusters, positioning instruments and control systems with a centralized manual position control and automatic heading control to maintain a desired position and heading at sea without external aid under specified maximum environmental conditions; and that the systems are in accordance with the applicable requirements Sing-Lloyd *Rules for Building and Classing Steel Vessels*. The assigned numeral **"0"** indicates the degree of redundancy.

The Iron Cross ✠ symbol signifies that compliance with these Rules was verified by the Sing-Lloyd during construction of the vessel. This includes survey of the machinery at the manufacturer's plant (where required), during installation on board the vessel; and during trials.

16. SYMBOL: ✠ **DPS-1**

DESCRIPTION

The **D**ynamic **P**ositioning **S**ystem notation **DPS-1** indicates that a self-propelled (or non-propelled) vessel is fitted with a system of thrusters, positioning instruments and control systems capable of automatically maintaining the position and heading at sea without external aid under a specified maximum environmental conditions as well as a centralized manual position control with automatic heading control; and that the systems are in accordance with the applicable requirements of the Sing-Lloyd *Rules for Building and Classing Steel Vessels*. The assigned numeral **"1"** indicates the degree of redundancy.

17. SYMBOL: ✠ **DPS-2**

DESCRIPTION

The **D**ynamic **P**ositioning **S**ystem notation **DPS-2** indicates that a self-propelled (or non-propelled) vessel is fitted with a system of thrusters, positioning instruments and control systems capable of automatically maintaining the position and heading at sea without external aid within a specified operating envelope under specified maximum environmental conditions during and following any single fault excluding a loss of compartment or compartments; and that the systems are in accordance with the applicable requirements of Sing-Lloyd *Rules for Building and Classing Steel Vessels*. The assigned numeral **"2"** indicates the degree of redundancy.

18. SYMBOL:✠ **DPS-3**

DESCRIPTION

The **D**ynamic **P**ositioning **S**ystem notation **DPS-3** indicates that a self-propelled (or non-propelled) vessel is fitted with a system of thrusters, positioning instruments and control systems capable of automatically maintaining the position and heading at sea without external aid within a specified operating envelope under specified maximum environmental conditions during and following any single fault including a loss of a compartment due to fire flood; and that the systems are in accordance with the applicable requirements of Sing-Lloyd *Rules for Building and Classing Steel Vessels*. The assigned numeral **"3"** indicates the degree of redundancy.

19. SYMBOL: **ES**

DESCRIPTION

Environmental **S**afety (**ES**) – This notation is assigned to a vessel complying with the requirements *for the Class Notation Environmental Safety (ES)*. Vessels in full compliance with the subject requirements are assigned the **ES** notation in recognition of environmental considerations incorporated into the design and operation of the vessel.

20. SYMBOL: **ESP, ESDC**

DESCRIPTION

Enhanced **S**urvey **P**rogram (**ESP**) – This notation is assigned to Oil Carriers, Bulk Carriers, Ore Carriers, Combination Carriers or Chemical Tankers, all in seawater services, that are in compliance with the specified survey requirements for the **ESP** notation in the Sing-Lloyd *Rules for Survey After Construction*.

Expanded **S**urvey Program for General **D**ry **C**argo Vessels (**ESDC**) – This notation is assigned to General Dry Cargo Vessels, as defined in the Sing-Lloyd *Rules for Survey After Construction*, in seawater services, that are in compliance with the specified survey requirements for the **ESDC** notation.

21. SYMBOL: **LAID UP**

DESCRIPTION

This additional notation is assigned to vessels that are lay-up in compliance with "Guide for Lay-Up and for Reactivation of Laid-up Ships" of the Sing-Lloyd *Rules for Survey After Construction* and drilling units that are lay-up
The notation allows for the vessel's surveys falling due during lay-up to be held in abeyance until the vessel reactivates, at which time they are to be brought up-to-date.

22. SYMBOL: **NIBS**

DESCRIPTION

Navigational **I**ntegrated **B**ridge **S**ystem (**NIBS**) – This notation is assigned to vessels which are fitted with an integrated bridges system (IBS) for the navigational purpose, and are found to comply with the requirements of the Sing-Lloyd *Guide for Navigational Bridge Design and Equipment/Systems*, and which have been constructed and installed under survey

23. SYMBOL: **PORT**

DESCRIPTION

This optional notation is assigned to vessels fitted with automatic and remote control and monitoring system installations which are found to comply with the requirements of the Sing-Lloyd *Guide for Automatic or Remote Control and Monitoring Systems for Vessels in Port* and which have been installed and tested under survey by the Surveyor.

24. SYMBOLS: **S, SE, SH, SQ, SQE, SHE, SHQ, HSQE**

DESCRIPTION

Optional notations assigned to a vessel to recognize that the classed vessel meets the applicable requirements of the Sing-Lloyd *Guide for Marine Health, Safety, Quality and Environmental Managemen*t for Safety Certification (**S**) or Safety and Environmental Certification (**SE**) or Safety and Health Certification (**SH**) or Safety and Quality Certification (**SQ**) or Safety, Quality and Environmental Certification (**SQE**) or Safety, Health and Environmental Certification (**SHE**) or Safety, Health and Quality Certification (**SHQ**) or Health, Safety, Quality and Environmental Certification (**HSQE**).

25. SYMBOL: **TCM**

DESCRIPTION

Tailshaft **C**ondition **M**onitoring **(TCM**) – This notation is assigned to vessels with tailshafts specifically arranged with oil-lubricated stern tube bearings

26. SYMBOL: **Bulk Carrier**

DESCRIPTION

A **Bulk Carrier** is a vessel that is constructed generally with single deck, topside tanks and hopper side tanks in cargo spaces, and is intended primarily to carry dry cargo in bulk. It includes vessels of such type as Ore Carriers or combination carriers such as Ore or Oil Carriers and Oil or Bulk/Ore (OBO) Carriers**.**

NOTATION

Bulk Carrier, BC-A
Bulk Carrier, BC-B
Bulk Carrier, BC-C
(no MP)

DESCRIPTION

BC-A: Bulk Carriers designed to carry dry bulk cargoes of cargo density 1.0 tonnes/m3 and above with specified holds empty in addition to **BC-B** conditions
BC-B: Bulk Carriers designed to carry dry bulk cargoes of cargo density 1.0 tonnes/m3 and above with all cargo holds loaded in addition to **BC-C** conditions
BC-C: Bulk Carriers designed to carry dry bulk cargoes of cargo density less than 1.0 tonnes/m3
(no MP): A notation added after the above Bulk Carrier **BC-A, BC-B** and **BC-C** notations where a bulk carrier has not been designed for loading and unloading in multiple ports

27. SYMBOL: **Ore Carrier**

DESCRIPTION

An **Ore Carrier** is a vessel having two longitudinal bulkheads and a double bottom throughout the cargo area, constructed for the carriage of ore cargoes in the center holds only.

28. SYMBOL: **Ore or Oil Carrier**

DESCRIPTION

An **Ore or Oil Carrier** is a vessel having two longitudinal bulkheads and a double bottom throughout the cargo area, constructed for the carriage of ore cargoes in the center holds or for the carriage of oil cargoes in the center holds and wing tanks.

29. SYMBOL: **Oil or Bulk/Ore (OBO) Carrier**

DESCRIPTION

An **Oil or Bulk/Ore (OBO) Carrier** is a single deck vessel of double skin construction, with a double bottom, lower and upper wing tanks, (hopper and topside tanks) intended for carriage of oil or dry cargoes including ore in bulk.

30. SYMBOL: **PMA+**

DESCRIPTION

This optional notation is assigned to Bulk Carriers of 20,000 gross tonnage and over constructed on or after1 January 2006 to signify that the vessel's means of access meets IMO Resolutions MSC.151(78) – "Adoption of Amendments to the International Convention for the Safety Of Life At Sea, 1974" and MSC.158(78) – "Adoption of Amendments to the Technical Provisions for Means of Access for Inspections", for the application of amended SOLAS regulation II-1/3-6 (resolution MSC.151 (78)) and revised Technical provisions for means of access for inspections (resolution MSC.158 (78)), plus additional ergonomic considerations.

31. SYMBOL: **Chemical Carrier**

DESCRIPTION

This notation is assigned to a vessel that is designed and constructed or adapted and specifically fitted for the carriage in bulk of any liquid product listed in IBC or BCH Code

32. SYMBOL: **Container Carrier**

DESCRIPTION

This notation is assigned to a vessel that is designed and constructed primarily for the carriage of containers in holds or on deck or both, with structures for that purpose, such as cell guides, pedestals, etc.

33. SYMBOL: **CSC**

DESCRIPTION

Container **S**ecuring **C**ertificate (**CSC**) – The **CSC** notation is an optional notation, which signifies that the initial installation of the container securing system has been certified by Sing-Lloyd. A certificate indicating that the initial installation is in compliance with the Sing-Lloyd *Guide for Certification of Container Securing Systems* may be issued upon satisfactory completion of plan review, testing of securing devices, approval of the Container Securing Manual and installation of the fixed securing devices to the satisfaction of the attending Surveyor.

34. SYMBOL: **Oil Tanker, TOA (Flashpoint above 60°C)**

DESCRIPTION

This notation is assigned to a vessel that is designed and constructed for the transportation of petroleum products in bulk, having flash points exceeding 60°C (140°F), closed cup test. Petroleum product refers to oil other than crude oil.

35. SYMBOL: **Oil Tanker, TOB (Flashpoint below 60°C)**

DESCRIPTION

This notation is assigned to a vessel that is designed and constructed primarily for the transportation of petroleum products (crude oil) in bulk, having flash points at or below 60°C (140°F), closed cup test, and includes vessels of similar types such as combination carriers (Ore/Oil Carriers), etc

36. SYMBOL: **VEC, VEC-L**

DESCRIPTION

Vapor **E**mission **C**ontrol (**VEC**) – The notation **VEC** is assigned to indicate that an oil carrier is fitted with a vapor emission control system

Vapor **E**mission **C**ontrol**-L**ightering (**VEC-L**) – The notation **VEC-L** is assigned to indicate that an oil carrier is fitted with a vapor emission control system that is also suitable for use during lightering operations

37. SYMBOL: **Passenger Vessel**

DESCRIPTION

This notation is assigned to a vessels designed and constructed and specifically fitted for the carriage of more than twelve (12) passengers.

38. SYMBOL: **IRCC**

DESCRIPTION

The **I**ntegral **R**efrigerated **C**ontainer **C**arrier notation **IRCC** indicates that a vessel is arranged for the carriage of refrigerated containers of plug-in or integral types which have their own individually mounted refrigeration machinery, hence requiring shipboard electrical power supply and in some cases the cooling water supply for the condensers and, where fitted, the associated temperature monitoring and control system.

39. SYMBOL: **RCC, RCCC**

DESCRIPTION

The **R**efrigerated **C**argo **C**arrier notation **RCC** indicates that a vessel is arranged for the carriage of refrigerated cargoes in insulated

The **R**efrigerated **C**argo **C**ontainer **C**arrier notation **RCCC** indicates that a vessel is arranged for the carriage of refrigerated containers of the porthole type, individually cooled by shipboard refrigeration machinery and associated systems.

40. SYMBOL: **RMC**

DESCRIPTION

The **R**efrigeration **M**achinery **C**ertified notation **RMC** indicates that an existing vessel is fitted with the arrangements necessary for the carriage of refrigerated cargoes which were not constructed and installed under survey to Sing-Lloyd

41. SYMBOL: **Water Carrier**

DESCRIPTION

This notation is assigned to a vessel that is designed and constructed and specifically fitted for the carriage of water cargo in bulk in cargo tanks.

42. SYMBOL: **Offshore Support Vessel; AH Offshore Support Vessel; WS**

DESCRIPTION

Offshore Support Vessel is a vessel primarily engaged in the transport of stores, materials and equipment to offshore installations and is designed with accommodation and bridge erections in the forward part of the vessel and an exposed cargo deck in the after part for handling of cargo at sea.

Anchor **H**andling (**AH**) Service – An **Offshore Support Vessel** that is also designed and built for anchor handling operations

Well **S**timulation (**WS**) Service – An **Offshore Support Vessel** that is also designed and built for well stimulation

43. SYMBOL: **HSC**

DESCRIPTION

High **S**peed **C**raft (**HSC**) – This notation is assigned to craft that have been built in accordance with the *Building and Classing High-Speed Craft*, or equivalent. Where approved for unrestricted ocean service, such craft will be distinguished in the *Record* by the symbols ✠ **S1 HSC** ✠ **SMS** indicating compliance with the hull and machinery requirements of the Guide.
Mono-hull Length of Craft (L) < 130 m
Multi-hull L < 100 m
Surface Effects Ship (SES) L < 90 m
Hydro Foil L < 60 m

44. SYMBOL: **HSC Crewboat**

DESCRIPTION

The notation **HSC Crewboat** is assigned to a craft that is designed and constructed and specifically fitted for the transferring/transporting of industrial personnel in the offshore oil and gas industry between a shore base and offshore installations and vice versa. These craft may also carry cargo.

45. SYMBOL: **Accommodation Barge; Hotel Barge**

DESCRIPTION

Accommodation Barge – This notation is assigned to barges designed and built to the Sing-Lloyd *Preliminary Rules for Accommodation Barges and Hotel Barges*.
Hotel Barge – This notation is assigned to barges designed and built to the Sing-Lloyd *Preliminary Rules for Accommodation Barges and Hotel Barges*.

46. SYMBOL: **Floating Production, Storage and Offloading System (FPSO)**

DESCRIPTION

This notation is assigned to cover the hull structure of ship type displacement hull designed, (and other hull configurations), equipment, and the marine machinery, position mooring system, and production facility. This notation covers the following components:

i) Vessel, including hull structure, equipment, and marine machinery under one of the above notations

ii) Position Mooring

iii) Production Facilities

47. SYMBOL: **Floating Storage and Offloading System (FSO)**

DESCRIPTION

This notation is assigned to cover the hull structure of ship type displacement hull designed, (and other hull configurations), equipment, and the marine machinery, position mooring system, and production facility. This notation covers the following components:
i) Vessel, including hull structure, equipment, and marine machinery under one of the above notations
ii) Position Mooring System
iii) Production Facilities

48. SYMBOL: Ⓔ

DESCRIPTION

Circle E, Ⓔ, is a classification symbol that signifies that the equipment number (EN) of anchors and chain cables of the vessel are calculated and approved for classification purposes.

PART E

CLASS NON-CONVENTIONS RULES AND REGULATIONS

RULES & GUIDANCE FOR NON-CONVENTION SHIPS

CHAPTERI GENERAL PROVISIONS

Regulation 1 – Application

1. Unless otherwise expressly provided, these Regulations shall apply to the following cargo ships:

   a. Cargo ships of gross tonnage less than 500 propelled by mechanical means engaged on international voyages;

   b. Barges of any tonnage engaged on international voyages; and

   c. Tankers of any tonnage engaged on 30-mile limit voyages or plying within the port subject to the national law of the countries where the ship is trading.

2. These Regulations shall not apply to:

   a. Ships of war and troop ships;

   b. Wooden ships of primitive build such as dhows, junks, etc;

   c. Pleasure yachts not engaged in trade;

   d. Fishing vessels; and

   e. Government vessels not used for commercial services.

Regulation 2 – Definitions

In these Regulations, the following terms as used as follows:

"*Barge*" means a cargo ship of any tonnage not propelled by mechanical means;

"*Breadth (B)*" means the maximum breadth of the ship, measured amidships to the moulded line of the frame in a ship with a metal shell and to the outer surface of the hull in a ship with a shell of any other material;

"*Control Station*" means the spaces in which the ship's radio or main navigation equipment or the emergency source of power is located, or where the fire recording or fire control equipment is centralised;

"*Depth (D)*" means the vertical distance measured amidships from the keel line to the top of the freeboard deck beam at side except that:

   a. In vessels having rounded gunwales, the depth shall be measured to the point of inter-section of the moulded lines of the deck and side shell plating, the lines extending as though the gunwale were of angular design;

   b. Where the freeboard deck is stepped and the raised part of the deck extends over the point at which the depth is to be determined, the depth shall be measured to a line of reference extending from the lower part of the deck along a line parallel with the raised part;

"*Existing Ship*" means a ship which is not a new construction;

"*Fishing Vessel*" means a vessel used for catching fish, whales, seals, walrus or other living resources of the sea;

"*Fuel Oil Unit*" means the equipment used for the preparation of fuel oil for delivery to an oil-fired boiler, or equipment used for the preparation of oil for delivery to an internal combustion engine, and includes any oil pressure pumps, filters and heaters dealing with oil at a pressure greater than $0.18N/mm^2$;

"*International Voyage*" means a voyage extending beyond 20 miles from the nearest land and 30 miles from the port limit subject to the national law of the countries which the ship is trading.

"*Length (L)*" in relation to a ship means 96% of the total length on a waterline at 85% of the least depth measured from the keel line, or as the length from the foreside of the stem to the axis of the rudder stock on that waterline, if that be greater. In ships designed with rake of keel the waterline on which this length is measured shall be parallel to the designed waterline;

"*Machinery Spaces of Category A*" means those spaces (including trunks to such spaces) which contain:

a. Internal combustion type machinery used for main propulsion or for other purposes where such machinery has in the aggregate a total power output of not less than 375 kilowatts; or

b. Any oil-fired boiler or fuel oil unit;

"*Machinery Spaces*" means those machinery spaces of Category A and all other spaces containing propulsion machinery, boilers, fuel oil units, steam and internal combustion engines, generators, steering gear, major electrical machinery, oil filling stations, refrigerating, stabilizing, ventilating and air conditioning machinery and similar spaces and trunks to such spaces;

"*Offshore Supply Vessel*" means a cargo ship propelled by mechanical means:

a. Whose primary use is the transport of stores, materials and equipment to offshore installations and which may also be used for the laying of anchors, towage of off-shore installations; and

b. Which is designed with accommodation and bridge erections in the forward part of the vessel and an exposed cargo deck in the after part for the handling of cargo at sea;

"*Service Barge*" means a barge especially designed (or suitably converted), fitted out or equipped to operate wholly or generally as a dredger, hopper dredger, sand carrier, hopper barge, reclamation craft or crane barge;

"*Tanker*" means a cargo ship constructed or adapted for the carriage in bulk of liquid cargoes of a flammable nature;
"*30-mile limit voyage*" means a voyage which does not extend beyond 20 miles from the nearest land and 30 miles from the port limit.

Regulation 3 – Exemptions

A cargo ship to which these Regulations apply, which is not normally engaged on international voyages but which, in exceptional circumstances, is required to undertake a single international voyage will need to seek the relevant exemptions from the Administration. In such circumstances, the relevant exemption certificates must be applied from the Administration.

Regulation 4 – Standard

The construction, installation, structural strength, fittings, materials, appliances and apparatus, unless expressly provided by these Regulations, shall be of a standard acceptable to Sing-Lloyd.

Regulation 5 – Alterations and Modifications

Alterations and modifications of a major character and outfitting related thereto shall meet the requirements prescribed for a new ship, or to such extent as deemed acceptable by Sing-Lloyd.

Regulation 6 – Surveys

1. Every cargo ship shall be subjected to the surveys specified below:

   a. An initial survey before the ship is put into service or before the certificate required under regulation 8 is issued for the first time, which shall include a complete survey of its:

      i. Structure, stability, machinery, arrangements and materials, including outside the ship's hull, and inside and outside of the boiler and equipment. This survey shall be such as to ensure the arrangements, materials and scantlings of the structure, boiler and other pressure vessels and their appurtenances, main and auxiliary machinery, electrical installations, compasses and other equipment fully comply with these Regulations;

      ii. Life-saving appliances, fire-detection and extinguishing systems and the lights and means of making sound signals and distress signals, required by these Regulations and the International Regulations for the Prevention of Collisions at Sea. Where pilot ladders are carried, these shall also be surveyed to ensure that they are in a safe working condition and comply with the relevant requirements of these Regulations; and

      iii. Radio installations, portable radio apparatus for survival craft and emergency position indicating radio beacon (EPIRB).

   b. Annual surveys, unless otherwise specified by Sing-Lloyd; and

   c. Intermediate surveys in the case of the structure or machinery and equipment of the ship at intervals specified by Sing-Lloyd. The survey shall be such as to ensure that alterations, which would adversely affect the safety of the ship or the crew, have not been made.

2. After any survey of the ship under this regulation has been completed, no significant change shall be made to the structure, equipment, fittings, arrangements or material covered by the survey without first informing Sing-Lloyd, except the direct replacement of such equipment or fittings.

Regulation 7 – Issue of Certificates

1. A Cargo Ship Safety Construction Certificate shall be issued to a cargo ship which complies with the relevant requirements of Chapters II-1, II-2 and IV.

2. A Cargo Ship Safety Equipment Certificate shall be issued to a cargo ship which complies with the relevant requirements of Chapters II-2, III, IV and the International Regulations for the Prevention of Collisions at Sea.

3. A Cargo Ship Safety Radio Certificate shall be issued to a cargo ship fitted with the radiotelephone installation which complies with the requirements of Part B of Chapter IV.

Regulation 8 – Availability of Certificate

All certificates or certified copies thereof issued under these Regulations shall be available onboard the ship.

Regulation 9 – Validity of Certificates

1. a. A Cargo Ship Safety Construction Certificate shall be valid for a period of not more than 5 years from the date of issue.

   b. A Cargo Ship Safety Equipment Certificate shall be valid for a period of not more than 5 years from the date of issue.

   c. A Cargo Ship Safety Radio Certificate shall be valid for a period of not more than 5 years from the date of issue.

2. If extension of certificate is required, such extension shall be granted only for the purpose of allowing the ship to complete its voyage to a port in which it is to be surveyed.

3. No certificate shall be thus extended for a longer period than 3 months, and a ship to which such extension is granted shall not, on its arrival to the port in which it is to be surveyed, be entitled by virtue of such extension to leave that port without having obtained a new certificate.

4. A certificate shall cease to be valid if:

   a. Major alterations have taken place in the construction, equipment, fittings, arrangements, or material required without the knowledge of Sing-Lloyd,

   b. Periodical or intermediate surveys are not carried out within the periods specified under regulation 6; or

   c. Unless it has been extended in accordance with paragraph (2).

CHAPTER II-1 CONSTRUCTION, EQUIPMENT, STABILITY, MACHINERY AND ELECTRICAL INSTALLATION AND PERIODICALLY UNATTENDED MACHINERY SPACES

PART A - GENERAL

Regulation 1 – Definitions

For the purposes of this Chapter:

"*Superstructure*" means the decked structure on the freeboard deck extending from side to side of the ship or with the side plating not being inboard of the shell plating more than 0.04B;

"*Watertight*" means capable of preventing the passage of water through the structure in any direction under a head of water for which the surrounding structure is designed;

"*Weathertight*" means that in any sea condition water will not penetrate into the vessel.

PART B – CONSTRUCTION AND EQUIPMENT

Regulation 2 – Application

This Part shall apply to all ships except regulations 3(2) to (5) and 6 which apply only to new constructions.

Regulation 3 – Construction

1. The strength and construction of hull, superstructures, deckhouses, machinery casings, companion ways and any other structure and equipment shall be sufficient to withstand all foreseeable conditions of the intended service.

2. All ships propelled by mechanical means shall be fitted with a collision bulkhead and with watertight bulkheads bounding the machinery spaces. Such bulkheads shall be extended up to the freeboard deck. In ships constructed of wood such bulkheads shall as far as practicable be watertight.

3. Pipes piercing the collision bulkhead shall be fitted with suitable valves operable from above the freeboard deck and the valve chest shall be secured at the collision bulkhead inside the forepeak. No door, manhole, ventilation duct or any other opening shall be fitted in the collision bulkhead below the freeboard deck.

4. Where a long forward superstructure is fitted, the collision bulkhead shall be extended weathertight to the deck above the freeboard deck. The extension need not be fitted directly over the bulkhead below provided it is located within the limits approved by Sing-Lloyd for such bulkhead and the part of the deck which forms the step is effectively weathertight.

5. The number of openings in the collision bulkhead above the freeboard deck shall be reduced to the minimum compatible with the design and normal operation of the ship. Such openings shall be capable of being closed weathertight.

6. No doors, manholes or access openings shall be provided in the collision bulkhead below the freeboard deck.

Regulation 4 – Chain Locker

1. In every ship, where the chain locker is located abaft the collision bulkhead or extends into the forepeak tank, it shall be watertight and provided with efficient means of drainage.

2. A chain locker shall not be used for any purpose other than stowage of anchor chain cables.

Regulation 5 – Protection of Wood

In every ship the hull of which is constructed of wood, metal trays shall be fitted under the auxiliary engines, main engines and fuel tanks to allow any spillage to drain to a safe place.

Regulation 6 – Watertight Doors

1. The number of openings in watertight bulkheads, as required by regulation 3(2) shall be reduced to the minimum compatible with the general arrangements and operational needs of the ship. Openings shall be fitted with watertight closing appliances to the satisfaction of Sing-Lloyd. Watertight doors shall be of an equivalent strength to the adjacent unpierced structure.

2. In a ship of less than 45m in length, such doors may be of the hinged type, which shall be capable of being operated locally from either side of the door and shall normally be kept closed while at sea. A notice shall be attached to the door on each side to state that the door shall be kept closed while at sea.

3. In a ship of length 45m and over, watertight doors shall be of the sliding type in:

a. Spaces where they are opened while the ship is at sea and where their sills are located below the deepest operating waterline, unless Sing-Lloyd considers it to be impracticable or unnecessary, taking into account the type and operation of the ship; and

b. The lower part of a machinery space where there is access to a shaft tunnel.

4. Sliding watertight doors shall be capable of being operated when the ship is listed up to 15 degrees either side.

5. Sliding watertight doors whether manually operated or otherwise shall be capable of being operated locally from either side of the door. In a ship of length 45m and over, these doors shall also be capable of being operated by remote control from an accessible position above the freeboard deck except when the doors are fitted in crew accommodation spaces.

6. Means shall be provided at remote operating positions to indicate when a sliding door is open or closed.

Regulation 7 – Sounding Devices

1. Sounding devices, to the satisfaction of Sing-Lloyd, shall be fitted to:

a. Bilges of those compartments which are not readily accessible at all times during the voyage; and

b. All tanks and cofferdams.

2. Where sounding pipes are fitted, their upper ends shall be extended to a readily accessible position and, where practicable, above the freeboard deck. Their openings shall be provided with permanently attached means of closing. Sounding pipes, which are not extended above the freeboard deck, shall be fitted with automatic self-closing devices.

Regulation 8 – Anchor and Mooring Equipment

1. Anchor equipment shall be designed for quick and safe operation and shall consist of anchors, anchor chains or wire ropes, stoppers and a windlass or other arrangements for dropping and hoisting the anchor and for holding the ship at anchor in all foreseeable service conditions. Ships shall also be provided with adequate mooring equipment for safe mooring in all operating conditions.

2. Fairleads intended for use with the wire rope referred to in paragraph (1) shall be designed to minimise wear and to avoid kinking or other similar damage to the rope.

Regulation 9 – Towing and Pushing Arrangement of Tugs

1. The design of the towing gear shall be such as to minimise the overturning moment due to the lead of the towline. The towing hook shall have a positive means of quick release, which can be relied upon to function correctly under all operating conditions. As far as practicable, the release mechanism shall be controlled from the wheelhouse, the after control position (if fitted) and at the hook itself. The local control at the hook should preferably be of the direct mechanical type capable of independent control.

2. In a tug employed as an inserted pusher for barges, where the tug and barge constitute a compact unit, the tug-barge coupling system shall be capable of being controlled and powered from the tug. Disassembly shall be capable of being made without causing damage to the tug or the barge.

3. In a pusher tug not employed as inserted pusher, a pushbow shall be fitted and fastening arrangement provided to the satisfaction of Sing-Lloyd.

4. In tugs and barges referred to in paragraphs (2) and (3), adequate reinforcements shall be made in contact areas of the structures of the tug and the barge.

Regulation 10 – Safety of Service Barges

1. This regulation applies only to manned self-propelled and non-self-propelled steel hopper barges, steel dredgers, sand carriers and reclamation craft constructed with their main propulsion machinery and/or sand pumps or dredging machinery (other than grab cranes) placed within the main hull structure and engaged on international voyages.

2. The areas of deck, which are liable to be subjected to regular heavy impact loads, shall have adequate thickness to prevent damage to the deck plating.

3. Ladder wells of bucket dredgers shall be isolated by cofferdams, the extent and widths of which shall be sufficient to contain any damage to the well side bulkheads or bottom shell plating that could result from the impact of large objects brought up in the dredge buckets. In the way of the buckets, the cofferdam may be extended outboard in the form of a local watertight double bottom. Cofferdams shall have means of access.

4. In general, bulwarks should not be fitted in the way of open hoppers. Under no circumstance shall bulwarks be fitted in the way of open hoppers where the hopper weirs discharge onto the deck instead of into enclosed overflow trunks.

5. Bulwarks shall not be fitted in the way of open hatches on sand carriers.

6. If bulwarks are fitted, freeing ports shall be provided throughout their length and be of sufficient size to permit the immediate overboard discharge of any spoil that may spill out of the hopper in the event of the dredger rolling excessively.

7. In all cases where damage might be likely, all side scuttles, scuppers and discharges including their valves, controls and indicators are to be well protected. Consideration shall be given to the likelihood of impact damage to scuttles and discharges due to barges coming alongside and to scuppers becoming blocked by sand or other spoil which may spill onto the decks or other areas being drained.

8. The Sing-Lloyd may permit relaxation of the requirements of paragraph (7) where the sheltered nature and conditions of the voyage are such as to render the application of these requirements unreasonable or unnecessary.

Regulation 11 - Additional Safety Measures Against Capsizing for Off-shore Supply Vessels

1. Provisions shall be made to ensure that air pipes and ventilators are sited in protected positions in order to avoid damage by cargo during operations, and to minimise the possibility of flooding. Air pipes and ventilators on the exposed cargo and forecastle decks shall be fitted with automatic closing devices.

2. Any access to the engine room from the exposed cargo deck shall be provided with two weathertight closures. Access to spaces below the exposed cargo deck shall be from a position within or above the superstructure deck.

3. Hatches, doors and other openings, which give access to the cargo deck, shall be clearly marked to indicate that these fittings are to be kept closed except during access.

4. Vessels engaged in towing operations shall be provided with means for the quick release of the towing hawser.

PART C – STABILITY

Regulation 12 – Application

This Part shall apply to all ships propelled by mechanical means engaged on all voyages except for regulations 13 and 14 which apply only to new constructions.

Regulation 13 – Stability Criteria

The following minimum stability criteria shall be met unless Sing-Lloyd is satisfied that operating experience justifies departure therefrom:

a. The area under the righting lever curve (GZ curve) shall not be less than 0.055m-rad up to 30^0 angle of heel and not less than 0.090m-rad up to 40^0 or the angle of flooding, θ_f, if this angle is less than 40^0. Additionally, the area under the righting lever curve (GZ curve) between the angles of heel of 30^0 and 40^0 or between 30^0 and θ_f if this angle is less than 40^0 shall not be less than 0.030m-rad. θ_f is the angle of heel at which openings in the hull, superstructure or deckhouses which cannot rapidly be closed watertight commence to immerse. In applying this criterion, small openings through which progressive flooding cannot take place need not be considered as open;

b. The righting lever GZ shall be at least 200mm at an angle of heel equal to or greater than 30^0 ;

c. The maximum righting level, GZ_{max}, shall occur at an angle of heel preferably exceeding 30 degrees but not less than 25^0; and

d. The initial transverse metacentric height GM shall not be less than 150mm.

Regulation 14 – Stability criteria for off -shore supply vessels of length 24m and above but not more than 100m

The off-shore supply vessels, whose characteristics render compliance with regulation 13 impossible, shall comply with the following criteria unless the Sing-Lloyd is satisfied that operating experience justifies departure therefrom:

a. The area under the righting lever curve (GZ curve) shall not be less than 0.070m-rad up to 15^0 angle of heel when the maximum righting lever, GZ_{max}, occurs at angle of heel of 15^0, and 0.055m-rad up to 30^0 angle of heel when the maximum righting lever, GZ_{max}, occurs at angle of heel of 30^0 and above. Where the maximum righting lever, GZ_{max}, occurs at angle of heel between 15^0 and 30^0, the corresponding requisite area under the righting lever curve shall be determined by the use of the formula:

Area = 0.055 + 0.001 (30 degrees - θ_{max})

Where θ_{max} is the angle of heel at which the righting lever curve reaches its maximum;

b. The area under the righting lever curve (GZ curve) between the angle of heel of 30^0 and 40^0, or between the angle of heel of 30^0 and θ_f if this angle is less than 40^0, shall be not less than 0.03m-rad;

c. The righting lever GZ shall be at least 200mm at an angle of heel equal to or greater than 30^0;

d. The maximum righting lever, GZ_{max}, shall occur at an angle of heel not less than 15^0 ; and

e. The initial transverse metacentric height GM shall not be less than 150mm.

Regulation 15 – Inclining Test

1. Every ship shall undergo an inclining test upon its completion and the actual displacement and position of the centre of gravity shall be determined for the light ship condition.

2. Where alterations are made to a ship affecting its light ship condition and the position of the centre of gravity, the ship shall, if Sing-Lloyd considers this necessary, be re-inclined and the stability information amended.

3. Sing-Lloyd may allow the inclining test of a ship to be dispensed provided basic stability data are available from the inclining test of a sister ship, and it is shown to the satisfaction of Sing-Lloyd that reliable stability information for that ship can be obtained from such basic data.

4. Sing-Lloyd may also allow the inclining test of a cargo ship or a class of ships, especially designed for the carriage of liquids or ore in bulk, to be dispensed with when reference to existing data for similar ships clearly indicates that due to ship proportions and arrangements more than sufficient metacentric height will be available in all probable loading conditions.

Regulation 16 – Stability Information

1. Suitable stability information shall be supplied to enable the master to assess with ease and certainty the stability of the ship under various operating conditions. Such information shall include

specific instructions to the master warning him of those operating conditions which could adversely affect either the stability or the trim of the ship. A copy of the stability information shall be submitted to the Sing-Lloyd for approval.

2. The approved stability information shall be kept on board, readily accessible at all times and inspected at the periodical surveys of the ship to ensure that it has been approved.

3. Where alterations are made to a ship affecting its stability, revised stability calculations shall be prepared and submitted to Sing-Lloyd for approval. If Sing-Lloyd decides that the stability information must be revised, the new information shall be supplied to the master and the superseded information removed.

4. Every manned barge assigned with a load line shall be supplied with suitable stability information. The stability criteria used shall agree in principle with the requirements referred to in regulation 13.

PART D – PROTECTION OF THE CREW

Regulation 17 – General Protection Measures

1. Hinged covers of hatchways, manholes and other openings shall be protected against accidental closing. In particular, heavy covers on escape hatches shall be equipped with counterweights, and so constructed as to be capable of being opened from either side of the cover.

2. In every new construction, the dimensions of access hatches shall not be less than 600mm by 600mm, or 610mm by 280mm, or 604mm diameter.

3. Hand-holds shall be provided over escape openings.

4. Skylights or other similar openings shall be fitted with protective bars spaced not more than 350mm apart.

5. The surface of all decks shall be so designed or treated as to minimise the possibility of personnel slipping. In particular, decks of working areas such as in machinery spaces, galleys, at winches and at the foot and head of ladders and in front of doors, shall be provided with anti-skid surfaces.

Regulation 18 – Stairways and Ladders

Stairways and ladders of adequate size and strength with handrails and non-slip treads shall be provided.

PART E – MACHINERY AND ELECTRICAL INSTALLATIONS

Regulation 19 – Application

This Part, unless otherwise expressly provided, shall apply to all ships propelled by mechanical means engaged on all voyages.

Regulation 20 – Definitions

For the purposes of this Part:

"*Auxiliary means of activating the rudder*" means the equipment, which is provided for effecting movement of the rudder, for the purpose of steering the ship in the event of failure of the main steering gear;

"*Dead ship condition*” means the condition under which the main propulsion plant and auxiliaries are not in operation due to the absence of power;

"*Main steering gear*" means the machinery, the steering gear power units, if any, and ancillary equipment and the means of applying torque to the rudder stock (e.g. tiller or quadrant) necessary for effecting movement of the rudder for the purpose of steering the ship under normal service conditions;

"*Main switchboard*" means a switchboard directly supplied by the main source of electrical power and intended to distribute electrical energy;

"*Maximum ahead speed*" means the greatest speed which the ship is designed to maintain in service at sea at its maximum permissible operating draught;

"*Maximum astern speed*" means the speed which it is estimated the ship can attain at the designed maximum astern power at its maximum permissible operating draught;

"*Periodically unattended machinery spaces*" means those spaces containing main propulsion and associated machinery and all sources of main electrical supply which are not at all times manned under all operating conditions, including manoeuvring;

"*Steering gear power unit*" means:

a. In the case of electric steering gear, an electric motor and its associated electrical equipment;

b. In the case of electro-hydraulic steering gear, an electric motor and its associated electrical equipment and connected pump;

c. In the case of other hydraulic steering gear, a driving engine and connected pump.

Regulation 21 – General

1. Main propulsion, control, steam pipe, fuel oil, compressed air and electrical systems; auxiliary machinery; boilers and other pressure vessels, piping and pumping arrangements; steering equipment and gears, shafts and couplings for power transmission shall be designed, constructed, tested, installed and serviced to the satisfaction of the Sing-Lloyd and shall be protected so as to reduce to a minimum danger to persons on board. Special attention shall be paid to moving parts, hot surfaces and other dangers.

2. Machinery spaces shall be so designed as to provide safe and free access to all machinery and its controls and to any other part which may require servicing. Such spaces shall be adequately ventilated.

3. a. Means shall be provided whereby the operational capability of the propulsion machinery can be sustained or restored even though one of the essential auxiliaries becomes inoperative. Special consideration shall be given to the functioning of the:

i. Arrangements which supply fuel oil pressure for main propulsion machinery;

ii. Normal sources of lubricating oil pressure;

iii. Hydraulic, pneumatic and electrical means far the control of main propulsion machinery, including controllable pitch propellers;

iv. Sources of water pressure for main propulsion cooling systems; and

v. Air compressor and an air receiver for starting or control purposes;

Provided that Sing-Lloyd may, having regard to overall safety considerations, accept a partial reduction in capability in lieu of full normal operation.

b. Means shall be provided whereby the machinery can be brought into operation from the dead ship condition without external aid.

4. Special consideration shall be given to the design, construction and installation of propulsion machinery systems so that any mode of their vibrations shall not cause undue stresses in such machinery systems in the normal operating ranges.

5. The design and construction of electrical installations shall be such as to provide:

a. Services necessary to maintain the ship in normal operational condition without having recourse to an emergency source of power;

b. Services essential to safety when failure of the main source of electrical power occurs; and

c. Protection of the crew and ship from electrical hazards.

6. In ships fitted with periodically unattended machinery spaces, documentary evidence of their fitness to operate in such mode shall be submitted to Sing-Lloyd.

Regulation 22 – Machinery

1. Main and auxiliary machinery essential for the propulsion and safety of the ship shall be provided with effective means of control.

2. Where main or auxiliary machinery including pressure vessels or any part of such machinery are subject to internal pressure and may be subject to dangerous overpressure, means shall be provided, where applicable, which will protect against such excessive pressure.

3. All gearing, shaft and coupling used for transmission of power to machinery essential for the propulsion and safety of the vessel or the safety of persons on board shall be so designed and constructed that it will withstand the maximum working stresses to which it may be subjected in all service conditions. Due consideration shall be given to the type of engines by which it is driven or of which it forms a part.

4. Main propulsion machinery and where applicable, auxiliary machinery shall be provided with automatic alarm arrangements in the case of failures, such as lubricating oil supply failure, which could lead rapidly to damage, complete breakdown or explosion.

Regulation 23 – Means of Going Astern

Ships shall have sufficient power for going astern to secure proper control of the ship in all circumstances.

Regulation 24 - Communications between the Wheelhouse and Machinery Space

1. Two separate means of communication between the wheelhouse and the machinery space shall be provided. One of the means shall be an engine room telegraph.

2. In ships fitted with two main propulsion machinery each driving its own propeller, each machinery shall have an engine room telegraph.

3. The engine room telegraph may be dispensed with if the main propulsion machinery is directly controlled from the wheelhouse.

Regulation 25 – Wheelhouse Control of Propulsion Machinery

1. This regulation applies only to new constructions, except for paragraph (2)(e) which also applies to existing ships.

2. Where remote control of propulsion machinery is provided from the wheelhouse, the following shall apply:

   a. Under all operating conditions, including manoeuvring, the speed, direction of thrust and, if applicable, the pitch of the propeller shall be fully controllable from the wheelhouse;

   b. Main propulsion machinery shall be provided with an emergency stopping device in the wheelhouse and be independent from the wheelhouse control system referred to in sub-paragraph (a);

   c. Control of the propulsion machinery shall be possible only from one station at a time;

   d. Indicators shall be fitted in the wheelhouse for:

      i. Propeller speed and direction in the case of fixed propellers; and

      ii. Propeller speed and pitch position in the case of controllable pitch propellers;

   e. It shall be possible to control the propulsion machinery locally, even in the case of failure in any part of the remote control system;

   f. Unless Sing-Lloyd considers it impracticable, the design of the remote control system shall be such that if it fails, an alarm will be given until local control is in operation; and

   g. An alarm shall be provided to indicate low starting air pressure and shall be set at a level which will still permit main engine starting operations.

3. Where the main propulsion and associated machinery including sources of main electrical supply are provided with various degrees of automatic or remote control and are under continuous manned supervision from a control room, the control room shall be so designed, equipped and installed that the machinery operation will be as safe and effective as if it were under direct supervision.

4. In general, automatic starting, operational and control systems shall include means for manually overriding the automatic means, even in the case of failure of any part of the automatic and remote control system.

Regulation 26 – Boilers and Other Pressure Vessels

1. The boilers and other pressure vessels shall be of a design and construction adequate for the service for which they are intended and shall be installed and protected so as to reduce to a minimum any danger to persons on board.

2. The boilers and the other pressure vessels and their respective mountings shall, before being put into service for the first time, be subjected to a pressure test to the satisfaction of the Sing-Lloyd.

Regulation 27 – Steam Boilers, Feed Systems and Steam Piping Arrangements

1. Every steam boiler and unfired steam generator shall be provided with at least two safety valves of adequate capacity provided that the Sing-Lloyd may, having regard to the output or any other features of any steam boiler or unfired steam generator, permit only one safety valve to be fitted if satisfied that it is adequately protected against overpressure.

2. Every oil-fired steam boiler, which is intended to operate without manual supervision, shall have safety arrangements which will shut off the fuel supply and give an alarm in the case of low water level, air supply failure or flame failure.

3. Sing-Lloyd shall give special consideration to steam boiler installations to ensure that feed systems, monitoring devices, and safety provisions are adequate in all respects to ensure the safety of boilers, steam pressure vessels and steam piping arrangements.

Regulation 28 – Compressed Air Systems

1. Means shall be provided to prevent excess pressure in any part of a compressed air system and wherever water-jackets or casings of air compressors and coolers might be subjected to dangerous excessive pressure due to leakage into them from air pressure parts. Suitable pressure-relief arrangements shall be provided.

2. The main starting air arrangements for main propulsion internal combustion engines shall be adequately protected against the effects of backfiring and internal explosion in the starting air pipes.
3. All discharge pipes from starting air compressors shall lead directly to the starting air receivers and all starting pipes from the air receivers to main or auxiliary engines shall be entirely separated from the compressor discharge pipe system.

4. Provision shall be made to reduce to a minimum the entry of oil into the air pressure systems and to drain these systems.

Regulation 29 - Arrangements for Fuel Oil, Lubricating Oil and Other Flammable Oils

1. Fuel oil, which has a flashpoint of less than 60^0C (closed cup test) as determined by an approved flashpoint apparatus, shall not be used as fuel, except in emergency generators, in which case the flashpoint shall not, be less than 43^0C; provided that Sing-Lloyd may permit the general use of fuel oil having a flashpoint of not less than 43^0C subject to such additional precautions as it may consider necessary and on condition that the temperature of the space in which such fuel is stored or used shall not rise to within $l0^0$C below the flashpoint of the fuel.

2. Safe and efficient means of ascertaining the amount of fuel oil contained in any oil tank shall be provided. If sounding pipes are installed, their upper ends shall terminate in safe positions and shall be fitted with suitable means of closure. Tubular gauge glasses shall not be fitted, but suitably protected gauges having flat glasses of substantial thickness and self-closing fittings may be used. Suitably protected tubular gauge glasses may be permitted on fuel tanks independent of the hull structure provided that they are fitted with self-closing valves to the satisfaction of Sing-Lloyd. Other means of ascertaining the amount of fuel oil contained in any fuel oil tank may be permitted provided that their failure or over-filling of the tanks will not permit release of fuel.

3. Provision shall be made to prevent overpressure in any oil tank or in any part of the fuel oil system including the filling pipes. Relief valves and air or overflow pipes shall discharge to a position and in a manner which is safe.

4. Subject to the satisfaction of Sing-Lloyd, fuel oil pipes which, if damaged, would allow oil to escape from a storage, settling or daily service tank situated above the double bottom, shall be fitted with a cock or valve on the tank capable of being closed from a safe position outside the space concerned in the event of a fire arising in the space in which such tanks are situated. In the special case of deep tanks situated in any shaft or pipe tunnel or similar space, valves on the tanks shall be fitted but control in the event of fire may be effected by means of an additional valve on the pipe or pipes outside the tunnel or similar space. If such an additional valve is fitted in the machinery space it shall be capable of being operated from outside this space.

5. Pumps forming part of the fuel oil systems shall be separate from any other system and the connections of any such pumps shall be provided with an efficient relief valve which shall be in closed circuit. Where fuel oil tanks are alternatively used as liquid ballast tanks, proper means shall be provided to isolate the fuel oil and ballast systems.

6. No oil tank shall be situated where spillage or leakage therefrom can constitute a hazard by falling on heated surfaces. Precautions shall be taken to prevent any oil that may escape under pressure from any pump, filter or heater from coming into contact with heated surfaces.

7. a. Fuel oil pipes and their valves and fittings shall be of steel or other equivalent material, provided that restricted use of flexible pipes may be permitted in positions where Sing-Lloyd is satisfied that they are necessary. Such flexible pipes and end attachments shall be of adequate strength and be constructed of approved fire-resistant materials or have fire resistant coatings.

b. Where necessary, fuel oil and lubricating ail pipelines shall be screened or otherwise suitably protected to avoid, as far as practicable, oil spray or oil leakage on heated surfaces or into machinery air intakes. The number of joints in piping systems shall be kept to a minimum.

8. As far as practicable, fuel oil tanks shall be part of the ship's structure and shall be located outside machinery spaces of Category A. Where fuel oil tanks, other than double bottom tanks, are necessarily located adjacent to or within machinery spaces of Category A, at least one of their vertical sides shall be contiguous to the machinery space boundaries, and shall preferably have a common boundary with the double bottom tanks where fitted, and the area of the tank boundary common with the machinery space shall be kept to a minimum. When such tanks are sited within the boundaries of machinery spaces of Category A, they shall not contain fuel ail having a flashpoint of less than 60^{0}C (closed cup test). In general, the use of free-standing fuel oil tanks shall be avoided in fire hazard areas, and particularly in machinery spaces of Category A. When free-standing fuel oil tanks are permitted, they shall be placed in an oil-tight spill tray of ample size having a suitable drain pipe leading to a suitably sized spill oil tank.

9. The ventilation of machinery spaces shall be sufficient under all normal conditions to prevent accumulation of oil vapour.

10. The arrangements for the storage, distribution and use of oil employed in pressure lubrication systems shall be to the satisfaction of Sing-Lloyd. Such arrangements in machinery spaces of Category A and wherever practicable, in other machinery spaces shall at least comply with the provisions of paragraphs (1), (3), (6) and (7) and in so far as the Sing-Lloyd may consider necessary with paragraphs (2) and (4). This does not preclude the use of sight flow glasses in lubrication systems provided they are shown by test to have a suitable degree of fire resistance.

11. The arrangements for the storage, distribution and use of flammable oils employed under pressure in power transmission systems other than oils referred to in paragraph (10) in control and activating systems and heating systems shall be to the satisfaction of Sing-Lloyd. In locations where means of ignition are present, such arrangements shall at least comply with the provisions of paragraphs (2) and (6) and with paragraphs (3) and (7) in respect of strength and construction.

Regulation 30 – Bilge Pumping Arrangements

1. This regulation applies to all ships, except for paragraph (3)(b) which applies only to new constructions.

2. An efficient bilge pumping plant shall be provided which under all operating conditions shall be capable of pumping from and draining any watertight compartment which is neither a permanent oil tank nor a permanent water tank whether the ship is upright or listed. Wing suctions shall be provided if necessary for that purpose. Arrangements shall be provided for easy flow of water to the suction pipes. Provided that if Sing-Lloyd is satisfied that the safety of the ship is not impaired, the bilge pumping arrangements may be dispensed with in particular compartments.

3. a. At least two independently driven power bilge pumps shall be provided, one of which may be driven by the main engine. A ballast pump or other general service pump of sufficient capacity may be used as a power driven bilge pump.

b. Power bilge pumps shall be capable of giving a speed of water of at least 2m/sec through the main bilge pipe which shall have an internal diameter of at least:

$$d = 25 + 1.68\,[L(B+D)]^{0.5}$$

Where d is the internal diameter in millimetres, and L, B and D are in metres.

c. Each of the bilge pumps provided in accordance with this regulation shall be provided with a direct bilge suction, one of these suctions drawing from the port side of the machinery space and the other from the starboard side, except that in the case of a ship of less than 75m in length, only one bilge pump need be provided with a direct bilge suction.

d. The arrangement and sizing of the bilge system shall be such that the full rated capacity of the pump specified above can be applied to each of the watertight compartments located between the collision and afterpeak bulkheads.

4. A bilge ejector in combination with an independently driven high pressure sea-water pump may be installed as a substitute for one independently driven bilge pump required by paragraph (3)(a), provided this arrangement is to the satisfaction of Sing-Lloyd.

5. Bilge pipes shall not be led through fuel oil, ballast or double bottom tanks, unless these pipes are of heavy gauge steel construction.

6. Bilge and ballast pumping systems shall be arranged so as to prevent water passing from the sea or from water ballast spaces into holds or into machinery spaces or from one watertight compartment to another. The bilge connection to any pump, which draws from the sea or from water ballast spaces, shall be fitted with either a non-return valve or a cock which cannot be opened simultaneously either to the bilges and to the sea or to the bilges and water ballast spaces. Valves in bilge distribution boxes shall be of a non-return type.

7. Any bilge pipe piercing a collision bulkhead shall be fitted with a positive means of closing at the bulkhead with remote control from the freeboard deck with an indicator showing the position of the valve provided that, if the valve is fitted on the after side of the bulkhead and is readily accessible under all service conditions, the remote control may be dispensed with.

Regulation 31 – Steering Gear

1. Ships shall be provided with a main steering gear and an auxiliary means of actuating the rudder to the satisfaction of Sing-Lloyd. The main steering gear and the auxiliary means of actuating the rudder shall be arranged so that, as far as is reasonable and practicable, the failure in one of them will not render the other one inoperative.

2. Where the main steering gear comprises two or more identical power units, an auxiliary steering gear need not be fitted if one of the power units is capable of operating the rudder as required by paragraph (7) when the other unit is out of operation.

3. The position of the rudder, if power operated, shall be indicated in the wheelhouse. The rudder angle indicator for power-operated steering gear shall be independent of the steering gear control system.

4. In the event of failure of any of the steering gear units, an alarm shall be given in the wheelhouse.

5. The main steering gear shall be of adequate strength and sufficient to steer the ship at maximum ahead speed. The main steering gear and rudder stock shall be so designed that they will not be damaged at maximum astern speed or by other manoeuvring operations.

6. The main steering gear power unit shall be arranged to start either by manual or automatic means when power is restored after a power failure.

7. The auxiliary means for actuating the rudder shall be of adequate strength and sufficient to steer the ship at a navigable speed and capable of being brought speedily into action in an emergency.

8. Electric or electro-hydraulic steering gear fitted in ships of length 75m and over shall be served by at least two circuits fed from the main switchboard and these circuits shall be as widely separated as possible.

Regulation 32 – Emergency Source of Electrical Power

1. A self-contained emergency source of electrical power located outside the machinery spaces of Category A shall be provided and so arranged as to ensure its functioning in the event of fire or other causes of failure of the main electrical installations.

2. The emergency source of electrical power shall be capable, having regard to the starting current and the transitory nature of certain loads, of serving the following simultaneously for a period of at least 3 hours:

a. Internal communication equipment, fire detecting systems and signals which may be required in an emergency;

b. Navigation lights if solely electrical;

c. The emergency lights:

i. Of launching stations;

ii. In all alleyways, stairways and exits;

iii. In spaces containing machinery or the emergency source of power; and

iv. In control stations; and

d. The operation of the emergency fire pump, if any.

3. The emergency source of power may be either:

a. An accumulator (storage) battery capable of carrying the emergency load without recharging or excessive voltage drop; or

b. A generator driven by a suitable prime mover with an independent fuel supply and with starting arrangements to the satisfaction of Sing-Lloyd. The fuel used shall have a flashpoint of not less than 43^0C.

4. An accumulator battery fitted in accordance with this regulation shall be installed in a well-ventilated space which shall not be the same space containing the emergency switchboard.

5. The emergency generator and its prime mover and any accumulator battery shall be so arranged as to ensure that they will function at full rated power when the ship is upright and when rolling up to an angle of 22.5^0 either side and simultaneously pitching 10^0 by bow or stern.

6. The emergency source of electrical power and starting equipment shall be so constructed and arranged as to enable adequate testing to be carried out by the crew while the ship is in operating condition.

Regulation 33 – Precautions against Shock, Fire and Other Hazards of Electrical Origin

1. a. Exposed permanently fixed metal parts of electrical machines or equipment which are not intended to be "live", but which are liable under fault conditions to become "live" shall be earthed (grounded) unless:

i. They are supplied at a voltage not exceeding 55V direct current or 55V, root mean square, between conductors; autotransformers shall not be used for the purpose of achieving this alternative current voltage;

ii. They are supplied at a voltage not exceeding 250V by safety isolating transformers supplying one consuming device only; or

iii. They are constructed in accordance with the principle of double insulation.

b. Portable electrical equipment shall operate at a safe voltage. Sing-Lloyd may require additional precautions for portable electric lamps, tools or similar apparatus for use in confined or exceptionally damp spaces where particular risks due to conductivity may exist.

2. Main and emergency switchboards shall be so arranged as to give easy access as may be needed to apparatus and equipment, without danger to attendants. The sides and backs and, where necessary, the fronts of switchboards, shall be suitably guarded. Exposed "live" parts having voltages to earth exceeding a voltage to be specified by Sing-Lloyd shall not be installed on the front of such switchboards. There shall be non-conducting mats or gratings at the front and rear, where necessary.

3. a. Where a hull return system of distribution is used, special precautions shall be taken to the satisfaction of the Sing-Lloyd.

b. A hull return system shall not be used in tankers.

4. a. Except as permitted by Sing-Lloyd in exceptional circumstances, all metal sheaths and armour of cables shall be electrically continuous and shall be earthed.

b. Where cables, which are installed in spaces where the risk of fire or explosion exists in the event of an electrical fault, special precautions against such risks shall be taken to the satisfaction of the Sing-Lloyd.

c. Wiring shall be supported in such a manner as to avoid chafing or other damage.

d. Terminations and joints in all conductors shall be made such that they retain the original electrical, mechanical, flame-retarding and, where necessary, fire-resisting properties of the cable.

5. a. Circuits shall be protected against short circuit.

b. The rating or appropriate setting of the overload protective device of each circuit shall be permanently indicated at the location of the protective device.

6. Lighting fittings shall be arranged to prevent temperature rises which could damage the wiring and to prevent surrounding material from becoming excessively hot.

7. Lighting or power circuits terminating in a space where the risk of fire or explosion exists shall be provided with isolating switches outside the space.

8. a. The housing of an accumulator battery shall be constructed and ventilated to the satisfaction of Sing-Lloyd.

b. Electrical and other equipment, which may constitute a source of ignition of flammable vapours, shall not be permitted in the housing except as permitted under paragraph (9).

c. An accumulator battery shall not be located in accommodation spaces unless installed in a hermetically sealed container.

9. In spaces, where flammable mixtures are liable to collect and in any compartment assigned principally to the containment of an accumulator battery, no electrical equipment shall be installed unless Sing-Lloyd is satisfied that it is:

a. Essential for operational purposes;

b. A type which will not ignite the mixture concerned;

c. Appropriate to the space concerned; and

d. Appropriately certified for safe usage in the dusts, vapours or gases likely to be encountered.

10. Lightning conductors shall be fitted to all wooden masts or topmasts. In ships constructed of non-conductive materials, the lightning conductors shall be connected by suitable conductors to a copper plate fixed to the vessel's hull well below the waterline.

PART F – PERIODICALLY UNATTENDED MACHINERY SPACES

Regulation 34 – Application

This Part shall apply to all cargo ships propelled by mechanical means engaged an all voyages.

Regulation 35 – Fire Safety

1. Special consideration shall be given to high pressure fuel oil pipes. Where practicable, leakages from such piping systems shall be collected in a suitable drain tank, which shall be provided with a high level alarm.

2. Where daily service fuel oil tanks are filled automatically or by remote control, means shall be provided to prevent overflow spillages. Similar consideration shall be given to other equipment which treats flammable liquids automatically, e.g. fuel oil purifiers, which whenever practicable, shall be installed in a special space reserved for purifiers and their heaters.

3. Where fuel oil daily service tanks or settling tanks are fitted with heating arrangements, a high temperature alarm shall be provided if the flashpoint of the fuel oil can be exceeded.

4. An approved fire detection system based on a self-monitoring principle and including facilities for periodical testing shall be installed in machinery spaces. In ships of less than 45m in length, the Sing-Lloyd may waive this requirement provided the location of the machinery space facilitates the detection of fire by persons on board.

5. The detection system shall initiate both audible and visual alarm in the wheelhouse, and in sufficient appropriate spaces to be heard and observed by persons on board, when the vessel is in harbour.

6. The fire detection system shall be fed automatically from an emergency source of power if the main source of power fails.

7. Internal combustion engines of 2,200kW and over shall be provided with crankcase oil mist detectors or engine bearing temperature detectors or equivalent devices.

8. The maintenance of the fire integrity of the machinery spaces, the location and centralization of the fire-extinguishing system controls, the shut-down arrangements provided for ventilation, fuel pumps, etc. shall be to the satisfaction of Sing-Lloyd who may require fire-extinguishing appliances and other fire-fighting equipment and breathing apparatus in addition to the relevant requirements of Chapter II-2.

Regulation 36 – Protection against Flooding

1. Bilges in machinery spaces shall be provided with a high level alarm in such a way that the accumulation of liquids is detected at normal angles of trim and heel. The detection system shall initiate an audible and visual alarm in the places where a continuous watch is maintained.

2. In ships of 45m in length and over, the controls of any valve serving a sea inlet, a discharge below the waterline or a bilge injection system shall be so sited as to allow adequate time for operation in case of influx of water to the space.

Regulation 37 – Communications

In ships of 75 metres in length and over, one of the two separate means of communication referred to in regulation 24 shall be a reliable means of vocal communication. An additional reliable means of vocal communication shall be provided between the wheelhouse and the engineers' accommodation.

Regulation 38 – Alarm System

1. An alarm system shall be provided which shall indicate any fault requiring attention.

2. a. The alarm system shall be capable of sounding in the machinery space an audible alarm and indicate visually each separate alarm function at a suitable position. However, in ships of less than 45m in length, Sing-Lloyd may permit the system to be capable of sounding and indicating visually each separate alarm function in the wheelhouse only.

   b. In ships of 45m in length and over, the alarm system shall have a connection to the engineers' cabins through a selector switch to ensure connection to one of these cabins and to the engineers' public rooms, if any. Sing-Lloyd may permit alternative arrangements which provide an equivalent measure of safety.

   c. Audible and visual alarms shall be activated in the wheelhouse for any situation requiring action by the responsible person on watch or which should be brought to his attention.

   d. The alarm system shall, as far as is practicable, be designed on the fail-safe principle.

3. The alarm system shall be:

   a. Continuously powered with automatic change-over to a stand-by power supply in case of loss of normal power supply; and

   b. Activated by failure of the normal power supply.

4. a. The alarm system shall be able to indicate at the same time more than one fault, and the acceptance of any alarm shall not inhibit another alarm.

b. Acceptance at the position referred to in paragraph (2)(a) of any alarm condition shall be indicated at the positions where it was shown. Alarms shall be maintained until they are accepted and the visual indications shall remain until the fault has been corrected, when the alarm system shall automatically reset to the normal operating condition.

Regulation 39 - Special Requirements for Machinery, Boiler and Electrical Installations

1. If the electrical power is normally supplied by more than one generating set simultaneously, there shall be provisions, e.g. by load shedding, to ensure that in case of loss of one of these generating sets, the remaining ones are kept in operation without overload to permit propulsion and steering.

2. Where required to be duplicated, other auxiliary machinery essential to propulsion shall be fitted with automatic change-over devices allowing transfer to a stand-by machinery. An alarm shall be given on automatic change-over.

3. Automatic control and alarm systems shall be provided as follows:

a. The control system shall be such that through the necessary automatic arrangements the services needed for the operation of the main propulsion machinery and its auxiliaries are ensured;

b. Means shall be provided to keep the starting air pressure at the required level where internal combustion engines are used for main propulsion;

c. An alarm system complying with regulation 38 shall be provided for all important pressures, temperatures, fluid levels, etc.; and

d. Where appropriate an adequate central position shall be arranged with the necessary alarm panels and instrumentation indicating any fault.

Regulation 40 – Safety System

A safety system shall be provided so that serious malfunction in machinery or boiler operations, which presents an immediate danger, shall initiate the automatic shutdown of that part of the plant, and an alarm shall be given. Shutdown of the propulsion system shall not be automatically activated except in cases which could lead to serious damage, complete breakdown or explosion. Where arrangements for overriding the shutdown of the main propelling machinery are fitted, these shall be such as to preclude inadvertent activation. Visual means shall be provided to show whether or not it has been activated.

CHAPTER II-2 FIRE PROTECTION, FIRE DETECTION, FIRE EXTINCTION AND FIRE FIGHTING

PART A–GENERAL

Regulation I – Application

Unless otherwise expressly provided, this Chapter shall apply to every cargo ship propelled by mechanical means engaged on international voyages and tankers engaged on 30-mile limit voyages or plying within the port.

Regulation 2 – Definitions

For the purposes of this Chapter:
"*Accommodation Spaces*" means those spaces used for public spaces, corridors, lavatories, cabins, offices, hospitals, cinemas, games and hobbies rooms, pantries containing no cooking appliances and similar spaces;

"Low Flame Spread" means that the surface thus described will adequately restrict the spread of flame, this being determined to the satisfaction of the Sing-Lloyd by an established test procedure;

"*Non-combustible Material*" means a material which neither burns nor gives off flammable vapours in sufficient quantity for self-ignition when heated to approximately 750°C, this being determined to the satisfaction of the Sing-Lloyd by an established test procedure. Any other material is a combustible material;

"*Public Spaces*" means those portions of the accommodation spaces which are used for halls, dining rooms, lounges and similar permanently enclosed spaces;

"*Service Spaces*" means those spaces used for galleys, pantries containing cooking appliances, lockers and storerooms, workshops other than those forming part of the machinery spaces, and similar spaces and trunks to such spaces;

"*Standard Fire Test*" means a test in which specimens of the relevant bulkheads or decks are exposed in a test furnace to temperatures corresponding approximately to the standard time-temperature curve. The specimen shall have an exposed surface of not less than 4.65m^2 and a height (or length of deck) of 2.44m resembling as closely as possible the intended construction and including where appropriate at least one joint. The standard time-temperature curve is defined by a smooth curve drawn through the following points:

- At the end of the first 5 minutes 538^{0}C,
- At the end of the first 10 minutes 704^{0}C,
- At the end of the first 30 minutes 843^{0}C,
- At the end of the first 60 minutes 927^{0}C;

"*Steel or Other Equivalent Material*" means steel or any material which, by itself or due to insulation provided, has structural and integrity properties equivalent to steel at the end of the applicable fire exposure to the standard fire test (e.g. aluminium alloy with appropriate insulation).

PART B – FIRE SAFETY MEASURES FOR ALL SHIPS

Regulation 3 – Structural Fire Protection

1. The hull, superstructure, structural bulkheads, decks and deckhouses shall be constructed of non-combustible materials. Sing-Lloyd may permit combustible construction in ships, other than a tanker, provided the requirements of this regulation are complied with.

2. In a ship, the hull of which is constructed of combustible materials, the decks and bulkheads shall be so constructed as to be capable of preventing the spread of fire to the unexposed side to the satisfaction of Sing-Lloyd, in particular in relation to the following divisions:

   a. Decks and bulkheads separating machinery spaces from accommodation spaces, service spaces or control stations;

   b. Boundary bulkheads and decks of spaces containing any emergency source of power;

c. Bulkheads and decks between galleys, paint room or any store room which contain appreciable quantities of highly flammable materials, and accommodation spaces, service spaces or control stations;

d. Decks and bulkheads separating control stations from accommodation and service spaces; and

e. Bulkheads of corridors serving accommodation spaces, service spaces and control stations.

f. Machinery space boundaries shall as far as practicable prevent the passage of smoke.

3. Interior stairways below the weather deck shall be of steel or other equivalent material.

4. Doors and other closures of openings in bulkheads and decks referred to in paragraph (2) and doors fitted in engine and boiler casings shall be, as far as practicable, equivalent in resisting fire to the divisions in which they are fitted. Doors to machinery spaces of Category A shall be self-closing.

5. Windows and skylights to machinery spaces shall be as follows:

a. Where skylights can be opened, they shall be capable of being closed from outside the space. Skylights containing glass panels shall be fitted with external shutters of steel or other equivalent material permanently attached;

b. Glass or similar materials shall not be fitted in machinery space boundaries. This does not preclude the use of wire-reinforced glass for skylights and glass in control rooms within the machinery spaces; and

c. In skylights referred to in sub-paragraph (a), wire-reinforced glass shall be used.

6. Insulating materials in accommodation spaces, service spaces (except domestic refrigerating compartments), control stations and machinery spaces shall be non-combustible. The surface of insulation fitted on the internal boundaries of machinery spaces of Category A shall be impervious to oil or oil vapours.

7. Deck coverings within accommodation spaces on the decks forming the crown of machinery and cargo spaces shall be of a type which will not readily ignite.

8. Pipes conveying oil or combustible liquids shall be of a material approved by Sing-Lloyd having regard to the fire risk. Materials readily rendered ineffective by heat shall not be used for overboard scuppers, sanitary discharges, and other outlets which are close to the waterline and where the failure of the material in the event of fire would give rise to danger of flooding.

9. Power ventilation of machinery spaces shall be capable of being stopped from an easily accessible position outside the machinery spaces.

10. Exposed surfaces within accommodation spaces, service spaces, control stations, corridor and stairway enclosures and the concealed surfaces behind bulkheads, ceilings, panels and linings in accommodation spaces, service spaces, and control stations shall have low flame spread characteristics.

11. All exposed surfaces of glass-reinforced plastic construction within accommodation and

service spaces, control stations, machinery spaces of Category A and other machinery spaces of similar fire risk shall have the final lay-up layer of approved resin having inherent fire-retardant properties or be coated with an approved fire-retardant paint or be protected by non-combustible materials.

12. Paints, varnishes and other finishes used on exposed interior surfaces shall not be capable of producing excessive quantities of smoke or toxic gases or vapours or being an undue fire hazard.

13. Machinery driving fuel oil transfer pumps, fuel oil unit pumps and other similar fuel pumps shall be fitted with remote controls situated outside the space concerned so that they can be stopped in the event of a fire arising in the space in which they are located.

14. Drip trays shall be fitted where necessary to prevent oil leaking into bilges.

Regulation 4 – Heating Installations

1. Electric radiators shall be fixed in position and so constructed, as to reduce fire risks to a minimum. No such radiator shall be fitted with an element so exposed that clothing, curtains or other similar materials can be scorched or set on fire by heat from the element.

2. Heating by means of open fires shall not be permitted. Heating stoves and other similar appliances shall be firmly secured and adequate protection and insulation against fire shall be provided beneath and around such appliances and in way of their uptakes. Uptakes of stoves which burn solid fuel shall be so arranged and designed as to minimise the possibility of becoming blocked by combustion products and shall have a ready means for cleaning. Dampers for limiting draughts in uptakes shall, when in the closed position, still leave an adequate area open. Spaces in which stoves are installed shall be provided with ventilators of sufficient area to provide adequate combustion air for the stave. Such ventilators shall have no means of closure and their position shall be to the satisfaction of Sing-Lloyd.

3. Open flame gas appliances, except cooking stoves and water heaters, shall not be permitted. Spaces containing any such stoves or water heaters shall have adequate ventilation to remove fumes and possible gas leakage to a safe place. All pipes conveying gas from container to stave or water heater shall be of steel or other approved material. Automatic safety gas shut-off devices shall be fitted to operate on loss of pressure in the gas main pipe or flame failure on any appliance.

Regulation 5 – Means of Escape

1. Stairways and ladders leading to and from all accommodation spaces and in spaces in which the crew is normally employed, other than machinery spaces, shall be so arranged as to provide ready means for escape to the open deck and thence to the survival craft.

2. Two means of escape shall be provided from every machinery space of Category A which shall be as widely separated as possible. Vertical escapes shall be by means of steel ladders. Where the size of the machinery spaces makes it impracticable, one of these means of escape may be omitted provided that the exit is to the satisfaction of Sing-Lloyd.

Regulation 6 – Automatic Fire Alarm and Fire Detection Systems

Where the Sing-Lloyd has permitted under regulation 3(1), a combustible construction or where otherwise appreciable amounts of combustible materials are used in the construction of accommodation spaces, service spaces and control stations, special consideration shall be given to the installation of an automatic fire alarm and fire detection system in those spaces, having due regard to the size of those spaces, their arrangement and location relative to control stations as well as, where applicable, the flame spread characteristics of the installed furniture.

Regulation 7 – Fire Pumps

1. a. All ships shall be provided with at least one independent power-operated fire pump.

   b. In ships of less than 24m in length, the fire pump may be driven by main propulsion machinery provided that the propeller shafting can be readily disconnected or that a controllable pitch propeller is fitted.

2. Sanitary, bilge, ballast, general service or any other pump may be used as fire pumps if they comply with the requirements of this Chapter and do not affect the ability to cope with pumping of the bilges. Fire pumps shall be so connected that they cannot be used for pumping oil or other flammable liquids.

3. Centrifugal pumps or other pumps connected to the fire main through which backflow could occur shall be fitted with non-return valves.

4. a. If fire in any one compartment can pull all the fire pumps out of action, there shall be an alternate means to extinguish the fire. This alternate means may be an emergency power-operated fire pump.

   b. An emergency power-operated fire pump shall be an independently driven self-contained pump either with its own prime mover and fuel supply fitted in an accessible position outside the compartment which contains the main fire pump, or be driven by a self-contained generator which may be an emergency generator of sufficient capacity and which is positioned in a safe place outside the engine room and above the freeboard deck.

   c. The emergency fire pump, sea suction and other valves shall be operable from outside the compartment containing the main fire pump and in a position not likely to be cut off by fire in that compartment.

5. The total capacity (Q) of the main power-operated fire pump shall be at least:

$$Q=\{0.15\ [L\ (B+D)]^{0.5} + 1\}^2\ m^3 \text{ per hour}$$

   Where L, B and D are in metres.

6. Where two independent power-operated fire pumps are fitted, the capacity of each pump shall not be less than 40% of the quantity required by paragraph (5).

7. When the main power fire pump is delivering the quantity of water required by paragraph (5) through the fire main, fire hoses and nozzles, the pressure maintained at any hydrant shall be not less than $0.21 N/mm^2$.

8. Where the power-operated emergency fire pump is delivering the maximum quantity of water through the jet required by regulation 9(1), the pressure maintained at any hydrant shall be to the satisfaction of Sing-Lloyd.

Regulation 8 – Fire Mains

1. Where more than one hydrant is required to provide a jet of water required by regulation 9(I), a fire main shall be provided.

2. Materials readily rendered ineffective by heat shall not be used for fire mains, unless adequately protected.

3. When the fire pump delivery pressure can exceed the designed working pressure of fire mains, relief valves shall be fitted.

4. Fire mains shall have no connections other than those required for fire fighting, except for the purposes of washing the deck and anchor chains or operating the chain locker bilge ejector.

Regulation 9 – Fire Hydrants, Fire Hoses and Nozzles

1. Fire hydrants shall be positioned so as to allow easy and quick connection of fire hoses and so that at least one jet of water can be directed into any part of the ship which is normally accessible during navigation.

2. The jet required in paragraph (1) shall be from a single length of fire hose.

3. In addition to the requirements of paragraph (1), in every machinery space of Category A:

   a. There shall be at least two fire hydrants each complete with fire hose and combined jet and spray nozzle. One of the hydrants shall be located near the entrance; or

   b. In a ship of less than 24m in length, there shall be at least one fire hydrant complete with fire hose and combined jet and spray nozzle. This hydrant shall be located outside the space and, near the entrance.

4. A single length of fire hose shall not exceed 15 metres.

5. Fire hoses shall be of an approved material. Each fire hose shall be provided with couplings and an approved nozzle.

6. Except where fire hoses are permanently attached to the fire main, the couplings of fire hoses and nozzles shall be completely interchangeable.

7. The nozzles as required by paragraph (5) shall be appropriate to the delivery capacity of the fire pumps fitted, but in any case shall have a diameter of not less than 12mm.

Regulation 10 – Fire Extinguishers

1. Fire extinguishers shall be of approved types. The capacity of required portable fluid extinguishers shall be not more than 14 litres and not less than 9 litres. Other extinguishers shall not be in excess of the equivalent portability of the 14-litre fluid extinguisher and shall not be less than the fire-extinguishing equivalent of a 9-litre fluid extinguisher. The Sing-Lloyd shall determine the equivalents of fire extinguishers.

2. Spare charges shall be provided to the satisfaction of Sing-Lloyd.

3. Fire extinguishers containing an extinguishing medium, which, in the opinion of Sing-Lloyd, either by itself or under expected conditions of use, gives off toxic gases in such quantities as to endanger persons, shall not be permitted.

4. Fire extinguishers shall be periodically examined and subjected to such tests as Sing-Lloyd may require.

5. One of the portable fire extinguishers intended for use in any space shall be stowed near an entrance to that space.

Regulation 11 – Fire Buckets

1. Fire buckets shall be of metal, painted red and clearly and permanently marked with the word "FIRE". Except in open ships, such fire buckets shall be kept filled with sand or water.

2. All fire buckets shall be provided with lanyards of sufficient length.

Regulation 12 - Portable Fire Extinguishers in Control Stations, Accommodation and Service Spaces

1. A sufficient number of approved portable fire extinguishers shall be provided in control stations, accommodation and service spaces to ensure that at least one extinguisher of a suitable type is readily available for use in any part of such spaces. The total number of extinguishers in these spaces, however, shall not be less than 3.

2. In addition to the requirements under paragraph (1), every ship shall be provided with at least 3 fire buckets.

3. Every manned barge when engaged on international voyages shall be provided with:

   a. One fire extinguisher in each separate crew compartment but in any case at least two such extinguishers in the barge; and

   b. At least two fire buckets.

Regulation 13 – Fire-Extinguishing Appliances in Machinery Spaces

1. a. In a ship of gross tonnage 1000 and above, spaces containing oil-fired boilers, fuel oil units, fuel oil settling tanks or internal combustion machinery having a total power output of not less than 746kW, shall be provided with one of the following fixed fire-fighting installations:

      i. A pressure water-spraying installation;

      ii. A fire-smothering gas installation;

      iii. A fire-extinguishing installation using froth having an expansion ratio not exceeding 12 to 1;

      iv. A fire-extinguishing installation using a high expansion froth having expansion ratio not exceeding 1,000 to 1.

b. Where the engine and boiler rooms are not entirely separated from each other or if fuel oil can drain from the boiler room into the engine room, the engine and boiler rooms shall be considered as one compartment.

2. Installations listed in paragraph (1)(a) shall be controlled from readily accessible positions outside such spaces not likely to be cut off by a fire in the protected space. Arrangements shall be made to ensure the supply of power and water necessary for the operation of the system in the event of fire in the protected space.

3. In all machinery spaces of Category A, at least two portable extinguishers of a type suitable for extinguishing fires involving fuel oil shall be provided. Where such spaces contain machinery, which has a total power output of not less than 350kW, at least 3 such extinguishers shall be provided. One of the extinguishers shall be stowed near the entrance to the space.

4. Every ship to which paragraph (1) does not apply, having machinery spaces not protected by a fixed fire-extinguishing system, shall be provided with at least a 45-litre foam extinguisher suitable for fighting oil fires. Where the size of the machinery spaces makes this provision impracticable, the extinguisher shall be positioned outside the machinery space in such a way as to be readily available for use in case of fire in such space.

5. In each firing space of every such ship fitted with auxiliary oil-fired boilers, a receptacle shall be provided which shall contain at least $0.28m^3$ of sand or other dry material suitable for quenching oil fires. Scoops shall be provided for distributing the contents of the receptacle.

6. Every manned barge fitted with internal combustion machinery shall be provided with at least two portable fire extinguishers suitable for fighting oil fires, in addition to the requirements referred to in regulation 12(3).

7. Where, in the opinion of Sing-Lloyd, a fire hazard exists in any machinery space for which no specific provision for fire-extinguishing appliances are prescribed in paragraph (1), (3) or (4), there shall be provided in, or adjacent to, that space a number of approved portable fire extinguishers or other means of fire extinction to the satisfaction of the Sing-Lloyd.

8. Where fixed fire-extinguishing systems, not required by this Part are installed, such systems shall be to the satisfaction of Sing-Lloyd.

Regulation 14 – Fireman's Outfit

1. Ships of gross tonnage 500 and above shall carry at least two fireman outfits.

2. Ships of gross tonnage less than 500 shall carry at least one fireman outfit.

3. The fireman outfit referred to in paragraphs (1) and (2) shall consist of:

a. A breathing apparatus of either the air hose type or self-contained compressed air type;

b. A fireproof lifeline of sufficient length and strength;

c. An electric safety lamp;

d. An axe;

e. A rigid helmet and a pair of boots and gloves; and

f. Two sets of protective clothing of material to protect the skin from radiation from the fire and from burns and scalding by steam.

In ships having machinery spaces of more than 36m in length, self-contained breathing apparatus shall be provided.

Regulation 15 – Fireman's Axe

Every ship and every manned barge shall carry at least one fireman's axe.

Regulation 16 – Fire Control Plan

There shall be a permanently exhibited fire control plan to the satisfaction of Sing-Lloyd. In small ships, Sing-Lloyd may dispense with this requirement.

Regulation 17 – Availability of Appliances

Fire-extinguishing appliances shall be kept in good order and available for immediate use at all times.

Regulation 18 – Acceptance of Substitutes

Where in this Part a special type of appliance, apparatus, extinguishing medium or arrangement is specified, any other type of appliance, etc., may be allowed provided the Certifying Authority is satisfied that it is not less effective.

PART C – FIRE SAFETY MEASURES FOR TANKERS

Regulation 19 – Application

1. Unless otherwise expressly provided, this Part shall apply to any tanker engaged on all voyages carrying crude oil and petroleum products having a flash-point not exceeding 60^0C (closed cup test) as determined by an approved flashpoint apparatus and whose Reid vapour pressure is below that of atmospheric pressure, and other liquid products having a similar fire hazard.

2. Where cargoes, other than those referred to in paragraph (1), which introduce additional fire hazards are intended to be carried, additional safety measures shall be required to the satisfaction of Sing-Lloyd.

3. Combination carriers shall not carry solid cargoes unless all cargo tanks are empty of oil and gas freed or unless, in each case, Sing-Lloyd is satisfied with the arrangements provided.

Regulation 20 – Construction

1. The hull, superstructure, structural bulkheads, decks and deckhouses shall be constructed of steel or other equivalent material except as otherwise specified in paragraph (2).

2. Crowns and casings of machinery spaces of Category A shall be of steel construction adequately insulated and any opening therein shall be suitably arranged and protected to prevent the spread of fire.

3. a. Boundary bulkheads and decks of machinery spaces of Category A and cargo rooms shall be of steel construction adequately insulated to the satisfaction of Sing-Lloyd.

b. Gastight bulkheads shall be provided for the isolation of all cargo pumps and piping from spaces containing stoves, electrical apparatus, propelling machinery, or other machinery where sources of ignition are normally present.

c. Where such bulkheads and decks are penetrated for the passage of electrical cables, pipes, trunks, ducts, etc., arrangements shall be made to ensure that the fire integrity of the bulkhead is not impaired.

4. Doors shall be resistant to fire, as far as practicable, equivalent to the division in which they are fitted.

5. Doors fitted in boundary bulkheads of machinery spaces of Category A shall be self-closing and reasonably gastight.

6. Doors required to be self-closing shall not be fitted with holdback hooks. However, holdback arrangements fitted with remote release fittings of the fail-safe type may be used.

7. Watertight doors need not be insulated.

8. Air space enclosed behind ceilings, panellings or linings in accommodation spaces, service spaces and control stations shall be divided by close-fitting draught stops spaced not more than 7m apart.

Regulation 21 – Separation of Spaces

Oil-tight and vented cofferdams, with widths as required for ready access, shall be provided for the separation of all cargo tanks from galleys, living quarters, general cargo spaces below the uppermost continuous deck, and spaces containing propelling machinery or other machinery where sources of ignition are normally present. Pump room, compartments arranged solely for ballast, and fuel-oil tanks may be considered as cofferdams for compliance with this regulation.

Regulation 22 – Ventilation

1. Ventilation openings may be permitted in and under the doors in corridor bulkheads except that such openings shall not be permitted in and under stairway enclosure doors. The openings shall be provided only in the lower half of a door. Where such opening is in or under a door, the total net area of any such opening or openings shall not exceed $0.05m^2$. When such opening is cut in a door, it shall be fitted with a grille made of non-combustible material.

2. Ventilation ducts for machinery spaces of Category A or galleys shall not in general pass through accommodation spaces, service spaces or control stations. Where Sing-Lloyd permits this arrangement, the ducts shall be constructed of steel or equivalent material and arranged to preserve the integrity of the divisions.

3. Ventilation ducts of accommodation spaces, service spaces or control stations shall not in general pass through machinery spaces of Category A or through galleys. Where Sing-Lloyd permits this arrangement, the ducts shall be constructed of steel or equivalent material and arranged to preserve the integrity of the divisions.

4. The arrangement and positions of openings in the cargo tank deck, from which gas emission can occur, shall be such as to minimise the possibility of gas being admitted to enclosed spaces containing a source of ignition, or collecting in the vicinity of deck machinery and equipment which may constitute an ignition hazard. In every case, the height of the outlet above the deck and the discharge velocity of the gas shall be considered in conjunction with the distance of any outlet from any deckhouse opening or source of ignition.

5. The arrangement of ventilation inlets and outlets and other deckhouse and superstructure boundary space openings shall be such as to complement the provisions of paragraph (4). Such vents, especially for machinery spaces, shall be situated as far aft as practicable. Due consideration in this regard should be given when the ship is equipped to load or discharge at the stern. Sources of ignition such as electrical equipment shall be so arranged as to avoid an explosion hazard.

6. Cargo pump rooms shall be mechanically ventilated and discharges from the exhaust fans shall be led to a safe place on the open deck. The ventilation of these rooms shall have sufficient capacity to minimise the possibility of accumulation of flammable vapours. The number of changes of air shall be at least 20 times per hour, based upon the gross volume of the space. The air ducts shall be so arranged that all of the space is effectively ventilated. The ventilation shall be of the suction type.

Regulation 23 – Means of Escape

In addition to the requirements of regulation 5(1), consideration shall be given by Sing-Lloyd to the availability of emergency means of escape for personnel from each cabin.

Regulation 24 – Cargo Tank Protection

1. Every tanker and manned or unmanned barge carrying flammable products referred to in regulation 19(1) engaged on voyages outside the port limit shall be provided with a suitable arrangement to the satisfaction of Sing-Lloyd for providing sufficient quantity of froth for:

a. Extinguishing spill fires and also preclude ignition of spill oil not yet ignited;

b. Combating fires in ruptured tanks; and

c. Discharging internally or externally to the tanks.

2. Where non-portable fire extinguishers are provided to comply with the requirements of paragraph (1), they shall be easily transportable to any part of the cargo deck in case of emergency.

Regulation 25 – Cargo Pump Room

1. Machinery and fittings, which are sources of ignition, shall not be permitted in the cargo pump room.

2. Each cargo pump room shall be provided with a fixed fire-fighting system operated from a readily accessible position outside the pump room. The system shall use water-spray or another suitable medium satisfactory to Sing-Lloyd.

3. Ships not fitted with a fixed fire-extinguishing system in the cargo pump room shall be provided with a 45 litre-foam extinguisher or its equivalent near the entrance to the pump room.

Regulation 26 – Hose Nozzles

All water hose nozzles provided shall be of an approved dual purpose type (i.e. spray/jet type) incorporating a shut-off.

CHAPTER III LIFE-SAVING APPLIANCES, EMERGENCY PROCEDURES, MUSTERS AND DRILLS

Regulation 1 – Application

This Chapter shall apply to all manned cargo ships.

Regulation 2 – Definitions

For the purposes of this Chapter:

"*Inflated Lifeboat*" means a permanently inflated survival craft subdivided and of strong, abrasion-resistant construction;

"Launching appliance" means a device capable of launching from the embarkation position, a craft fully loaded with the number of persons it is certified to carry and with its equipment;

"*Survival Craft*" means a craft provided for accommodating the persons on board in the event of abandonment of the ship and includes lifeboats, liferafts and any other craft approved as suitable for the protection and preservation of persons in such circumstances.

Regulation 3 – Numbers and Types a f Survival Craft

1. a. All ships propelled by mechanical means engaged on international voyages other than tankers referred to in paragraph (2) shall carry:

   i. On each side one or more survival craft of sufficient aggregate capacity to accommodate the total number of persons the ship is certified to carry; or

   ii. At least two survival craft capable of being launched on both sides of the ship of sufficient aggregate capacity to accommodate 200% of the total number of persons the ship is certified to carry. The maximum capacity of each survival craft shall not be more than 100% of the total number of persons the ship is certified to carry.

   b. All ships propelled by mechanical means engaged on 30-mile limit voyages and tankers plying within the port (other than tankers referred to in paragraph (2)) may, in lieu of the requirements referred to in sub-paragraph (a) carry one or more survival craft capable of being launched on both sides of the ship and of sufficient aggregate capacity to accommodate all persons the ship is certified to carry.

2. a. All tankers carrying crude oil and petroleum products having a flash point not exceeding 60^{0}C (closed cup test) as determined by an approved flashpoint apparatus and whose Reid vapour pressure is below atmospheric pressure, and other liquid products having a similar fire hazard, shall carry on each side one or more rigid lifeboats of sufficient aggregate capacity to accommodate the total number of persons the ship is certified to carry.

   b. Such tankers engaged on 30-mile limit voyages or plying within the port may, in lieu of the requirements referred to in sub-paragraph (a) carry:

   i. On each side one or more rigid liferafts of sufficient aggregate capacity to accommodate all persons the ship is certified to carry; or

ii. One or more rigid lifeboats or rigid liferafts capable of being launched on both sides of the ship and of sufficient aggregate capacity to accommodate all persons the ship is certified to carry.

3. Every manned barge to which these Regulations apply shall be provided with one or more survival craft of sufficient capacity to accommodate at least all persons the barge is certified to carry.

Regulation 4 – Marking of Survival Craft

1. The dimensions of a lifeboat and the number of persons, which it is certified to carry, shall be clearly marked on it with permanent characters. The name of the ship and the Port of Registry shall be painted on each side of the bow.

2. An inflatable liferaft and its valise or container shall be marked with the number of persons it is certified to carry, the serial number and the manufacturer's name. In addition, the liferaft shall be marked with the name of the ship and the Port of Registry.

3. Every rigid liferaft shall be marked with the name of the ship, the Port of Registry, and with the number of persons it is certified to carry.

4. No survival craft shall be marked for a greater number of persons than that obtained in the manner specified in regulations 5 and 6.

Regulation 5 – Construction and Capacity of Lifeboats

1. Lifeboats shall be constructed to the satisfaction of Sing-Lloyd and be of such form and proportions that they shall have adequate freeboard and stability in a seaway when loaded with their full complement of persons and equipment. Lifeboats loaded with their full complement of persons and equipment shall, when flooded and open to the sea, be capable of keeping afloat with positive stability.

2. The number of persons, which a rigid lifeboat shall be permitted to accommodate, shall:

a. Be equal to the greatest whole number obtained by dividing the capacity in cubic metres by a factor of:

i. 0.283 for a boat of 7.3m in length or over;

ii. 0.396 for a boat of 4.9m in length; and

iii. Obtained by linear interpolation between 0.396 and 0.283 for boats over 4.9m but less than 7.3m; and

b. In no case exceed the number of adult persons wearing lifejackets who can be properly seated without in any way interfering with the use of oars or the operation of other propulsion equipment.

3. The number of persons, which an inflated lifeboat shall be permitted to accommodate, shall be the lesser of the following numbers:

a. The greatest whole number obtained by dividing by 0.72 the volume of the main buoyancy tubes measured in cubic metres reduced by 0.40 cubic metres, which for this purpose shall include neither the thwarts nor the centreline tube if fitted; or

b. The greatest whole number obtained by dividing by 0.32 the area of the floor measured in square metres, which for this purpose may include the thwarts and centreline tube if fitted.

In no case shall it exceed the number of adult persons wearing lifejackets who can be properly seated without in any way interfering with the use of oars or the operation of other propulsion equipment. No inflated lifeboat shall be approved which has a carrying capacity of fewer than 10 persons.

Regulation 6 – Construction and Capacity of Liferafts

1. Rigid liferafts shall be of approved type and shall:

a. Be so constructed that if they are dropped into the water from their stowed position, neither the liferaft nor its equipment will be damaged; and

b. At all times be effective and stable when floating either way up.

2. The number of persons, which an inflatable liferaft shall be permitted to accommodate, shall be the lesser of the following numbers:

a. The greatest whole number obtained by dividing by 0.096 the volume measured in cubic metres of the main buoyancy tubes (which for this purpose shall include neither the arches nor the thwart or thwarts if fitted) when inflated; or

b. The greatest whole number obtained by dividing by 0.372 the area measured in square metres of floor (which for this purpose may include the thwart or thwarts if fitted) of the liferaft when inflated.

3. The number of persons, which a rigid liferaft shall be deemed fit to accommodate, shall be the lesser of the following numbers:

a. The greatest whole number obtained by dividing by 0.096 the volume measured in cubic metres of the air cases or buoyant material; or

b. The greatest whole number obtained by dividing by 0.372 the deck area of the liferaft measured in square metres.

Regulation 7 – Availability and Stowage of Survival Craft

1. Survival craft shall:

a. i. Be readily available in case of emergency; and

ii. Be capable of being launched safely and rapidly even under unfavourable conditions of trim and against 15 degrees of list; and

b. Be stowed such that:

i. The marshalling of persons at the embarkation deck is not impeded;

ii. Their prompt handling is not impeded;

iii. Embarkation can be effected rapidly and in good order; and

iv. The operation of any other survival craft is not interfered with.

2. Survival craft and launching appliances shall be in working order and available for immediate use before the ship leaves port and so kept at all times when at sea.

3. a. Every lifeboat shall be attached to a separate set of davits or approved launching appliance.

b. Survival craft shall be positioned as close to accommodation and service spaces as possible, stowed in suitable positions to ensure safe launching, with particular regard to clearance from the propeller and steeply overhanging portions of the hull, so ensuring as far as practicable that they can be launched down the straight side of the ship. If positioned forward they shall be stowed abaft the collision bulkhead in a sheltered position, and in this respect the Authority shall give special consideration to the strength of the davits.

c. Davits shall be of an approved design.

d. i. The liferafts shall be so stowed as to be readily available in case of emergency in such a manner as to permit them to float free from their stowage, inflate in the case of inflatable liferaft and break free from the vessel in the event of its sinking. However, davit-launched liferafts need not float free.

ii. Lashings, if used, shall be fitted with an automatic (hydrostatic) release system of an approved type.

Regulation 8 – Embarkation into Survival Craft

1. Suitable arrangements shall be made for embarkation into the survival craft, which shall include:

a. At least one ladder, or other approved means, on each side of the vessel to afford access to the survival craft when it is waterborne;

b. Means for illuminating the stowage position of survival craft and their launching appliances during preparation for and the process of launching, and also for illuminating the water into which the survival craft are launched until the process of launching is completed, the power for which is to be supplied from the emergency source required by regulation 32 of Chapter II-1;

c. Arrangements for warning all persons on board that the ship is about to be abandoned; and

d. Means for preventing any discharge of water into the survival craft.

Regulation 9 – Lifejackets

1. For every person on board, a life-jacket of an approved type shall be carried.

2. Life-jackets shall be so placed as to be readily accessible and their position shall be plainly indicated.

3. a. In addition to the life-jackets required by paragraph (1), additional life-jackets shall be provided in accordance with the following table:

The number of persons that the ship is certified to carry	***Minimum number of additional life-jackets***
More than 16 persons	Not less than 25% of the total number of persons the ship is certified to carry
Between 4 and 16 persons	Not less than 4
Fewer than 4 persons	2

b. The additional life-jackets shall be of an approved type and shall be stowed at or near the normal embarkation positions. In the cases of smaller ships, they may be stowed in boxes on deck on in the bridge.

c. A suitable dry stowage position, unlocked and clearly marked, shall be provided.

Regulation 10 – Lifebuoys

1. Every ship propelled by mechanical means engaged on all voyages shall carry at least 8 lifebuoys.

2. Every manned barge engaged on international voyages shall carry at least 4 lifebuoys.

3. At least half of the number of lifebuoys referred to in paragraphs (1) and (2) shall be provided with self-igniting lights, which shall be near the lifebuoys to which they belong, with the necessary means of attachment.

4. The self-igniting lights required by paragraph (3) shall be such that they cannot be extinguished by water. They shall be capable of burning for not less than 45 minutes and shall have a luminous intensity of not less than two candelas in all directions of the upper hemisphere.

5. In ships of 45m in length and over, at least two of the lifebuoys provided with self-igniting lights in accordance with paragraph (3) shall also be provided with an efficient self-activating smoke signal capable of producing smoke of a highly visible colour for at least 15 minutes, and shall where practicable, be capable of quick release from the wheelhouse.

6. At least one lifebuoy on each side of the ship shall be fitted with a buoyant lifeline of at least 27.5m in length. Such lifebuoys shall not have self-igniting lights.

7. All lifebuoys shall be so placed as to be readily accessible to the persons on board and shall always be capable of being rapidly cast loose and shall not be permanently secured in any way.

Regulation 11 – Line-Throwing Appliances

1. Every ship of 24m in length and above propelled by mechanical means engaged on international voyages other than 30-mile limit voyages shall carry a line-throwing appliance of an approved type.

2. A line-throwing appliance shall be capable of carrying a line, not less than 230m, with reasonable accuracy and shall include not less than two projectiles and two lines.

3. The rockets, with the means of igniting them and the lines shall be kept in a watertight case.

Regulation 12 – Distress Signals

1. Every ship shall be provided, to the satisfaction of the Authority, with means of making effective distress signals by day and by night, including at least 12 parachute signals capable of giving a bright red light at a high altitude.

2. Distress signals shall be of an approved type. They shall be so placed as to be readily accessible and their position shall be plainly indicated.

Regulation 13 – Portable Radio Equipment for Survival Craft

1. Every ship propelled by mechanical means engaged on international voyages other than 30-mile limit voyages shall carry a portable radio apparatus or an emergency position-indicating radio beacon (EPIRB), each of an approved type and located in such a way as to be readily accessible.

Regulation 14 – Muster List and Abandon Ship Procedure

1. A muster list shall be drawn up for every ship to which these Regulations apply and shall include the following information:

   a. Duties assigned to different members of the crew in the event of an emergency in connection with:

      i. Closing of any watertight doors, valves and closing mechanisms of scuppers, over-board shoots, side scuttles and fire doors;

      ii. Equipping of survival craft (including portable radio apparatus for survival craft);

      iii. Launching of the survival craft;

      iv. General preparation of other life-saving appliances;

      v. Manning of fire parties assigned to deal with fires; and

      vi. Special duties assigned in respect of the operation of fire-fighting equipment and installations; and

   b. Signals for summoning the crew to their survival craft and fire stations and particulars of these signals including the emergency signal for summoning the crew to muster stations which shall be a succession of 7 or more short blasts followed by one long blast on the whistle or siren.

2. In ships of less than 45m in length, and that the number of crew members is small, no muster list is necessary.

3. The muster list shall be updated whenever there is a change in any of the crew.

4. The list of emergency signals shall be posted up in the wheelhouse and in the crew accommodation. Copies of the muster list shall be posted up in several parts of the ship and, in particular, in the crew accommodation.

5. Emergency signals specified in the muster list shall be made with the whistle or siren. Ships of 45m in length and over shall be fitted with an electrical system of alarm bells capable of being operated from the wheelhouse.

Regulation 15 – Practice Musters and Drills

1. A muster of the crew for abandon ship drill and fire drill shall take place at intervals of not more than one month, except that these musters shall take place as soon as practicable whenever more than 25% of the crew has been replaced since the last muster.

2. When holding musters, the master shall examine the life-saving, fire-fighting and other safety equipment to ensure that they are complete and in satisfactory working order.

3. The dates, on which musters are held, shall be recorded in the official log book and if no muster is held within the prescribed interval or a part muster is held, an entry shall be made stating the circumstances and extent of the muster held. A report of the examination of the life-saving equipment shall be entered in the log book, together with a record of the survival craft used.

4. In ships fitted with lifeboats, different boats shall be swung out at successive drills. The lifeboats shall, where practicable, be lowered into the water at least once every 4 months, at which time, checks shall be carried out for the reliability of all apparatus and systems, and the watertight integrity of the boats, as well as the operation of the releasing devices.

5. Musters shall be conducted to ensure that the crew thoroughly understand and are familiar with the duties they have to perform including the handling and operation of liferafts where these are carried.

CHAPTER IV MISCELLANEOUS

Regulation 1 – Application

This Chapter shall apply to all ships propelled by mechanical means.

PART A – SHIPBOARD NAVIGATION EQUIPMENT

Regulation 2 – Compasses

1. Every ship of gross tonnage 150 and above engaged on voyages other than 30-mile limit voyages shall be fitted with:

   a. A standard magnetic compass in a suitable binnacle positioned on the ship's centreline. The standard magnetic compass, or any repeater from it, which provides the primary means of navigating the ship shall be sited in the vicinity of the position from which the ship is ordinarily navigated, and the view of the horizon from this position shall be as uninterrupted as possible for the purpose of taking bearings. In the sector from right ahead to 115 degrees on either side the view of the horizon shall be uninterrupted as far as practicable by such permanent structures as masts, derrick posts, etc.; and

   b. A second magnetic compass in a suitable binnacle adjacent to the main steering position for the helmsman to steer by.

2. Where a projected or reflected image of the standard compass referred to in sub-paragraph (1)(a) is provided at the main steering position for the helmsman to steer by, the second magnetic compass referred to in sub-paragraph (1)(b) need not be fitted.

3. Ships of gross tonnage less than 150 engaged on international voyages and all ships on 30-mile limit voyages and tankers plying within the port shall be fitted with a magnetic compass in a suitable binnacle at the main steering position for the helmsman to steer by.

4. In ships fitted with only one magnetic compass, a spare magnetic compass, which is interchangeable with the fitted magnetic compass, shall be carried.

5. Every magnetic compass fitted shall be positioned in such a way that:

a. The helmsman can efficiently steer by the compass; and

b. The compass is located at a safe distance away from the other equipment and fittings which affect the performance of the compass.

6. Means shall be provided to ensure that compass bearings can be taken by day and by night.

7. Magnetic compasses shall be properly compensated and a table or curve of residual deviations shall be provided on board the ship.

8. In a ship fitted with a dry magnetic compass, spare compass cards in sufficient quantity shall be carried.

9. Means of illumination and facilities for dimming shall be provided to enable reading of the compass card at all times.

10. The magnetic compasses installed in a ship shall be adjusted whenever:

a. The compasses are first installed;

b. The ship undergoes structural repairs or alterations that are liable to affect her permanent or induced magnetism;

c. Any alteration, which may have an effect on compass performance, is made to any electrical apparatus or equipment made of magnetic materials in the vicinity of the compass; or

d. A magnetic compass becomes unreliable from causes unknown.

11. A voice pipe or other adequate means of communication between the normal navigation control position and the standard compass position or emergency steering position shall be provided.

Regulation 3 – Nautical Instruments and Publications

Suitable nautical instruments, adequate and updated charts, sailing directions, list of lights, notices to mariners, tide tables and all other nautical publications necessary for the intended voyage shall be carried.

Regulation 4 – Signalling Equipment

1. All ships shall be provided with a full complement of flags and pendants to enable communication using the International Code of Signals in force.

2. In all ships a copy of the International Code of Signals in force shall be carried.

3. In addition to the requirements referred to in paragraphs (1) and (2), all ships of gross tonnage 150 and above, when engaged on voyages other than 30-mile limit voyages, shall have on board an efficient daylight signalling lamp which shall not be solely dependent upon the ship's main source of electrical power.

PART B - RADIOTELEPHONY

Regulation 5 – VHF Radiotelephone Station

A ship of gross tonnage less than 300, propelled by mechanical means engaged on voyages outside the port limit, shall be provided with a Very High Frequency (VHF) radiotelephone station.

Regulation 6 – Radiowatches

1. A ship which is fitted with a radiotelephone station shall carry at least one radiotelephone operator (who may be the master, an officer or a member of the crew holding a certificate for radiotelephony) who shall, while the ship is at sea, maintain continuous watch on the radiotelephone distress frequency in the place on board from which the ship is usually navigated, by use of a radiotelephone distress frequency watch receiver, using a loudspeaker, a filtered loudspeaker or radiotelephone auto alarm.

2. A ship which is fitted with a radiotelegraph station shall carry a radio operator holding at least a Special Radiotelegraph Operator's Certificate of Competency, who shall while the ship is at sea, maintain continuous watch on the radio-telephone distress frequency by use of a radiotelephone distress frequency watch receiver, using a loud-speaker, a filtered loudspeaker or radiotelephone auto alarm.

3. On a ship fitted with a VHF radiotelephone station, a listening watch shall be maintained while the ship is at sea, on the VHF radiotelephone distress frequency except when the VHF radiotelephone station is engaged in communications on a working frequency.

Regulation 7 – Radio Logs

1. The radio log (diary of the radio service) required for a ship, which is fitted with a radiotelegraph station, shall be kept in the radiotelegraph operating room while the ship is at sea. Every radio operator shall enter in the log his name, the time at which he goes on and off watch, and all incidents connected with the radio service, which occur during his watch, which may appear to be of importance to safety of life at sea. In addition, there shall be entered in the log:

   a. Details as required by the relevant statutory regulations;

   b. Details of maintenance, including a record of the charging of the batteries; and

   c. Details of the maintenance and tests of portable radio apparatus for survival craft and EPIRB referred to in regulation 13 of Chapter III.

2. The radio log required for a ship, which is fitted with a VHF radiotelephone station, shall be kept at the place where the listening watch is maintained. Every crew maintaining a listening watch shall enter in the log the details of all communications connected with distress.

PART C - CARRIAGE OF GRAINS, DANGEROUS GOODS AND STORES

Regulation 8 – Carriage of Grains

The International Code for the Safe Carriage of Grain in Bulk, and SOLAS, 1974, as amended, Chapter VI, shall apply to every ship, where the Code applies, when engaged on international voyages.

Regulation 9 – Carriage of Dangerous Goods and Stores

1. The International Maritime Dangerous Goods Code, and SOLAS, 1974, as amended, Chapter VII, shall apply to every ship, where the Code applies, when engaged on international voyages.

2. Every cargo ship to which these Regulations apply shall comply with the following stowage requirements of gas cylinders and dangerous materials:

   a. Cylinders for compressed, liquefied or dissolved gases shall be clearly marked by means of prescribed identifying colours, have a clear legible-identification of the name and chemical formula of their contents and properly secured;

   b. Cylinders containing flammable or other dangerous gases and expended cylinders shall be stored and properly secured on open decks. All valves, pressure regulators and pipes leading from such cylinders shall be protected against damage. Cylinders shall be protected against excessive variation in temperature and direct rays from the sun.

   c. Spaces containing highly flammable liquids, such as volatile paints, paraffin, benzole, etc, and, where permitted, liquefied gas, shall have direct access from open decks only. Pressure-adjusting devices and relief valves shall exhaust within the compartment. Where boundary bulkheads of such compartments adjoin other enclosed spaces they shall be gastight;

   d. Except as necessary for service within the space, electrical wiring and fittings shall not be permitted within compartments used for the storage of highly flammable liquids or liquefied gases. Sources of heat shall be kept clear of such spaces and "No Smoking" and "No Naked Light" notices shall be displayed in a prominent position; and

e. Separate storage shall be provided for each type of compressed gas. Compartments used for the storage of such gases shall not be used for storage of other combustible products nor for tools or objects not part of the gas distribution system.

PART F

TYPES OF SHIP

CHAPTER 1
OIL TANKERS

SECTION 1
General

101. Application

1. The construction and equipment of ships intended to be registered and classed as “tanker” are to be in accordance with the requirements in this Chapter, where “tanker” means a ship intended to carry crude oil, petroleum products having the vapour pressure (in gauge) less than 0.2 MPa at 38°C or other similar liquid cargoes in bulk.

2. Except where specifically required in this Chapter, the general requirements for steel ships are to be applied.

3. The requirements in this Chapter are framed for tankers with machinery aft, having one or more rows of longitudinal bulkheads, single decks, single bottoms and longitudinal framing.

4. In tankers intended to carry liquid cargoes other than crude oil and petroleum products, having the vapour pressure (in gauge) less than 0.2 MPa at 38°C and having no hazard as poisonous, corrosive, etc. and moreover less inflammability than that of crude oil and petroleum products, the structural arrangements and scantlings are to be to the satisfaction of the Society, having regard to the properties of the cargoes to be carried.

102. Arrangement of bulkheads

In cargo oil tanks, longitudinal and transverse oiltight bulkheads and wash bulkheads are to be arranged suitably.

103. Cofferdams

1. Cofferdams of airtight construction and having sufficient width as required for ready access are to be provided at the forward and after ends of cargo oil spaces and between cargo oil spaces and accommodation spaces. In tankers intended to carry oils having a flash point exceeding 60°C, however, the preceding requirements may be modified.

2. The cofferdams described in the preceding Paragraph may be used as pump rooms.

3. Ullage plugs, sighting ports and tank cleaning openings are not to be arranged in enclosed spaces.

4. Fuel oil or ballast water tanks may be concurrently used as the cofferdams to be provided between cargo oil tanks and fuel oil or ballast water tanks, subject to the approval by the Society.

5. Location and separation of spaces in tankers of 500 *tons gross* and above carrying oils having a flash point not exceeding 60°C are to be in accordance with the requirements in **Pt 8, Ch 1, Sec 4.**

104. Airtight bulkheads

Airtight bulkheads are to be provided for the isolation of all cargo oil pumps and pipings from spaces containing stoves, boilers, propelling machinery, electric installations other than those of explosion-proof type specified in **Pt 6, Ch 1, Sec 9** or machinery space where source of ignition is normally present. In tankers carrying oils having a flash point exceeding 60°C, however, the preceding requirements may be modified.

105. Ventilation

1. Efficient ventilation is to be provided in spaces adjacent to cargo oil tanks. Air holes are to be cut in every part of the structure where there might be a chance of gases being pocketed.

2. Efficient means are to be provided for clearing oil tanks and pump rooms of dangerous vapours by means of mechanical ventilation or by steam.

3. In tankers carring oils having a flash point exceeding 60°C the capacity of ventilation in the pump rooms specified in **1006.** may be modified.

4. The requirements in **1006.** are applied to the ventilation fans and wire mesh screens for the spaces adjacent to the cargo oil tank specified in **Par 1.**

106. Openings for ventilation

Ventilation inlets and outlets are to be arranged so as to minimize the possibilities of vapours of cargoes being admitted to an enclosed space containing a source of ignition, or collecting in the vicinity of deck machinery and equipment which may constitute an ignition hazard. Especially, openings of ventilation for machinery spaces are to be situated as far afterwards apart from the cargo spaces as practicable.

107. Openings of superstructure and deckhouse

The arrangement of openings on the boundaries of superstructure and deckhouse are to be such as to minimize the possibility of accumulation of vapours of cargoes. Due consideration in this regard is to be given when the ship is equipped to load or unload at the stern. Side scuttles to the poop front or other similar walls are to be of fixed type. Such openings of tankers of 500 *tons gross* and above carrying oils having a flash point not exceeding 60°C are to be in accordance with the requirements in **Pt 8, Ch 1, 402.3.**

108. Thickness of structural members in cargo oil spaces

The thickness of structural members in cargo oil spaces is to be in accordance with the following:

(1) The thickness of shell plating is not to be less than that obtained from the formulae in **Pt 3, Ch 4, 302., 304., 305.** and **404.** using 2.0 in lieu of 1.5 in the formulae.

(2) The thickness of deck plating of freeboard deck is not to be less than that obtained from the formulae in **Pt 3, Ch 5, 301.** using 2.0 in lieu of 1.5 in the formulae.

(3) Where frames, beams, stiffeners and other members for which the scantlings are specified by the section modulus only consist of flanged plates, special sections or web and face plates, the thickness of web plates is not to be less than that obtained from the following formula. Where the depth of web plates, however, is specially made deeper due to the reason from other than strength, the preceding requirements may be modified.

$$t = 0.015\ k_0 d_0 + 2.5 \quad (mm)$$

where:

d_0 = depth of web plates (mm)

k_0 = as given in the following formulae. However, value of f_B and f_D is not to be less than 1.0.

Longitudinals located not more than $0.25D$ above top of keel:

$$k_0 = \sqrt{\frac{1}{4}\left(3\,f_B + \frac{1}{K}\right)}$$

Longitudinals located not less than $0.25D$ below deck:

$$k_0 = \sqrt{\frac{1}{4}\left(3\,f_D + \frac{1}{K}\right)}$$

Other members:

$$k_0 = \sqrt{\frac{1}{4}\left(3 + \frac{1}{K}\right)}$$

(4) Various girders, longitudinal, transverse, vertical or horizontal, the cross ties and end connecting brackets thereof and various bulkhead platings are not to be of less thickness than determined from **Table 7.1.1** according to the length of ship.

Table 7.1.1 Minimum Thickness

Length of ship (m)	Thickness (mm)
L 〈 105	8.0
105 $\le L$ 〈 120	8.5
120 $\le L$ 〈 135	9.0
135 $\le L$ 〈 150	9.5
150 $\le L$ 〈 165	10.0
165 $\le L$ 〈 180	10.5
180 $\le L$ 〈 195	11.0
195 $\le L$ 〈 225	11.5
225 $\le L$ 〈 275	12.0
275 $\le L$ 〈 325	12.5
325 $\le L$ 〈 375	13.0
375 $\le L$	13.5

(5) The thickness of flat bar and tripping bracket, etc. fitted up on web of longitudinal girders, transverses and girders of bulkheads is not to be less than that obtained from the following formula. The thickness need not, however, exceed that of web plates to which they are connected.

$$t = 0.5\sqrt{L} + 2.5 \quad (mm)$$

(6) In no case is the thickness of structural members to be less than 7 mm.

109. Direct calculation

Where approved by the Society, the scantlings of structural members may be determined basing upon direct calculation defined in **Pt 3, Ch 1, 206.**

SECTION 2
Hatchways, Gangways and Freeing Arrangements

201. Ships having unusually large freeboard

Relaxation from the requirements specified hereunder will be considered to ships having an extraordinarily large freeboard.

202. Hatchways to cargo oil tanks

1. The thickness of coaming plates is not to be less than 10 mm. Where the length and coaming height of a hatchway exceed 1.25 m and 760 mm respectively, vertical stiffeners are to be provided to the side or end coamings and the upper edge of coamings is to be suitably stiffened.

2. Hatchway covers are to be of steel or other approved materials. The construction of steel hatchway covers is to comply with the following requirements. The construction of hatchway covers of materials other than steel is to be in accordance with the discretion of the Society.

(1) The thickness of cover plates is not to be less than 12 mm. In ships not more than 60 m in length, however, the requirement may be modified.

(2) Where the area of a hatchway exceeds 1 m^2 but does not exceed 2.5 m^2, cover plates are to be stiffened by flat bars of 100 mm in depth spaced not more than 610 mm apart. Where, however, the cover plates are 15 mm or more in thickness, the stiffeners may be dispensed with.

(3) Where the area of a hatchway exceeds 2.5 m^2, cover plates are to be stiffened by flat bars of 125 mm in depth spaced not more than 610 mm apart.

(4) Covers are to be secured oiltight by fastenings spaced not more than 457 mm apart in circular hatchways or 380 mm apart and not more than 230 mm far from the corners in rectangular hatchways.

3. In small ships, the requirements in the preceding Paragraph may be suitably modified.

4. The cover is to be provided with an opening at least 150 mm in diameter which is to be so constructed as to be capable of being closed oiltight by means of a screw plug or a cover of peep hole.

5. Hatchway coamings are to be provided with gas cocks or other suitable exhausting devices.

203. Hatchways to spaces other than for cargo oil tanks

In exposed positions on the freeboard and forecastle decks or on the tops of expansion trunks, hatchways serving spaces other than cargo oil tanks are to be provided with steel watertight covers having scantlings complying with the requirements in **Pt 4, Ch 2, Sec 2.**

204. Permanent gangway and passage

1. A fore and aft permanent gangway complying with the requirements of **Pt 4, Ch 4, 503.** is to be provided at the level of the superstructure deck between the midship bridge or deck house and the poop or aft deck house, or equivalent means of access is to be provided to carry out the purpose of the gangway, such as passage below deck. Elsewhere and in ships without midship bridge or deck house, arrangements to the satisfaction of the Society are to be provided to safeguard the crew in reaching all parts used in the necessary work of the ship.

2. Safe and satisfactory access from the gangway level is to be available between crew accommodations and machinery space or between separated crew accommodations.

205. Freeing arrangements

1. Ships with bulwarks are to have open rails fitted for at least a half of the length of the exposed part of the freeboard deck or other effective freeing arrangements. The upper edge of sheer strake is to be kept as low as practicable.

2. Where superstructures are connected by trunks, open rails are to be provided for the whole length of the exposed parts of the freeboard deck.

SECTION 3
Longitudinal Frames and Beams in Cargo Oil Spaces

301. General

Longitudinal frames and beams provided in permanent ballast water tanks and cargo oil spaces including void spaces and pump rooms are to be in accordance with the requirements stated hereunder.

302. Scantlings

1. The section modulus of bottom longitudinals and side longitudinals including bilge frames is not to be less than that obtained from the formulae given in **Table 7.1.2.**

2. The section modulus of longitudinal beams is not to be less than 1.1 times that obtained from the formula in **Pt 3, Ch 10, 303.**

3. Notwithstanding the provisions in **Pars 1** and **2,** the section modulus of longitudinal frames and beams is not to be less than that obtained assuming them as stiffeners on deep tank bulkhead and taking the distance up to the top of hatchway as h.

4. Longitudinal beams and side longitudinals attached to sheer strake are to be of such dimensions as to have slenderness ratio not exceeding 60 at the midship part as far as practicable. This requirement, however, may be suitably modified for small vessels.

5. As for flat bars used for longitudinal beams and frames, the ratio of depth to thickness is not to exceed 15.

6. The extreme width of face plates of longitudinal beams and frames is not to be less than that obtained from the following formula:

$$b = 2.2\sqrt{d_0\, l} \qquad (mm)$$

where:
d_0 = depth of web of longitudinal beams or frames (mm).
l = spacing of transverses (m).

303. Attachment

Longitudinal frames and beams are to be continuous or to be attached at their ends in such a man-

Table 7.1.2 Section Modulus of Bottom and Side Longitudinals

Position	Section modulus (cm^3)	
	Bottom longitudinals	Side longitudinals including bilge frames
Midship part and between a point 0.15L from the fore end and the collision bulkhead	$Z = 110\, C_1 C_2 K S h l^2$	$Z = 110 C_1 C_2 K S h l^2$ $Z_{min} = 3.2\, K\sqrt{L} S l^2$
Forward and afterward end parts	$Z = 93.5\, C_1 C_2 K S h l^2$	$Z = 93.5\, C_1 C_2 K S h l^2$ $Z_{min} = 2.72\, K\, \sqrt{L} S l^2$

l = spacing of bottom transverses (m).
S = spacing of longitudinals (m).
h = distance from the bottom longitudinal under consideration to the point h' above the top of keel given in the following table (m).
C_1, h', C_2 = as given by the following table.

	C_1	h' (m)	C_2
Bottom longitudinals	$\dfrac{1}{24 - 15.0\, f_B K}$	$h' = d + 0.026\, L'$	1.0 : Where L is 230m and under. 1.07 : Where L exceeds 400m. For the intermediate values of L, C_2 is to be obtained by linear interpolation.
Side longitudinals including bilge frames	$\dfrac{1}{24 - \alpha K}$	$h' = d + 0.038\, L'$	

L' = length of ship (m). Where, however, L exceeds 230m. L' is to be taken as 230m.
α = either α_1 or α_2 according to value of y. However, value of α is not to be less than β.

$$\alpha_1 = 15.0\, f_D\left(\frac{y - y_B}{Y'}\right) \quad \text{for} \quad y \geq y_B$$

$$\alpha_2 = 15.0 f_B\left(\frac{y_B - y}{y_B}\right) \quad \text{for} \quad y < y_B$$

β = coefficient determined according to values of L as specified below :
β = $6/a$ when L is 230m and under
β = $10.5/a$ when L is 400m and above
For intermediate values of L, β is to be obtained by linear interpolation.
y = Vertical distance from the top of keel to the lower edge of the bulkhead plating under consideration(m).
y_B = Vertical distance from top of keel amidship to the horizontal neutral axis of the athwartship section of the hull(m).
Y' = the greater of the value specified in **Pt 3, Ch 3, 203.,** (5) (a) or (b).
a = $\sqrt{K}$, when high tensile steels are used for not less than 80% of side shell plating at the transverse section amidship and 1.0 for other parts.

ner as to effectively develop the sectional area and the resistance to bending.

SECTION 4
Girders, Transverses and Cross Ties in Cargo Oil Spaces

401. General

1. The requirements specified hereunder are intended to be applied to structures consisting of two to five transverses arranged at approximately equal intervals between transverse bulkheads or between the transverse bulkhead and the wash bulkhead.

2. Girders or transverses in the same plane are to be so arranged that abrupt change in the strength and rigidity is avoided; they are to have brackets of sufficient scantling and with properly rounded corners at their ends.

3. The depth of girders or transverses is not to be less than 2.5 times that of slots for frames, beams and stiffeners.

4. As for the face plates composing girders, the thickness is not to be less than that of web plates and the width of the face plates is not to be less than that obtained from the following formula:

$$b = 2.7\sqrt{d_0\, l} \qquad (mm)$$

where:

d_0 = depth of girder (mm). In case where it is a balanced girder, d_0 is the depth from the surface of plate to the face plate (mm).

l = distance between supports of girder (m). Where, however, effective tripping brackets are provided, they may be taken as supports.

5. The requirements of **401.** to **406.** are also to be applied to pump rooms, ballast water tanks or void spaces in the midship part so far as practicable.

402. Transverses and girders provided in centre or side tanks in ships having two or more longitudinal bulkheads

1. Bottom transverses and bottom girders:

(1) The depth, web thickness and section modulus of bottom transverses and the web thickness and section modulus of bottom girders provided in the middle between longitudinal bulkheads are not to be less than those obtained from the given in **Table 7.1.3** respectively.

(2) Where one or two intercostal side girders are provided between longitudinal bulkhead and bottom girders provided at mid-distance of longitudinal bulkheads, and the bottom transverses are of the reduced scantlings in accordance with (3) below, the sectional area of web plates and moment of inertia of side girders are not to be less than those obtained from the following formulae:

Sectional area of web plates:

$$A = \alpha_1 \cdot \frac{L_0}{B_0} \cdot d_0\, t_0 \qquad (cm^2)$$

Moment of inertia:

$$I = \alpha_2 \cdot \left(\frac{L_0}{B_0}\right)^3 \cdot I_0 \qquad (cm^4)$$

where:

α_1, α_2 = coefficients given in **Table 7.1.4.**

I_0 = moment of inertia of bottom transverses (cm^4).

L_0, B_0, d_0, t_0 = as specified in **Table 7.1.3.**

Table 7.1.4 Coefficients α_1 and α_2

Number of side girders	Coefficient	
	α_1	α_2
1	0.0085	0.67
2	0.0045	0.42

(3) Where intercostal side girders are provided in accordance with (2), the bottom transverses and girders may be of the scantlings obtained from the formulae in (1), using coefficients C_0, C_1, C_2, C_3 and C_4 reduced by 10% where two transverses are provided and 5% where three transverses are provided.

(4) In ships without longitudinal centre line bulk heads, a centre girder with brackets at proper intervals is to be provided so as to maintain sufficient strength where the ship is dry-docked on keel blocks.

2. Deck transverses and girders:

(1) The depth and section modulus of deck transverses are not to be less than those obtained from the following formulae:

Depth of transverses:

$$d = C_0 l_0 \quad (m)$$

Section modulus of transverses:

$$Z = CKk^2\sqrt{L}\,S\,l_0^{\,2} \qquad (cm^3)$$

where:

C_0, C = coefficients given in **Table 7.1.5** respectively.

Table 7.1.3 Scantlings of Bottom Transverses and Bottom Girders

	Depth (mm)	Web thickness (mm)	Section modulus (cm^3)
Bottom transverses	$d = C_0 l_0$	Thickness at the inner edge of bracket attached to longitudinal bulkhead $t = \left(C_1 - 87\frac{b}{l_0}\right)\frac{KQ}{d_0' - a} + 2.5$	$Z = C_2 Kk^2 Q l_0$
Bottom girders	—	$t = C_3 \frac{\eta KQ}{d_1'} + 2.5$	$Z = C_4 KkQ l_1$

Q = $\alpha S h_1 l_0$

α = 1.0: where L is 230 m and under
1.2: where L exceeds 400 m.
For the intermediate values of L, α is to be obtained by linear interpolation.

h_1 = as given by the following formula:

$d + 0.026L'$ (m).

L' = length of ship (m). Where, however, L exceeds 230 m, L is to be taken as 230 m.

S = spacing of transverses (m), (see **Fig. 7.1.2**)

l_0 = overall length of transverses (m). Which is equal to B_0 or $(B_0 - d_3)$ where d_3 depth of vertical web attached to the centre line bulkhead (m).

b = length of horizontal arm of bracket connecting transverse to longitudinal bulkhead (m). (see **Fig. 7.1.1**)

d'_0 = depth of transverse at the inner edge of the above mentioned bracket (mm). (see **Fig. 7.1.1**)

a = depth of slot (mm). Where, however, the slots near the inner edge of brackets are provided with collar plates, a may be taken as zero.

d'_1 = depth of girder including bracket at the transverse nearest to the bulkhead (mm). (see **Fig. 7.1.2**)

l_1 = overall length of girder, which is equal to $(L_0 - d_2)$ (m), where d_2 is depth of vertical web on transverse bulkhead (m). (see **Fig. 7.12**)

k = correction factor due to bracket given by the following formula:

$$k = 1 - \frac{0.65(b_1 + b_2)}{l}$$

b_1, b_2 = arm length of brackets at both ends of girders and transverses respectively (m).

l = overall length of girders and transverses (m), which is equal to l_0 or l_1.

η = as given by the following table.

Number of transverses	$\beta = \frac{S - d_2}{S}$ (see **Fig. 7.1.2**)	η
Two rows	$0 \le \beta < \frac{2}{3}$	$\eta = 2 - 1.5\beta$
	$\frac{2}{3} \le \beta$	$\eta = 1.0$
Three to five rows	$0 \le \beta < 0.5$	$\eta = 1.6 - 1.2\beta$
	$0.5 \le \beta$	$\eta = 1.0$

d_0, t_0 = depth (mm) and web thickness (mm) of transverses respectively.

d_1, t_1 = depth (mm) and web thickness (mm) of girders respectively.

B_0 = distance between longitudinal bulkheads (m).

L_0 = distance between transverse bulkheads (m).

C_0, C_1, C_2, C_3, C_4 = as obtained from the following table according to K_0 respectively.

Number of transverses	Coef-ficient	$K_0 = \frac{d_0 t_0}{d_1 t_1} \cdot \frac{L_0}{B_0}$									
		$K_0 \le 0.2$	0.2 〈 K_0 ≤ 0.3	0.3 〈 K0 ≤ 0.4	0.4 〈 K_0 ≤ 0.5	0.5 〈 K_0 ≤ 0.6	0.6 〈 K_0 ≤ 0.7	0.7 〈 K_0 ≤ 0.8	0.8 〈 K_0 ≤ 1.0	1.0 〈 K_0 ≤ 1.2	Where no girder is provided
Two rows	C_0	0.090	0.095	0.100	0.105	0.110	0.115	0.120	0.125	0.135	0.160
	C_1	23.6	24.3	25.5	26.7	27.8	29.0	30.1	31.8	34.0	43.7
	C_2	1.44	1.47	1.54	1.63	1.77	1.94	2.12	2.43	2.87	5.69
	C_3	36.8	34.5	32.3	30.5	28.5	26.6	24.8	22.2	18.8	-
	C_4	8.08	7.65	7.04	6.51	6.25	5.73	5.21	4.09	4.17	-
Three rows	C_0	0.090	0.095	0.100	0.105	0.110	0.115	0.120	0.125	0.135	0.160
	C_1	24.0	25.5	26.7	27.8	29.4	30.5	31.7	33.6	36.3	43.7
	C_2	1.47	1.54	1.63	1.79	1.96	2.19	2.43	2.84	3.41	5.69
	C_3	57.2	54.0	50.9	47.5	44.6	42.3	39.9	36.0	31.3	-
	C_4	10.42	9.65	8.97	8.34	7.67	7.06	6.51	5.73	4.69	-
Four rows	C_0	0.090	0.095	0.100	0.105	0.110	0.115	0.120	0.125	0.135	0.160
	C_1	24.4	25.9	27.1	28.6	30.0	31.3	32.7	34.8	37.5	43.7
	C_2	1.47	1.54	1.70	1.87	2.03	2.28	2.52	3.01	3.73	5.69
	C_3	76.0	68.1	64.2	60.3	56.4	52.5	48.5	43.5	36.8	-
	C_4	10.69	9.65	8.86	8.08	7.34	6.80	5.99	5.27	4.17	-
Five rows	C_0	0.095	0.100	0.105	0.110	0.115	0.120	0.125	0.135	0.145	0.160
	C_1	24.7	26.3	27.4	29.4	30.9	32.5	34.0	36.7	40.2	43.7
	C_2	1.54	1.63	1.79	2.03	2.28	2.52	2.83	3.50	4.46	5.69
	C_3	94.0	83.8	78.3	72.8	67.5	62.6	57.2	49.5	39.2	-
	C_4	15.64	13.56	12.50	11.46	10.16	9.12	8.08	6.78	4.69	-

NOTES:

1. Where strong vertical girders are provided on transverse bulkheads at one side only in case of four or five transverses, coefficient C_4 is to be increased appropriately.
2. Where the depth of centre line bottom girder is of extremely large depth, coefficient C_4 may be suitably modified.

Table 7.1.5 Coefficients C_0 and C

Number of transverses	$K_0 = \frac{d_0 t_0}{d_1 t_1} \cdot \frac{L_0}{B_0}$	C_0	C
Two and three	$K_0 \le 0.5$	0.07	0.79
	$K_0 \ge 1.5$	0.10	1.82
Four	$K_0 \le 0.4$	0.07	0.79
	$K_0 \ge 1.4$	0.10	1.82
Five	$K_0 \le 0.3$	0.07	0.79
	$K_0 \ge 1.3$	0.10	1.82
NOTE: For intermediate values of K_0, C_0 and C are to be obtained by linear interpolation.			

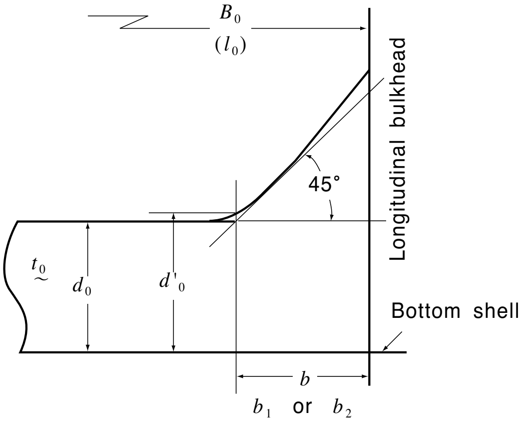


Fig. 7.1.1 Measurement of b, d_0, d_0', etc.

d_0, t_0 = depth (mm) and web thickness (mm) of transverses respectively.

d_1, t_1 = depth (mm) and web thickness (mm) of girders respectively.

L_0, B_0, S, k = as specified in **Table 7.1.3.**

l_0 = overall length of transverses (m), which is equal to B_0 or $(B_0 - d_3)$, where d_3 is depth of vertical web on centre line bulkhead (m).

(2) Deck girders provided at the mid-distance of longitudinal bulkheads may be of scantlings determined in relation to those of deck transverse specified in (1). Where deck girders from a ring system together with strong vertical webs on transverse bulkheads as specified in **505.**, the depth of girders is not to be less than that obtained from the following formula.

$$d = \frac{L_0 D}{9 B_0} \quad (m)$$

where:

B_0, L_0 = as specified in **Table 7.1.3.**

3. Transverses provided on longitudinal centre line bulkheads are not to be of less scantling than determined in accordance with **403. 2**(2) for transverses on longitudinal bulkheads in wing tanks.

403. Transverses and girders provided in wing tanks in ships having two or more longitudinal bulkheads

1. Side transverses

(1) Symbols used in this Paragraph are defined as frollows:

$$Q = \alpha S h l_0$$

α = 1.0 where L is 230 m and under,
1.2 where L exceeds 400 m

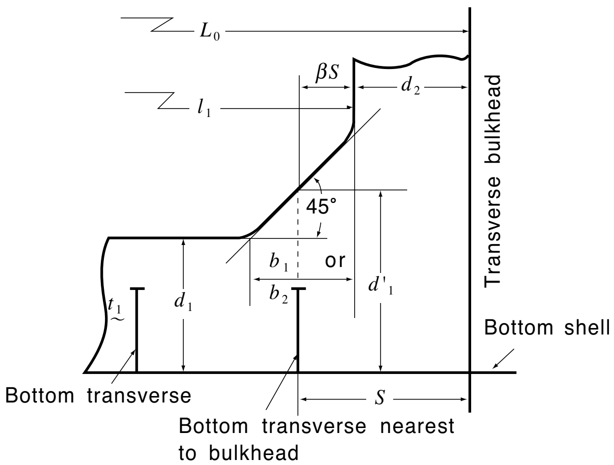


Fig. 7.1.2 Measurement of d_1, d_1', d_2, S, etc.

For intermediate values of L, α is to be obtained by linear interpolation.

h = distance from the mid-point of l_0 to the point H_2 above the top of keel (m).

h_S = distance from the mid-point of b_S to the point H_2 above the top of keel (m).

$$H_2 = d + 0.038 L' \quad (m)$$

L' = length of ship (m). Where L' exceeds 230 m, L' is to be taken as 230 m.

l_0 = overall length of side transverses (m), which is equal to the distance between the inner surfaces of face plates of bottom transverses and deck transverses. (See **Fig. 7.1.3**)

S = spacing of transverses (m) .

S' = spacing of stiffeners provided depthwise on the web plates of transverses at the portion where cross ties are connected (m).

k = as specified in **Table 7.1.3.**

b = length of arm of the lowest bracket (m). (See **Fig. 7.1.3**)

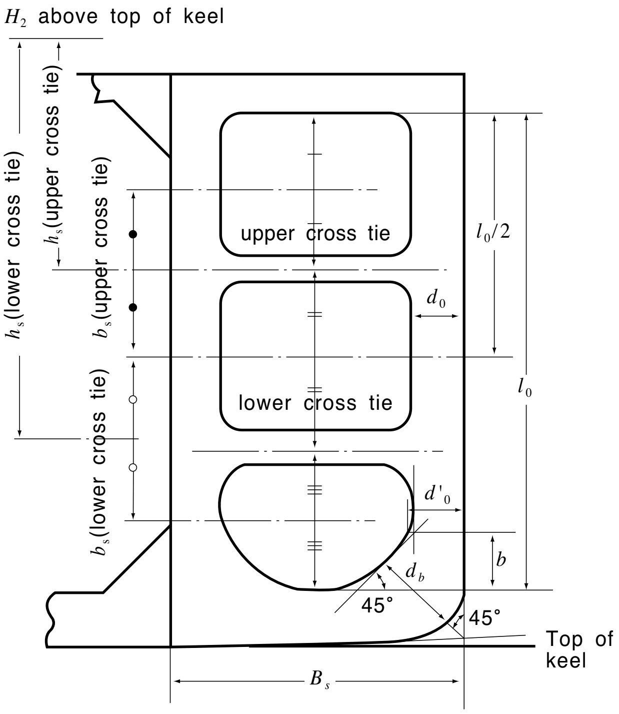


Fig. 7.1.3 Measurement of l_0, d_0', b, b_S, etc.

b_S = width of the area supported by cross ties (m). (See **Fig. 7.1.3**)

d_0' = depth of side transverses at the inner edge of the lowest bracket (mm). (See **Fig. 7.1.3**)

a = depth of slot in the vicinity of inner edge of the lowest bracket. Where, however, the slots are provided with collar plates, a may be taken as zero.

A = section area effective to support the axial force from cross tie (cm^2), which is to be taken as follows:

(a) Where the face plates of cross ties are continuous to the face plates of transverses in an arc form or a similar form, A is the total sum of the sectional area of the web plate of transverse at the portion between the contact points of the tangents to the arc or the similar curve making an angle of 45° to the direction of cross tie, that of the stiffener provided in the axial direction of cross tie on the web plate between the contact points, and 0.50 times that of the face plates at the contact points. (See **Fig. 7.1.4** (a))

(b) Where the face plates of cross ties are continuous to the face plates of transverses in the form of straight line with rounded corners, A is the total sum of the sectional area of the web plate of transverse at the portion between the midpoints of the intersections of the extensions of the lines of inner surface of face plates of both cross tie and transverse with the lines making an angle of 45° to the direction of cross tie in contact with the inner surface of face plates at the transforming parts, that of the stiffener provided in the axial direction of cross tie on the web plate between the above mentioned mid-points and 0.50 times that of the face plates at the mid-points. (See **Fig. 7.1.4** (b))

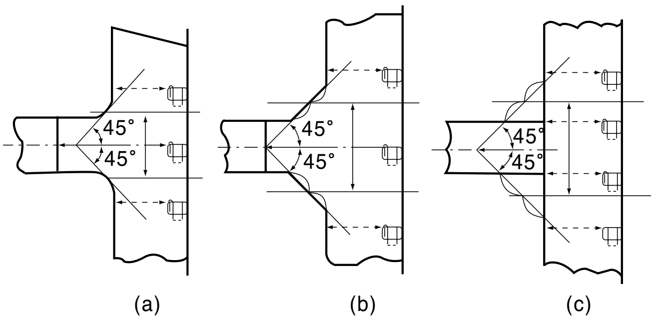


Fig. 7.1.4 Extent for Total Sectional Area

(c) Where the face plates of cross ties are joined directly to the face plates of transverses with a right or nearly right angle and both face plates are connected with brackets and further, stiffeners are provided on the web plate of transverses on the extended lines of face plates of cross tie, A is the total sum of the sectional area of the web plate of transverse at the portion between the mid-points of the intersections of the extensions of lines of inner surface of face plates of both cross tie and transverse with the lines making an angle of 45° to the direction of cross tie in contact with the free edge lines of brackets, and that of the stiffeners provided as mentioned above. (See **Fig. 7.1.4** (c))

C_0, C_1, C_2 = coefficients given in **Table 7.1.6** according to the number of cross ties respectively.

Table 7.1.6 Coefficients C_0, C_1, C_2 and C_2'

Number of cross ties	C_0	C_1	C_2	C_2'
0	0.150	55.7	5.07	7.14
1	0.110	44.8	2.70	4.42
2	0.100	39.4	2.28	3.74
3	0.095	36.2	2.12	3.49

(2) The depth of transverses is not to be less than $C_0 l_0$ (m) at the mid-point of l_0. Where the transverses are of tapered form, the reduction in depth at the upper end is not to exceed 10% of the depth at the mid-point of l_0, and the rate of increase in depth at the lower end is not to be less than that of reduction at the upper end.

(3) The web thickness of transverses at the inner edge of brackets at the lower ends is not to be less than that obtained from the following formula. Where, however, bottom transverses and longitudinal bulkheads in centre tanks or inner tanks are connected with large brackets extending to the lowest cross ties, the web thickness of side transverses may be properly reduced.

$$t = \left(C_1 - 148\frac{b}{l_0}\right)\frac{KQ}{d_0 - a} + 2.5 \quad (mm)$$

(4) The web thickness of transverses at the portion where cross ties are connected is not to be less than that obtained from the following formula. Where slots are provided in the web at the portion where cross ties are connected, the slots are to be effectively covered with collar plates.

$$t = 16\sqrt{\frac{\alpha S b_s h_s}{A}} \cdot S' \quad (mm)$$

(5) The section mudulus of transverses at the span is not to be less than that obtained from the following formula:

$$Z = C_2 K k^2 Q\, l_0 \quad (cm^3)$$

2. Vertical webs on longitudinal bulkheads

(1) Vertical webs on longitudinal bulkheads connected to side transverses with effective cross ties are to be of the scantlings required in **Par 1** for side transverses with cross ties.

(2) Vertical webs on longitudinal bulkheads without cross ties are generally to be of the scantlings required in **Par 1** for side transverses without cross ties. However, h is to be the distance from the mid-point of l_0 to the top of hatches of inner tanks or centre tanks (m).

3. Bottom transvenes

(1) The rigidity of bottom transverses is to be well balanced with that of side transverses.

(2) The section modulus of bottom transverses at the span is not to be less than that obtained from the following formula:

$$Z = 9.3 K\alpha k^2 S h_1 l_1^2 \quad (cm^3)$$

where:
α, k, S = as specified in **Par 1** (1).
h_1 = as specified in **Table 7.1.3.**
l_1 = overall length of bottom transverses (m), which is equal to the distance between the inner surface of face plates of bottom transverses and that of vertical webs on longitudinal bulkheads.

(3) The section modulus of transverses at bilge and at the lower end of longitudinal bulkheads is not to be less than that obtained from the following formula. Where, however, bottom transverses and vertical webs on longitudinal bulkheads in centre tanks or inner tanks are connected with large brackets extending to the lowest cross ties, the section modulus of transverses specified above may be properly reduced. In calculating the section modulus, the neutral axis of section is to be taken as located at the middle of the depth d_b (See **Fig. 7.1.3**) of transverses.

$$Z = C'_2 KQ\, l_0 \quad (cm^3)$$

where:
Q, l_0 = as specified in **Par 1** (1) respectively.
C'_2 = coefficient given in **Table 7.1.6** according to the number of cross ties.

4. Deck transverses

(1) The rigidity of deck transverses is to be well balanced with that of side transverses.

(2) The section modulus of deck transverses is not to be less than that obtained from the following formula:

$$Z = 3 K k^2 S\sqrt{L} \cdot l_2^2 \quad (cm^3)$$

where:
k, S = as specified in **Par 1**(1) respectively.
l_2 = overall length of deck transverses (m), which is equal to the distance between the inner edges of face plates of side transverses and that of vertical webs on longitudinal bulkheads.

5. Transverses and girders where longitudinal girders are provided on ship's side and on longitudinal bulkheads:

The requirements in this Paragraph are intended to be applied to the structures consisting of one, two or three side stringers or horizontal girders and three thansverses in association with cross ties provided only at the crossing point of middle transverses and side stringers to connect ship's sides to longitudinal bulkheads.

(1) The scantlings of side transverses and the section modulus of transverses at bilge are not to be less than those obtained from the

formulae given in **Pars 1** and **3** respectively, using C_0, C_1, C_2, and C_2' as given in **Table 7.1.7** according t_0 the value of K given by the following formula:

$$K = \frac{d_0}{d_1} \cdot \left(\frac{l_1}{l_0}\right)^2$$

where:

d_0 = mean depth of side transverses (mm).
l_0 = as specified in **Par 1**(1).
d_1 = mean depth of side stringers (mm).
l_1 = overall length of side stringers (m), which is equal to the distance between transverse bulkheads minus the depth of horizontal girders on transverse bulkheads.

(2) The section modulus of side stringers and the web thickness of side stringers in the span from the end of side stringer to the crossing point of side stringer and side transverse at the end are not to be less than those obtained from the following formulae respectively. Where three side stringers are provided, the web thickness of the uppermost stringers may be properly reduced.

Web thickness:

$$t = C_3 K \frac{Q}{d_1} + 2.5 \quad (mm)$$

Section modulus of side stringer:

$$Z = C_4 KkQ\, l_1 \quad (cm^3)$$

where:

Q, k = as specified in **Par 1** (1) respectively.
d_1, l_1 = as specified in (1) respectively.
C_3, C_4 = coefficients given in **Table 7.1.7** according to the value of K.

(3) The web thickness of transverses and side stringers at the portion where cross ties are

Table 7.1.7 Coefficients C_0, C_1, C_2, C'_2, C_3 and C_4

Number of girders	Coefficient	$K = \frac{d_0}{d_1}\left(\frac{l_1}{l_0}\right)^2$											
		$K \le 0.2$	$0.2 < K \le 0.3$	$0.3 < K \le 0.4$	$0.4 < K \le 0.5$	$0.5 < K \le 0.6$	$0.6 < K \le 0.7$	$0.7 < K \le 0.8$	$0.8 < K \le 0.9$	$0.9 < K \le 1.0$	$1.0 < K \le 1.2$	$1.2 < K \le 1.4$	$1.4 < K \le 1.6$
One	C_0	0.070	0.080	0.085	0.090	0.095	0.095	0.100	0.100	0.100	0.105	0.105	0.110
	C_1	36.9	37.8	39.0	40.0	41.1	41.8	42.5	42.9	43.2	43.6	43.9	44.3
	C_2	1.44	1.60	1.77	1.89	2.03	2.11	2.22	2.29	2.37	2.45	2.53	2.63
	C_2'	2.89	3.06	3.23	3.40	3.55	3.69	3.81	3.91	4.00	4.08	4.18	4.24
	C_3	45.0	39.6	36.9	34.5	32.4	30.6	28.9	27.4	26.1	24.3	22.0	19.8
	C_4	4.06	3.55	3.26	3.03	2.81	2.61	2.44	2.30	2.16	2.00	1.85	1.70
Two	C_0	0.060	0.072	0.075	0.080	0.085	0.085	0.090	0.090	0.090	0.095	0.095	0.100
	C_1	27.2	29.1	30.8	32.4	33.4	34.3	35.1	35.7	36.3	37.1	38.0	38.9
	C_2	0.76	0.93.	110	1.25	1.40	1.51	1.61	1.70	1.81	1.94	2.11	2.19
	C_2'	1.62	1.87	2.13	2.34	2.55	2.72	2.89	30.4	3.13	3.31	3.46	3.57
	C_3	30.6	27.9	26.0	24.3	23.0	21.8	20.7	19.7	18.7	17.3	15.3	13.5
	C_4	2.96	2.66	2.48	2.30	2.14	1.98	1.85	1.72	1.62	1.48	1.33	1.18
Three	C_0	1.050	0.060	0.065	0.070	0.075	0.080	0.080	0.085	0.085	0.090	0.090	0.095
	C_1	23.2	25.1	26.8	28.1	29.2	30.2	31.1	32.0	32.9	33.9	34.8	35.7
	C_2	0.050	0.68	0.84	0.98	1.11	1.24	1.35	1.44	1.53	1.69	1.86	2.03
	C_2'	1.19	1.45	1.70	1.87	2.10	2.30	2.47	2.64	2.78	2.98	3.15	3.32
	C_3	26.1	24.3	23.4	22.5	21.6	20.7	19.8	18.9	18.0	16.7	15.0	13.2
	C_4	2.52	2.22	2.07	1.92	1.78	1.66	1.56	1.47	1.39	1.26	1.11	0.96

NOTE:

1. Where two side stringers are provided, 1.2 C_3 and 1.2 C_4 are to be used for the lower stringer, and 0.8 C_3 and 0.8 C_4 for the upper stringer, in place of C_3 and C_4 respectively.
2. Where three side stringers are provided, 1.3 C_4 is to be used for the lowest stringer, and 0.7 C_4 for the uppermost stringer, in place of C_4 respectively.

connected is not to be less than that determined in accordance with **Par 1** (4). However, in the formula therein:

S = a half of l_1 specified in (1).

S' = spacing of stiffeners provided in depthwise on webs of side transverses and vertical webs on longitudinal bulkheads, or on side stringers and stringers on longitudinal bulkheads respectively at the portion where the cross ties are connected (m).

A = effective sectional area to support the axial force from cross ties (cm^2). Where cross ties consist of the members provided both on web plate of transverses and stringers, the area is equal to the total sectional area of these members which are to be determined in general as required in **Par 1** (1).

(4) Vertical webs and horizontal girders on longitudinal bulkheads are not to be of less scantlings than determined in accordance with (1) and (2).

(5) Where n tiers of horizontal girders are provided, the distances between the girders, the girder and the deck, and the girder and the top of keel are not to be less than $0.85D/(n+1)$ nor more than $1.15D/(n+1)$ as far as practicable.

(6) Where two or more horizontal girders are provided, the uppermost girder may, if properly arranged, be of the depth reduced by not more than 10% from the mean depth of the girders.

404. Cross ties

1. In ships having two or more longitudinal bulkheads where side transverses and vertical webs on longitudinal bulkheads in wing tanks are connected with cross ties and where the structural arrangements are as given in **403. 5,** the cross ties are to be in accordance with the following requirements.

2. As regards the spacing of cross ties, the requirements in **403. 5** (5) are to be applied in general.

3. The sectional area of cross ties connecting side transverses to vertical webs on longitudinal bulkheads in wing tanks is not to be of less than section area obtained from the formula given in **Table 7.1.8.**

4. (1) Brackets are to be provided at the ends of cross ties to connect to transverses or girders.

(2) Transverses are to be provided with tripping brackets at the junction with cross ties.

(3) Where the breadth of face plates forming cross ties exceeds 150 mm on one side of the web, stiffeners connected to web and face plates are to be fitted at proper intervals.

Table 7.1.8 Section Area of Cross Tie and Thickness of Web

Section area (cm^2)	Thickness of web (mm)
Whichever is the greater : $A = \dfrac{0.77K\alpha S b_S h_S}{1-0.5\dfrac{l}{k\sqrt{K}}}$; $A = 1.1K\alpha \cdot S \cdot b_S \cdot h_S$	$t = 16\sqrt{\dfrac{\alpha \cdot S \cdot b_S \cdot h_S}{A}} \times d_0$

α = as specified in **403. 1** (1).
S = spacing of transverses (m). Where, however, constructed as specified in **403. 5,** S is to be taken as a half of l_1 specified in **403. 5** (1) (m).
b_S = width of the area supported by cross ties (m). (See **Fig. 7.1.3**).
h_S = distance from the mid-point of b_S to the point H_2 specified in **403. 1** (1) above the top of keel (m).
l = length of cross ties measured between the inner edges of the side transverses (or stringers) and the vertical webs (or horizontal girders) on longitudinal bulkheads (m).

$k = \sqrt{I/A}$ (cm)

I = the least moment of inertia of cross ties (cm^4).
A = sectional area of cross ties (cm^2).
d_0 = depth of web plates (mm). Where, however, stiffeners are provided lengthwise on the web plates, the depth may be considered to be divided by the stiffeners.

405. Minimum thickness of web plates, scantling of stiffeners

1. (1) The web thickness of girders situated below the position of approximately 0.25 D above the top of keel is not to be less than that required by **108.** (4) or that obtained from the following formula, whichever is the greater.

$$t = 13.2\frac{Cd_0}{\sqrt{K}} + 2.5 \quad (mm)$$

where:

d_0 = depth of web plates (m). Where stiffeners are provided horizontally on the mid-part of web plates, distance between the stiffener and shell plating or face plate (m), or between the stiffeners (m).

C = coefficient which is determined from **Table 7.1.9** according to the ratio of S to d_0 where

Table 7.1.9 Coefficient C

S/d_0	C
$\dfrac{S}{d_0} \geq 1.0$	1.0
$\dfrac{S}{d_0} < 1.0$	$\sqrt{\dfrac{S}{d_0}}$

S is the spacing of stiffeners provided on web plates in the depthwise (m).

(2) The web thickness of girders situated above the position of approximately 0.25 D below the lower edge of deck at ship's sides is not to be less than that required by **108.** (4) or that obtained from the following formula, whichever is the greater:

$$t = 11.0 \frac{Cd_0}{\sqrt{K}} + 2.5 \quad (mm)$$

where:
d_0, C = as specified in (1).

(3) The web thickness of transverse girders and longitudinal girders other than those specified in the above (1) and (2) is not to be less than that required by **108.** (4) or that obtained from the following formula, whichever is the greater. The girders situated higher than $D/3$ above the top of keel or the lower edge of face plate at the lower side of the second cross ties from deck, whichever is the lower, may have the web thickness as obtained from the formula with its first term multiplied by 0.85, subject to the requirements of (i) and (ii) in this Sub-paragraph (b).

$$t = \frac{Cd_0}{\sqrt{K}} + 2.5 \quad (mm)$$

where:
d_0 = as specified in (1).
C = coefficient determined from **Table 7.1.10,** according to the ratio of S to d_0 and the stiffened panel arrangement, where S is the spacing of stiffeners provided on web plates in the depthwise (m). For the intermediate value of S/d_0, C is to be obtained by linear interpolation.

Table 7.1.10 Coefficients C_1, C_2 and C_3

S/d_0	C_1	C_2	C_3
0.2 or less	2.6	2.1	3.7
0.4	4.5	3.7	6.7
0.6	5.6	4.9	8.6
0.8	6.4	5.8	9.6
1.0	7.1	6.6	9.9
1.5	7.8	7.4	10.3
2.0	8.2	7.8	10.4
2.5 or more	8.4	8.0	10.4

(a) Where no stiffener is provided in parallel with face plates ----------------------------- C_1
Where, however, slots are provided, C_2 is to be used and the web thickness is not to be less than that obtained by applying the requirements of (i) in this sub-paragraph.

(b) Where stiffeners are provided in parallel with face plates,
For panel between face plate and stiffener or between stiffeners ----------------------- C_3
However, the thickness need not exceed the value obtained by using coefficient C_1, Subject to no stiffener in parallel to face plate and no slot being provided. For panel between stiffener and shell plating------ C_2

(i) Where slots are provided on webs with no reinforcement, the first term of the formula is to be multiplied by the following factor:

$$\sqrt{4.0 \frac{d_1}{S} - 1.0}$$

where d_1/S is 0.5 or less, the multiplier is to be taken as 1.0.

where:
d_1 = depth of slots (m).

(ii) Where openings are provided on webs with no reinforcement, the first term of the formula is to be multiplied by the following factor:

$$1 + 0.5 \frac{\phi}{a}$$

where:
a = length at the longer side of the panel surrounded by the web stiffeners (m).
ϕ = diameter of openings (m). Where openings are of oblong, ϕ is to be the length of the longer diameter (m).

(4) The depth of flat bar stiffeners provided on girders and transverses is not to be less than 0.08 d_0. Where, however, the stiffeners are fitted to the full depth of girders, d_0 is to be taken as the depth of girders, and where the stiffeners are fitted to the length from the top of longitudinal frames which penetrate girders to the face plate of girders, d_0 is to be taken as the depth of girders minus the height of longitudinal frames, and where the stiffeners are fitted in parallel with face plates, d_0 is to be taken as the spacing of tripping brackets.

(5) Tripping brackets are to be provided on the web plate of transverses at the inner edge of end brackets and at the connecting part of crossties, etc. and also at the proper intervals in order to support transverses effectively. Where the breadth of face plates exceeds 180 mm on one side of the web, the tripping brackets are to be connected to face plates as well.

2. Where horizontal flat bar stiffeners are provided on bottom and deck girders, the stiffeners are not to be of less depth than $0.06\,l$, notwithstanding the requirements in **Par 1** (4). For strong bottom girders supporting bottom transverses, however, the horizontal stiffeners are not to be of less depth than $0.08\,l$, where l is the spacing of transverses (m), except that where brackets extending for the full depth of girders are provided at the midpoint of l, l may be taken as a half of the spacing of transverses.

3. Where flat bar stiffeners are connected at their ends to face plates, tripping brackets, etc., the depth of stiffeners as specified in **Par 1** (4) and **Par 2** may be properly reduced.

406. Special consideration on stiffening girders, webs and end connection brackets

Connecting brackets of bottom transverses to web plates on longitudinal bulkheads and the web plates in the vicinity of the inner edge of connecting brackets, and connecting brackets of bottom girders to web plates on transverse bulkheads (oiltight, watertight and wash) and the web plates in the vicinity of the inner edge of connecting brackets which are respectively stituated in centre tanks or inner tanks, and side transverses and connecting brackets at the lower end of vertical webs on longitudinal bulkheads and the web plates in the vicinity of the inner edge of connecting brackets, and connecting brackets of side stringers to web plates on transverse bulkheads and the web plates in the vicinity of the inner edge of connecting brackets which are respectively situated in wing tanks, are to be specially provided with stiffeners in a close spacing. Further, on the web plates at the portions specified above is to be given a special consideration to prevent buckling, where the plates are unavoidably lap jointed.

SECTION 5
Bulkheads in Cargo Oil Spaces

501. Sectional area of transverse bulkhead plating in centre tanks

The sectional area of transverse bulkhead plating in the depthwise direction of ship in centre tanks is not to be less than that obtained from the following formula:

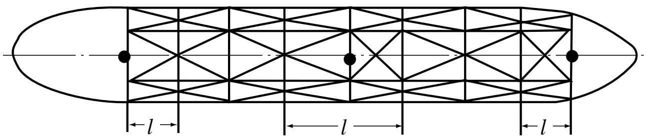
$$A = 0.95\,KS(h - 0.32\,d)(l - S)\left(C + \frac{Y}{l - S}\right) \quad (cm^2)$$

where:

S = spacing of bottom transverses (m).

h = distance from the top of keel to the top of hatches in centre tanks (m).

l = distance between two bulkheads of watertight, oiltight or wash, which are situated respectively forward and afterward of the bulkhead concerned (m). Where the bulkhead concerned, however, is situated at the fore or after end of cargo oil spaces, l is to be the distance from such end bulkhead to the bulkhead of watertight, oiltight or wash, which is situated forward or afterward of the bulkhead respectively (m). (See **Fig. 7.1.5**)



● marks show the bulkheads concerned

Fig. 7.1.5 Measurement of l

Y = distance measured athwartship from ship's centre line (m).

C = coefficient which is to be taken as zero where no centre line girder is provided in the bottom structure of centre tanks, and to be obtained from the following formula where centre line girder is provided:

$$C = \frac{0.175}{1 + 131.0\,\dfrac{a}{D}\left(\dfrac{1.5\,K_b^{\,3}}{1 + 15.6\,K_b^{\,2}} + \dfrac{K_d^{\,3}}{1 + 15.6\,K_d^{\,2}}\right)} \cdot \frac{a}{S}$$

where:

a = half-breadth of centre tanks (m).

K_b, K_d = ratio of h_b/l and h_d/l, respectively, where h_b is the height of centre line bottom girder (m) and h_d is the height of centre line deck girder (m).

502. Thickness of bulkhead plating

1. The thickness of bulkhead plating is not to be less than that obtained from the formula in **Pt 3, Ch 15, 202.** for deep tank bulkhead plating, using h measured from the lower edge of plating to the top of hatches (m) or $0.3\sqrt{L}$ (m), whichever is the greater.

2. The breadth of the uppermost and lowest strakes of longitudinal bulkhead plating is not to be less than $0.1\,D$ and the thickness of these is not to be less than that obtained from the following formulae:

For lowest strakes: $t = 1.1\,S\sqrt{KL} + 2.5 \quad (mm)$

For uppermost strakes: $t = 0.85\,S\sqrt{KL} + 2.5 \quad (mm)$

where:
S = spacing of stiffeners (m).

3. The thickness of longitudinal bulkhead plating is to comply with the requirements of **Pt 3, Ch 3, Secs 3** and **4.**

503. Stiffeners

1. The section modulus of stiffeners is not to be less than that obtained from the formula in **Pt 3, Ch 15, 203.** and **207.** for deep tank bulkhead stiffeners, using h measured from the midpoint of l in case of vertical stiffeners or from the centre of the width of plating supported by the stiffener in case of horizontal stiffeners to the top of hatches (m) or $0.3\sqrt{L}$ (m), whichever is the greater.

2. Horizontal stiffeners provided on upper and lower parts of longitudinal bulkhead plating are to be of increased scantling above those specified in the preceding Paragraph.

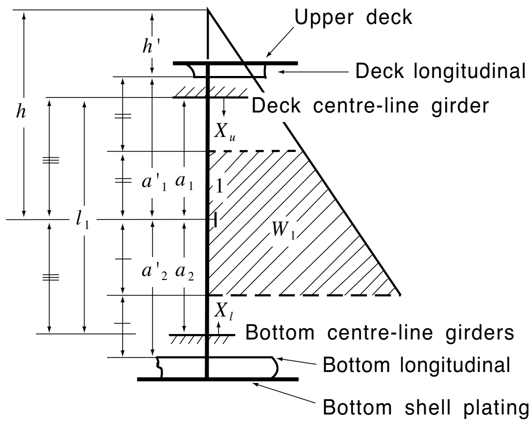
3. The full width of face plates of horizontal stiffeners on longitudinal bulkhead is not to be less than that required in **302. 6.**

504. Strong vertical webs

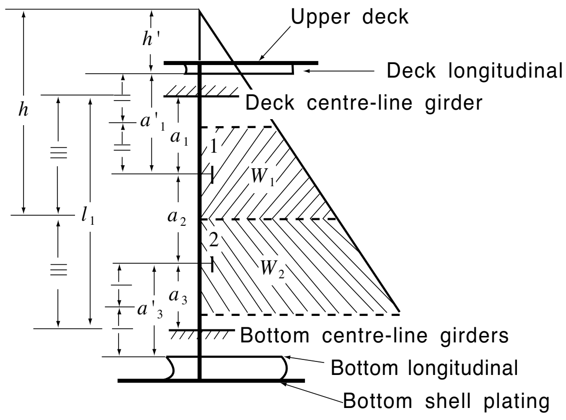
Where strong vertical webs are provided in support of horizontal girders on transverse bulkheads at the mid-distance of longitudinal bulkheads, the vertical webs are to be in accordance with the following requirements, according to the case where transverse bulkhead is of vertical stiffener system or horizontal stiffener system.

(1) In the case of vertical stiffener system, the depth, web thickness and section modulus of strong vertical webs supporting horizontal girders are not to be less than those obtained from the following formulae respectively. (See **Fig. 7.1.6**)

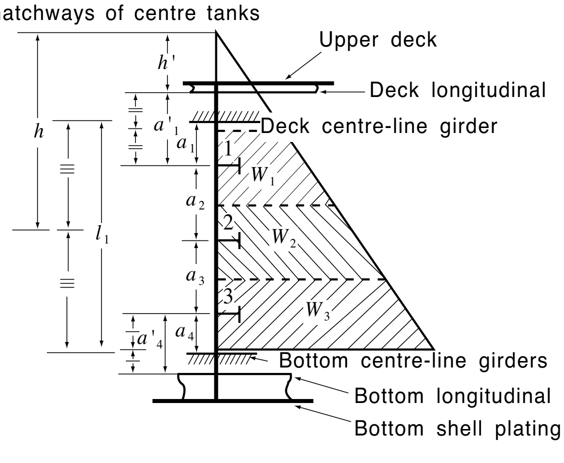
Depth of webs: $d = 3\left(\dfrac{l_1}{B_0}\right)^2 d_0 \quad (mm)$



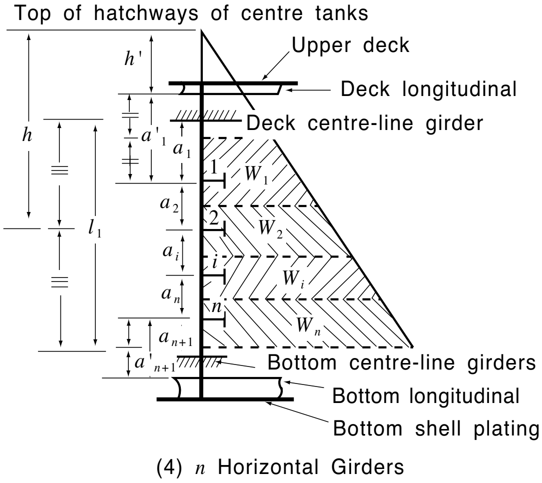
(1) One Horizontal Girder



(2) Two Horizontal Girders



(3) Three Horizontal Girders



(4) n Horizontal Girders

Fig. 7.1.6 Measurement of Each Dimension and Load

Web thickness:

Web thickness of vertical webs in the portion between the top of face plate of bottom girder and the horizontal girder just above the bottom girder, and web thickness of vertical webs in the portion between the said horizontal girder and the horizontal girder just above it in case where the said horizontal girder is provided within 1/3 length of vertical arm of bracket at the lower end of vertical webs above the face plate of bottom girder:

In case of one horizontal girder:

$$t_1 = \frac{87}{d_l} K W_1 \left(\frac{a_1}{l_1}\right)^2 \left(1 + \frac{2\,a_2}{l_1}\right) + 2.5 \qquad (mm)$$

In case of two horizontal girders:

$$t_2 = \frac{87}{d_l} K \left[W_1 \left(\frac{a_1}{l_1}\right)^2 \left\{1 + \frac{2\left(a_2 + a_3\right)}{l_1}\right\} + W_2 \left(\frac{a_1 + a_2}{l_1}\right)^2 \times \left(1 + \frac{2\,a_3}{l_1}\right)\right] + 2.5 \qquad (mm)$$

In case of three horizontal girders:

$$t_3 = \frac{87}{d_l} K \left[W_1 \left(\frac{a_1}{l_1}\right)^2 \left\{1 + \frac{2\left(a_2 + a_3 + a_4\right)}{l_1}\right\} + W_2 \left(\frac{a_1 + a_2}{l_1}\right)^2 \left\{1 + \frac{2\left(a_3 + a_4\right)}{l_1}\right\} + W_3 \left(\frac{a_1 + a_2 + a_3}{l_1}\right)^2 \left(1 + \frac{2\,a_4}{l_1}\right)\right] + 2.5 \qquad (mm)$$

In case of n horizontal girders:

$$t_n = \frac{87}{d_l} K \left[\sum_{i=1}^{n} W_i \left(\sum_{j=1}^{i} \frac{a_j}{l_1} \right)^2 \left(1 + 2 \sum_{k=i+1}^{n+1} \frac{a_k}{l_1} \right) \right] + 2.5 \qquad (mm)$$

Thickness of vertical webs in the portion between the lower surface of face plate of deck girders and the horizontal girder just below the said face plate.

In case of one horizontal girder:

$$t_1 = \frac{87}{d_u} K W_1 \left(\frac{a_2}{l_1}\right)^2 \left(1 + \frac{2\,a_1}{l_1}\right) + 2.5 \qquad (mm)$$

In case of two horizontal girders:

$$t_2 = \frac{87}{d_u} K \left[W_1 \left(\frac{a_2 + a_3}{l_1}\right)^2 \left(1 + \frac{2\,a_1}{l_1}\right) + W_2 \left(\frac{a_3}{l_1}\right)^2 \times \left\{1 + \frac{2\left(a_1 + a_2\right)}{l_1}\right\}\right] + 2.5 \qquad (mm)$$

In case of three horizontal girders:

$$t_3 = \frac{87}{d_u} K \left[W_1 \left(\frac{a_2 + a_3 + a_4}{l_1}\right)^2 \left(1 + \frac{2\,a_1}{l_1}\right) + W_2 \left(\frac{a_3 + a_4}{l_1}\right)^2 \times \left\{1 + \frac{2\left(a_1 + a_2\right)}{l_1}\right\} + W_3 \left(\frac{a_4}{l_1}\right)^2 \times \left\{1 + \frac{2\left(a_1 + a_2 + a_3\right)}{l_1}\right\}\right] + 2.5 \qquad (mm)$$

In case of n horizontal girders:

$$t_n = \frac{87}{d_u} K \left[\sum_{i=1}^{n} W_i \left(\sum_{j=i+1}^{n+1} \frac{a_j}{l_1} \right)^2 \left(1 + 2 \sum_{k=1}^{i} \frac{a_k}{l_1} \right) \right] + 2.5 \; (mm)$$

Section modulus of webs:

$$Z = 4\,K k^2 B_0 h l_1^2 \qquad (cm^3)$$

where:

- l_1 = overall length of vertical webs (m), which is equal to the distance between the inner surface of face plates of bottom and deck girders. In case where horizontal girder is provided within 1/3 of the length of vertical arm of bracket at the lower end of vertical webs above the top of bottom girders, l_1 is to be the distance between the said horizontal girder and the inner surface of face plate of deck girders (m).
- B_0 = distance between longitudinal bulkheads (m)
- d_0 = mean depth of horizontal girders (m).
- d_l = depth of webs at the lower portion of vertical webs considered (mm).
- d_u = depth of webs at the upper portion of vertical webs considered (mm).
- n = number of horizontal girders provided within the length of l_1.
- W_i ($i = 1,\ 2, \ldots n$) = load which vertical webs receive from the number n horizontal girder counting from the top of l_1 and which is obtained from the following formulae:

In case of one horizontal girder:

$$W_1 = \frac{B_0}{4}\left(a'_1 + a'_2\right)\left(h' + \frac{3}{4}a'_1 + \frac{1}{4}a'_2\right) \qquad (t)$$

In case of two horizontal girders:

$$W_1 = \frac{B_0}{4}\left(a'_1 + a_2\right)\left(h' + \frac{3}{4}a'_1 + \frac{1}{4}a_2\right) \qquad (t)$$

$$W_2 = \frac{B_0}{4}\left(a_2 + a'_3\right)\left(h' + a'_1 + \frac{3}{4}a_2 + \frac{1}{4}a'_3\right) \quad (t)$$

In the case of three horizontal girders:

$$W_1 = \frac{B_0}{4}\left(a'_1 + a_2\right)\left(h' + \frac{3}{4}a'_1 + \frac{1}{4}a_2\right) \quad (t)$$

$$W_2 = \frac{B_0}{4}\left(a_2 + a_3\right)\left(h' + a'_1 + \frac{3}{4}a_2 + \frac{1}{4}a_3\right) \quad (t)$$

$$W_3 = \frac{B_0}{4}\left(a_3 + a'_4\right)\left(h' + a'_1 + a_2 + \frac{3}{4}a_3 + \frac{1}{4}a'_4\right) \quad (t)$$

In case of n horizontal girders:

$$W_1 = \frac{B_0}{4}\left(a'_1 + a_2\right)\left(h' + \frac{3}{4}a'_1 + \frac{1}{4}a_2\right) \quad (t)$$

$$W_i = \frac{B_0}{4}\left(a_i + a_{i+1}\right)\left(h' + \sum_{j=1}^{i-1} a_j + \frac{3}{4}a_i + \frac{1}{4}a_{i+1}\right) \quad (t)$$

$$(i = 2, 3 \cdots\cdots, n-1)$$

$$W_n = \frac{B_0}{4}\left(a_n + a'_{n+1}\right)\left(h' + \sum_{j=1}^{n-1} a_j + \frac{3}{4}a_n + \frac{1}{4}a'_{n+1}\right) \quad (t)$$

Where j = 1 in the above formulae for W_i and W_n, a_j is to be taken as a_1'.

where:

a_i (i = 1, 2, ..., n) = distance between the top of l_1 and the horizontal girder just below the top, distance between the adjacent horizontal girders or distance between the bottom of l_1 and the horizontal girder just above the bottom (m). (i is to be counted from the top.)

a_1' = distance between the lower surface of deck longitudinals and the uppermost horizontal girder (m).

a'_{n+1} = distance from the lowest horizontal girder within the length of l_1 to the horizontal girder just below it or to the upper surface of bottom longitudinals (m).

h = distance from the mid-point of l_1 to the top of hatchways in centre tanks (m).

h' = distance from the lower surface of deck longitudinals to the top of hatchways in centre tanks (m).

k = correspondingly as specified in **Table 7.1.3.**

(2) In case where one horizontal girder is provided, the depth, web thickness and section modulus of strong vertical webs supporting the horizontal girder are not to be less than those obtained from the following formulae respectively:

Depth of webs;

$$d = 3\left(\frac{l_1}{B_0}\right)^2 d_0 \quad (mm)$$

Web thickness:

Web thickness of vertical webs in the portion between the top of face plates of bottom girders and the horizontal girders:

$$t_1 = \frac{87}{d_l - a}K\left[\frac{1}{4}B_0 h l_1\left\{\frac{1}{2} - \frac{X_l}{l_1} + \frac{l_1}{2h}\left(\frac{1}{5} - \frac{X_l}{l_1} + \frac{X_l^2}{l_1^2}\right)\right\} + W_1\left(\frac{a_1}{l_1}\right)^2\left(1 + \frac{2a_2}{l_1}\right)\right] + 2.5 \quad (mm)$$

Web thickness of vertical webs in the portion between the lower surface of face plates of deck girders and the horizontal girders:

$$t_2 = \frac{87}{d_u - a}K\left[\frac{1}{4}B_0 h l_1\left\{\frac{1}{2} - \frac{X_u}{l_1} - \frac{l_1}{2h}\left(\frac{1}{5} - \frac{X_u}{l_1} + \frac{X_u^2}{l_1^2}\right)\right\} + W_1\left(\frac{a_2}{l_1}\right)^2\left(1 + \frac{2a_1}{l_1}\right)\right] + 2.5 \quad (mm)$$

Section modulus of webs:

$$Z = 5.2\,Kk^2 B_0 h l_1^2 \quad (cm^3)$$

where:

X_l = distance measured upward from the top of face plates of bottom girders (m).

X_u = distance measured downward from the lower surface of face plates of deck girders (m).

$$W_1 = \frac{B_0}{8}\left(a'_1 + a'_2\right)\left(h' + \frac{3}{4}a'_1 + \frac{1}{4}a'_2\right) \quad (t)$$

l_1, B_0, d_0, d_l, d_u, a_1, a_2, a_1', a_2', h, h', K = as specified in (1) respectively.

a = depth of slot (m). Where, however, the slots are effectively covered by collar plates, a may be taken as zero.

505. Vertical webs supported by horizontal girders

Where vertical webs provided on transverse bulkhead are supported by the horizontal girders specified in **506.**, the depth, web thickness and section modulus of vertical webs are not to be less than those obtained from the following formulae respectively.

Depth of webs:

d = 143 l (mm) or 2.5 a (mm), whichever is the greater.

Web thickness:

$$t = C_1 K \frac{Shl}{d_0 - a} + 2.5 \quad (mm)$$

Section modulus of webs:

$$Z = C_2 K k^2 S h l^2 \qquad (cm^3)$$

where:

a = depth of slots (mm).

l = overall length between the points of support of vertical webs (m), which is equal to the distance from the inner surface of face plates of bottom girders to the horizontal girder just above it, that between the horizontal girders, or that from the inner surface of face plates of deck girders to the horizontal girders just below it.

S = spacing of vertical webs (m).

h = distance from the mid-point of l to the top of hatchways of the tanks concerned (m) or $0.3\sqrt{L}$ (m), whichever is the greater.

d_0 = depth of webs at the point under consideration (mm).

k = correspondingly as specified in **Table 7.1.3.**

C_1, C_2 = coefficients given by the following formulae respectively:

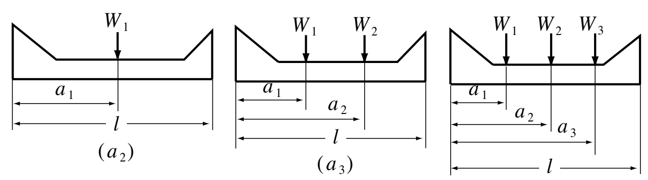
$$C_1 = 87\left\{\frac{1}{2} - \frac{X}{l} + \frac{1}{2}\cdot\frac{l}{h}\left(\frac{1}{5} - \frac{X}{l} + \frac{X^2}{l^2}\right)\right\}$$

$$C_2 = 8\left(1 + \frac{l}{10h}\right)$$

X = distance measured upward from the lower end of l (m).

506. Horizontal girders supporting vertical webs

Where vertical webs are supported by horizontal girders provided on transverse bulkheads, the depth, web thickness and section modulus of horizontal girders are not to be less than those obtained from the following formulae respectively. The section modulus, however, is not to be less than that obtained from the formulae taking the starting point of a_i each end of the girders, whichever is the greater. (See **Fig. 7.1.7**)



(1) One Vertical Web (2) Two Vertical Webs (3) Three Vertical Webs

Fig. 7.1.7 Measurement of l, a_1, a_2, etc.

Depth of girders:

$$d = 143\,l \quad (mm)$$

Web thickness in the portion between the ends of horizontal girders and the vertical webs at ends:

In case of one vertical web:

$$t_1 = \frac{87}{d_0} K W_1 \left(1 - \frac{a_1}{l}\right)^2 \left(1 + \frac{2a_1}{l}\right) + 2.5 \qquad (mm)$$

In case of two vertical webs:

$$t_2 = \frac{87}{d_0} K \left[W_1 \left(1 - \frac{a_1}{l}\right)^2 \left(1 + \frac{2a_1}{l}\right) + W_2 \left(1 - \frac{a_2}{l}\right)^2 \times \left\{1 + \frac{2a_2}{l}\right\}\right] + 2.5 \qquad (mm)$$

In case of three vertical webs:

$$t_3 = \frac{87}{d_0} K \left\{ W_1 \left(1 - \frac{a_1}{l}\right)^2 \left(1 + \frac{2a_1}{l}\right) + W_2 \left(1 - \frac{a_2}{l}\right)^2 \times \left(1 + \frac{2a_2}{l}\right) + W_3 \left(1 - \frac{a_3}{l}\right)^2 \left(1 + \frac{2a_3}{l}\right) \right\} + 2.5 \qquad (mm)$$

Section modulus of griders:

In case of one vertical web:

$$Z_1 = 85.5\, K k W_1 a_1 \left(1 - \frac{a_1}{l}\right)^2 \qquad (cm^3)$$

In case of two vertical webs:

$$Z_2 = 85.5\, K k \left\{ W_1 a_1 \left(1 - \frac{a_1}{l}\right)^2 + W_2 a_2 \left(1 - \frac{a_2}{l}\right)^2 \right\} \qquad (cm^3)$$

In case of three vertical webs:

$$Z_3 = 85.5\, K k \left\{ W_1 a_1 \left(1 - \frac{a_1}{l}\right)^2 + W_2 a_2 \left(1 - \frac{a_2}{l}\right)^2 + W_3 a_3 \left(1 - \frac{a_3}{l}\right)^2 \right\} \qquad (cm^3)$$

where:

l = overall length between the points of support of horizontal girders (m), which is equal to the distance between side shell plating and longitudinal bulkhead or that between the longitudinal bulkheads (m). Where, however, side stringers and longitudinal girders on longitudinal bulkheads are provided, the distance between the face plates of longitudinal girders is to be taken as l and where the strong vertical webs specified in **504.** are provided in the middle between the longitudinal bulkheads, a half of the distance between the longitudinal bulkheads is to be taken as l.

W_i (i = 1,2,3) = load which horizontal girders receive from the vertical web of number i counting from the end of l, which is given by the following formulae:

$$W_1 = \frac{1}{2} a_2 bh \quad (t)$$

$$W_2 = \frac{1}{2}(a_3 - a_1) bh \quad (t)$$

$$W_3 = \frac{1}{2}(l - a_2) bh \quad (t)$$

b = width of the area to be supported by horizontal girders (m).

h = distance from the mid-point of b to the top of hatchways of the tanks concerned (m) or $0.3\sqrt{L}$ (m), whichever is the greater

a_i(i = 1,2,3) = distance from the end of l to the vertical web of number i counting from the end of l (m).

k = correspondingly as specified in **Table 7.1.3.**

507. Horizontal girders supporting vertical stiffeners

Where vertical stiffeners are supported by horizontal girders provided on transverse bulkheads, the depth, web thickness and section modulus of horizontal girders are not to be less than those obtained from the following formulae respectively:

Depth of girders:

d = 143 l (mm) or 2.5 a (mm), whichever is the greater.

Web thickness:

$$t = CK\frac{Shl}{d_1 - a} + 2.5 \quad (mm)$$

Section modulus of girders:

$$Z = C'Kk^2Shl^2 \quad (cm^3)$$

where:

a = depth of slots (mm).

l = overall length between points of support of horizontal girders (m), which is equal to the distance between side shell plating and longitudinal bulkhead or that between longitudinal bulkheads. Where, however, side stringers and longitudinal girders on longitudinal bulkhead are provided, the distance between the face plates of longitudinal girders is to be taken as l.

S = width of area to be supported by girders (m).

h = distance from the mid-point of S to the top of hatchways of the tanks concerned (m) or $0.3\sqrt{L}$ (m), whichever is the greater.

d_1 = depth of girders at the point under consideration (mm).

k = correspondingly as specified in **Table 7.1.3.**

C = coefficient given by the following formula:

$$C = \left| 87\left(\frac{1}{2} - \frac{X}{l}\right) \right|$$

X = distance measured from the end of l (m).

C' = coefficient given in **Table 7.1.11.**

Table 7.1.11 Coefficient C'

	Where side stringers and vertical webs on longitudinal bulkheads are provided	Others
Wing tank	7	10
Centre tank	7	$10 \times \frac{B_S}{B_C}$

NOTES:

B_S = width of wing tanks (m), Which is equal to the distance between side shell plating and longitudinal bulkhead.

B_C = width of centre tanks (m), which is equal to the distance between longitudinal bulkheads. Where, however, B_S/B_C exceed 1.0, B_S/B_C is to be taken as 1.0 and where less than 0.7, to be taken as 0.7.

508. Web plates, face plates and stiffeners of girders

1. The thickness of vertical webs and horizontal girders provided on transverse bulkheads is not to be less than that required by the following:

(1) The web thickness of strong vertical webs specified in **504.** is to be as required in **405. 1** (1) in general. However, for the upper 2/3 of l_1, excluding the portion nearby the top of vertical arm of lower bracket of vertical webs, the formula may have its first term multiplied by 0.85.

(2) The web thickness of those webs and girders specified in **505.** to **507.** is to be as required in **405. 1** (3) in general.

2. The thickness and breadth of face plates forming vertical webs and horizontal girders specified in **Par 1** is not to be of less scantlings than required in **401. 4.** However, the depth of girders of corrugated bulkheads is to be measured from the middle of the depth of corrugation.

3. The girders specified in **Par 1** are to be provided with flat bar stiffeners, applying the requirements of **405.**

509. Special stiffening of web plates and end connection brackets

As regards the strong vertical webs specified in **504.** the lower brackets and the web plates between the top of face plate of bottom girders and the horizontal girders situated directly above the bottom girders, including the web plates up to the horizontal girder situated directly above the said horizontal girder in case where the said girder is situated within 1/3 the length of vertical arm of brackets above face plate of bottom girders, are to be provided with stiffeners specially in close spacing. Regarding the horizontal girders specified in **506.** and **507.**, the end brackets and the web plates in the vicinity of the inner edge of brackets are also to be provided with stiffeners in close spacing. Further, a special consideration is to be given to the web plates at the portion specified above to be protected from buckling, in case where the said plates are unavoidably lap jointed.

510. Additional strengthening of bulkhead in large tanks

As for large tank boundaries, the scantlings of bulkhead plates, stiffeners, vertical and horizontal girders are not to be less than those obtained from relevant formulae in **501.** to **507.**, where the value of h or h' is the one specified in each requirement or that given by the following formula, whichever is the greater.

$$H = 0.85\ (h + \Delta h) \quad (m)$$

where:

h = h or h' as specified in each requirement.

Δh = as specified in **Pt 3, Ch 15,105.**

511. Wash bulkheads

1. Stiffeners and girders are to be of adequate strength in conformity with the size and opening ratio of tanks.

2. The sectional area of wash bulkhead plating to the depthwise direction of the ship in centre tanks is not to be less than that required in **501.** as far as practicable.

3. The thickness of bulkhead plating is not to be less than that required by **108.** (4) or that obtained from the following formula, whichever is the greater. The thickness of the lowest strake of transverse wash bulkheads is to be properly increased.

$$t = 0.3\,S\sqrt{(L+150)\,K} + 2.5 \quad (mm)$$

where:

S = spacing of stiffeners (m).

4. The breadth and thickness of the uppermost and the lowest strakes in centre line wash bulkheads are to be as required in **502. 2** as far as practicable.

5. It is recommended that a special consideration be given to the thickness of wash bulkhead plating to prevent the plating from shear buckling.

SECTION 6
Relative Deformation of Wing Tanks

601. Relative deformation of wing tanks

As regards wing tanks, where the value obtained from the following formula exceeds 0.15, a special consideration is to be given to the structure of wing tanks.

$$\delta = \frac{h - 0.32\,d}{n_b K_b + n_s \eta_s K_s + n_t \eta_t K_t} \cdot \frac{a}{b}\, l$$

where:

a = half-breadth of centre tanks (m).

b = breadth of wing tanks (m).

h = distance from the top of keel to the top of hatches of centre tanks (m).

l = length of one tank situated between oil- and/or water-tight bulkheads in centre tanks (m).

n_b, n_S, n_t = number of transverse bulkheads, wash bulkheads and transverse rings in wing tanks located within l, respectively. The bulkheads at the fore and aft ends of l are to be counted 1/2, respectively.

η_S, η_t = values given in **Table 7.1.12** in accordance with the opening ratio. For intermidiate value of opening ratio, η_S and η_t are to be obtained by linear interpolation.

Table 7.1.12 Coefficiens η_S and η_t

Opening raltio (%)	η_S and η_t
0	1.00
5	0.95
10	0.80
20	0.55
30	0.35
40	0.23
50	0.15
60	0.10
70	0.06

K_b, K_S, K_t = values obtained from the following formula:

$$81.0\,\frac{Dt}{\alpha b} \quad (t\,/\,cm)$$

where:

t = mean thickness of transverse bulkhead plating in wing tanks (mm), in obtaining K_b value.
Mean thickness of wash bulkhead plating in wing tanks (mm), in obtaining K_S value.
Mean thickness of transverse rings in wing tanks (mm), in obtaining K_t value.

α = value obtained from the following formulae, in case where transverse bulkheads or wash bulkheads in wing tanks are of corrugated form, in accordance with the case where the corrugation is vertical or horizontal:

For vertical corrugation:

$$\frac{\text{Girth length of ship in athwartships } (m)}{b}$$

For horizontal corrugation:

$$\frac{\text{Girth length of ship in depthwise } (m)}{D}$$

For the case other than above, the value is to be 1.0.

SECTION 7
Welding

701. Welding

1. The welding in tankers is to be in accordance with the requirements given in **Pt 3, Ch 1, Table 3.1.6** except where specially prescribed in this Article for cargo oil tanks.

2. The application of the fillet welding is to be as given in **Table 7.1.13.**

SECTION 8
Supplementary Provisions for Tankers Having Longitudinal Bulkhead at Centre Line Only

801. Application

The requirements specified hereunder apply to tankers not exceeding 120 m in length having longitudinal bulkhead at the centre line only. As regards the matters not specially provided in these requirements, the requirements in each previous Articles concerned are to be applied. Application of **406.** and **509.,** however, may be dispensed with.

802. Trunks

1. The thickness of trunk top and side plating is not to be less than that obtained from the following formula:

$$t = 6.5\frac{S}{\sqrt{K}} + 2.0 \quad (mm)$$

where:

S = spacing of longitudinal stiffeners (m).

2. The section modulus of longitudinal stiffeners provided on trunks is not to be less than that obtained from the following formula:

Table 7.1.13 Fillet Welding

Column	Item		Where applied	Kind of weld
1	Transverse girders and webs	Web plates	Shell, deck or longitudinal bulkhead plating	F1
2			Web plates	F1
3			Face plates	F2
4		Slots in web plates	Web plates longitudinal frames, beams and horizontal stiffeners on longitudinal bulkheads	F2
5		Tripping brackets and stiffeners provided on web plates	Web plates	F3
6			Web plates of longitudinal frames, beams and horizontal stiffeners on longitudinal bulkheads	F1
7	Longitudinal frames, beams and horizontal stiffeners on longitudinal bulkheads		Shell, deck or longitudinal bulkhead plating	F3
8	Cross ties		Members forming cross ties (web plates to face plates)	F3
9			Face plates of transverses, side stringers or longitudinal girders	F1

NOTE:
Where the radius at the toe of end brackets is small, it is recommended that F1 be used for appropriate length at the toe of bracket.

$$Z = 2K\sqrt{L}Sl^2 \quad (cm^3)$$

where:
l = spacing of transverses (m).
S = spacing of longitudinal stiffeners (m).

803. Transverses in cargo oil spaces

1. Transverses in cargo oil spaces are to be in accordance with the requirements of **401.** to **406.** except those specially specified in this Article. In small ships, however, the brackets at ends of transverses may be dispensed with, subject to the approval by the Society.

2. The depth and section modulus of bottom transverses are not to be less than those obtained from the following formulae respectively:

Depth of transverses:

$$d = 0.16\, l_0 \quad (m)$$

Section modulus of transverses:

$$Z = 9.7\, Kk^2 (d + 0.026\, L')\, Sl_0^2 \quad (cm^3)$$

where:
l_0 = overall length of transverses (m), which is equal to the distance from the inner surface of face plates of side transverses to the inner surface of face plates of vertical webs on centre line bulkhead.
S = spacing of transverses (m).
k = correspondingly as specified in **Table 7.1.3.**

3. The depth and section modulus of side transverses are not to be less than those obtained from the following formulae respectively. Where the transverses are of tapered from, the requirements in **403. 1** (2) are to be applied.

Depth of transverses:

$$d = 0.15\, l_0 \quad (m)$$

Section modulus of transverses:

$$Z = 87\, Kk^2 Shl_0^2 \quad (cm^3)$$

where:
l_0 = overall length of side transverses (m), which is equal to the distance between the inner surfaces of face plates of bottom transverses and deck transverses. (See **Fig. 7.1.3**)
S = spacing of transverses (m).
h = distance from the mid-point of l_0 to the point high as given by the following formula above the top of keel (m):

$$h = d + 0.038\, L$$

k = correspondingly as specified in **Table 7.1.3.**

4. The section modulus of transverses at bilge is not to be less than that obtained from the following formula. However, in calculating the section modulus of transverses, the netural axis of section is to be assumed as to situate at the mid-point of the depth of transverses d_b. (See **Fig. 7.1.3**)

$$Z = 7.8\, KShl_0^2 \quad (cm^3)$$

where:
S, h, l_0 = as specified in **Par 3** respectively.

5. Deck transverses

(1) The depth and section modulus of deck transverses in ships having no trunk are not to be less than those determined correspondingly in accordance with the requirements in **402. 2** (1).

(2) In trunk ships, it is a standard arrangement that transverses extending from side to side of the ship across the trunk are provided In this case, the depth of deck transverses regarded as being supported by trunks may be 0.03 B.

6. As for vertical webs provided on the centre line bulkhead, the requirements in **Par 3** for side transverses are to be correspondingly applied, but the depth and section modulus of deck transverses are not to be less than those obtained from the formulae with each coefficient multiplied by 0.8 respectively.

804. Stiffening transverse

Trunks are to be provided with stiffening transverses in line with the deck transverses. The section modulus of stiffening transverses is not to be less than that obtained from the following formula:

$$Z = 1.4K\sqrt{L}Sl^2 \quad (cm^3)$$

where:
l = half-breadth of trunks (m).
S = spacing of stiffening transverses (m).

SECTION 9
Special Requirements for Wing Tanks at Fore Parts

901. Application

In case of oil tankers of 200 *metres* and over in length, the members provided in wing tanks not being ballasted at full load condition which are located between 0.15 L from the bow and the collision bulkhead are to comply with the requirements specified hereunder as well as the requirements in each previous Articles concerned.

902. Side longitudinal frames

1. The section modulus of side longitudinal frames is not to be less than that obtained from the following formula:

$$Z = 9KShl^2 \quad (cm^3)$$

where:

l = spacing of transverses (m).
S = spacing of longitudinal frames (m).
h = distance measured from the frame concerned to the point of the height which is to be obtained from the following formula above the top of keel:

$$h' = 0.7d + 0.05L \quad (m)$$

In any case, however, the distance is not to be less than that obtained trom the following formula:

$$h = 0.2\sqrt{L} + 0.03L \quad (m)$$

2. Where side longitudinal frames are connected to transverse by brackets, the section modulus may be taken as the value obtained from the formula in the preceding Paragraph multiplied by the following factor:

$$(1-C)^2$$

Where C is obtained from the following formulae:

In case where brackets are provided at both ends.

$$C = \frac{b_1 + b_2 - 0.3}{l}$$

In case where a bracket is provided at one end.

$$C = \frac{b - 0.15}{l}$$

b, b_1, b_2 = arm length of brackets on longitudinal frames respectively (m). In case, C is negative, C is to be taken as zero. (See **Fig. 7.1.8**)

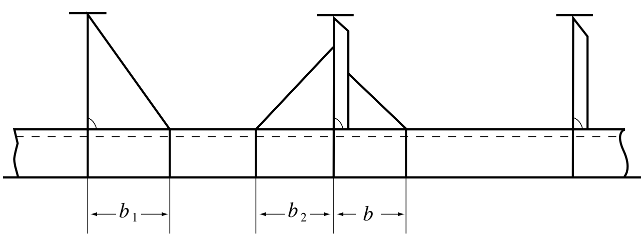


Fig. 7.1.8 Measurement of b, b_1 and b_2

903. Side Transverses

1. The section modulus of side transverses is to be in accordance with the requirement in **403. 1** (5). In applying the formula, however, h is the distance from the mid-point of l_0 to $0.1L$ above the top of keel (m)

2. The thickness of webs of side transverses at inner edge of brackets at lower ends is to be in accordance with the requirements in **403. 1** (3). In applying the formula, however, h is the distance from the midpoint of l_0 to $0.1L$ above the top of keel (m).

3. The thickness of webs between cross ties is not to be less than that obtained from the following formula:

$$t = 43.5CK\frac{Sh_il_i}{d_i - a_i} + 2.5 \quad (mm)$$

where:

S = spacing of transverses (m).
d_i = depth of web at the mid-point of each span (mm).
a_i = maximum depth of slots in each span (mm). The depth, however, may be taken as zero where the slots are provided with collar plates.
l_i = span of each transverse (m). However, for the part between cross ties and bottom or deck transverses. l_i is the distance between the centre of cross ties and the face plate of bottom or deck transverses; for the part between cross ties, the distance between centres of cross ties. (See **Fig. 7.1.9**)
h_i = distance from the mid-point of each l_i to the point $0.1L$ above the top of keel. Where, however, the distance is less than $0.06L$ (m), h_i is to be taken as $0.06L$ (m).
C = coefficient given by the following formula:

$$C = 1.2 - \frac{2b_i - 0.3}{l_i}$$

b_i = arm length of brackets at both ends of span, whichever is the smaller (m). (See **Fig. 7.1.9**)

4. The thickness of web at the portion where cross ties are connected is to be as required in **403. 1** (4). In applying the formula, however, h is the distance from the mid-point of b_S to the point $0.1L$ above the top of keel (m), except that h is to be taken as $0.06L$ (m) where the distance is less than $0.06L$ (m).

904. Special stiffening of web plates at ends of transverses

The upper and lower end brackets connected to side transverses and vertical webs on longitudinal bulkheads, and the web plates of transverses at the

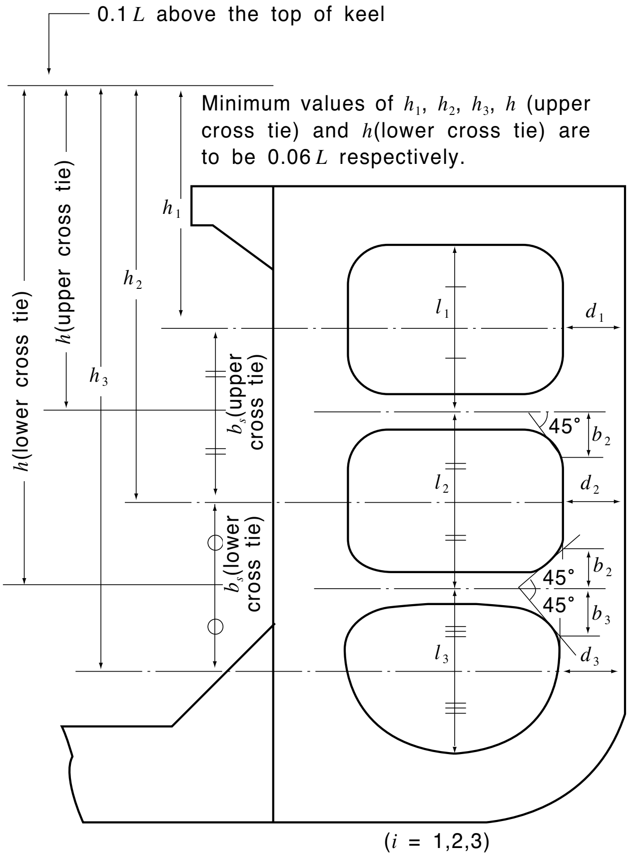


Fig. 7.1.9 Measurement of l, b, etc.

inner edge of the brackets and in the vicinity of the portion where cross ties are connected, are to be provided with stiffeners in specially close spacing.

905. Cross ties

The cross sectional area of cross ties and web thickness are to be in accordance with the requirements in **404.** In applying the formula, however, h is the distance from the mid-point of b_S to the point 0.1 L above the top of keel (m), except that h is to be taken as 0.06 L (m), where the distance is less than 0.06 L (m).

906. Vertical webs on longitudinal bulkheads

The scantlings of vertical webs on longitudinal bulkheads are not to be less than generally those determined in accordance with the requirements for side transverses.

SECTION 10
Piping Systems and Venting Systems for Oil Tankers

1001. General

1. Application

(1) The requirements in this Section apply to the piping systems and venting systems for ships intended to be registered as oil tankers.

(2) The requirements in this Section apply to oil tankers which have all the following features. The piping systems and venting systems for other types of oil tankers will be considered by the Society in each case.
(a) Tankers carrying crude oil and petroleum products having a flash point not exceeding 60°C (closed cup test) and a Reid vapour pressure which is below atmospheric pressure and other liquid products having a similar fire hazard.
(b) Tankers of which the machinery spaces and cargo oil tanks (including slop tanks, the same being referred hereinafter in this Section) are arranged in accordance with the requirements in **Pt 8, Ch 1, 402.**
(c) Tankers of which the cargoes are loaded by land facilities and unloaded by cargo pumps on board ship.

2. Drawings and Data

Drawings and data to be submitted are generally as follows.

(1) Drawings and data for approval (with materials, dimensions, design pressures, etc. of pipes, valves, etc. and the arrangement of devices to prevent the passage of flame)
(a) Piping diagram of cargo oil pipes and instrumentation
(b) General arrangement of bilge systems and ventilation systems of a cargo oil pump room
(c) General arrangement of venting systems for cargo vapours, etc.
(d) Other drawings and data considered necessary by the Society

(2) Drawings and data for reference
(a) Capacity calculation sheet for pressure/vacuum valves and overpressure protective device of cargo oil tanks
(b) Other drawings and data considered necessary by the Society

3. Special type

Where ships are equipped with new types of pumps and/or piping systems, specifications and detailed drawings are to be submitted to the Society for approval. The Society may require additional detailed investigations or tests of their own, where deemed necessary by the Society.

1002. Cargo oil pumps and piping systems

1. Cargo oil pumps

(1) Cargo oil pumps are to comply with the following (a) to (e).
(a) Each pump is to be so designed as to

minimize the risk of sparking and oil leakage at the seal.

(b) Where machinery is driven by shafting passing through a bulkhead or deck, shafting is to be provided with flexible couplings, and gastight seals with efficient lubrication or other means of ensuring the permanence of the gastight seal are to be fitted in way of the bulkhead or deck. If a bellows piece is incorporated in the design, it is to be pressure tested before fitting. The gastight seals or other means are to be so designed as to minimize the risk of sparking, and the sealing parts contacted with the shafting are to be material that will not initiate sparks. Cargo pumps, ballast pumps and stripping pumps, installed in cargo pump rooms and driven by shafts passing through pump room bulkheads are to be fitted with temperature sensing devices for bulkhead shaft glands, bearings and pump casings. Alarm device which can initiate visible and audible alarm in the cargo control room or the pump control station are to be provided at a suitable position.

(c) A stop valve is to be provided on the delivery side of the pump. However, such stop valve may be omitted, provided that the cargo oil pipe on the delivery side of the pump is provided with a stop valve in a proper position.

(d) Where a relief valve is provided on the delivery side of the pump, the arrangement is to be such that the escaped oil is led to the suction side of the pump.

(e) A pressure measuring device is to be fitted on the delivery side of each pump. Where the pump is driven by a prime mover which is installed in the space other than the pump room, an additional pressure measuring device is to be fitted at a suitable position visible from the controlling position.

(2) Where prime movers, other than steam engines or hydraulic motors, for driving the cargo oil pumps are installed in the cargo oil pump room, descriptions and construction of the prime movers and the driving system are to be submitted for the approval by the Society.

(3) Where deep well pumps, submerged pumps, etc. are installed, construction of the pumps and driving systems are to be submitted for approval by the Society.

(4) In general, cargo oil pumps are not to be used for other purposes than transferring cargo oil or ballast in cargo oil tanks, transferring tank cleaning water for cargo oil tanks, discharging bilge as specified in **1003. 1**(2), or discharging ballast as specified in **1003. 2**(2).

2. Arrangement of cargo oil piping systems

(1) Cargo oil pipes are classified into Class III, except where considered necessary by the Society.

(2) Each cargo oil tank is to be provided with a cargo oil suction pipe(s) so arranged that cargo unloading can be carried out with one of the cargo oil pumps out of use.

(3) Cargo oil pipes are to be so arranged as to be capable of loading cargo oil to cargo oil tanks without passing through cargo oil pumps. Where loading pipes are led directly to the tanks from above the deck, the opening ends of these pipe are to be led to the lower part of the tanks as far as practicable to prevent the accident caused by the generation of static electricity.

(4) Where sea suction pipes for ballasting purpose are connected to cargo oil pipes, stop valves are to be provided between the sea suction valves and the cargo piping.

(5) Slip joints used in the cargo oil pipes are to have a sufficient strength.

(6) Sea suction pipes and discharge pipes for permanent ballast tanks are not to be connected to the sea suction pipes and discharge pipes for cargo oil tanks.

3. Alternative use of tanks

Where cargo oil tanks are so designed that they can also be used as exclusive ballast tanks or fuel oil tanks, the tanks are to be provided with devices which the Society requires, and approved drawings or documents having descriptions on a detailed operating manual for the alternative use are to be provided on board the ship.

4. Separation of cargo oil pumps and cargo oil pipes

(1) Cargo oil pipes are to be entirely separated from other pipes, except where permitted in **1002. 2**(2) and **1003. 1** and **2.**

(2) Cargo oil pipes are not to be led through fuel oil tanks nor engine room and accommodation spaces where sources of vapour ignition are normally present. In addition, these pipes are not to be led to spaces forward the collision bulkhead or after the front bulkhead of the engine room.

(3) Cargo oil pipes on the weather deck are to be arranged sufficiently apart from the accommodation spaces.

(4) Where a cargo hose connection is arranged for bow and/or stern loading and discharge of cargo oil outside the cargo tank area, the pipe leading to such connections is to be provided with means of segregation such as a spectacle flange, removable spool piece or equivalent located within the cargo area and a blank flange at the bow and/or stern end connections.

(5) Cargo oil pipes and similar pipes to cargo oil tanks are not to pass through ballast

tanks. However, these pipes may pass through the ballast tanks provided that these pipes in ballast tanks are of short length and the connections of these pipes are of welded joints or flanged joints which have no risk of leakage.

(6) Notwithstanding preceeding (5), for oil tankers other than double hull tankers, cargo oil pipes may pass through the ballast tanks provided that the connections of these pipes are of welded joints or flanged joints which have no risk of leakage. Expansion bends only, not glands, are permitted in these lines within ballast tanks.

5. Bulkhead valves of cargo oil piping systems

(1) Cargo oil pipes passing through oiltight bulkheads between cargo oil tanks and pump rooms are to be provided with stop valves as close to the bulkhead as practicable.

(2) Where the valves prescribed in (1) are located inside the pump room, they are to be made of steel or cast iron products with an elongation of 12% and above. These values are to be capable of being closed at the position of the valves and from a readily accessible position outside the compartment in which they are located. However, if the valves operated at a position above the deck are fitted on each cargo oil branch pipe, the valves located inside the pump room may be of cast iron products with an elongation of less than 12% without remote control device.

(3) Where the valves prescribed in (1) are located inside the tank, the valves may be of cast iron and need not be capable of being closed at the position of the valves, but they are to be provided with remote control devices, and the pipes are to be provided with another valve in the pump room.

(4) Where the valves are required to be remote controlled according to the requirements in (2) and (3), means are to be provided to show whether they are open or closed.

6. Valve operation rod penetrating through decks

Stuffing boxes are to be provided at positions at which operating rods from cargo valves pass through gastight or oiltight decks.

7. Piping in cargo oil tanks

(1) Pipes other than cargo oil pipes, cargo oil heating pipes, ballast pipes of cargo tanks and pipes permitted in (2) to (4) are not to pass through cargo oil tanks nor to have any connection to these spaces.

(2) Pipes for remote control of cargo oil piping systems, and vapour discharge pipes, tank cleaning pipes and sounding devices of cargo oil tanks may be led to cargo oil tanks.

(3) Scupper pipes, sanitary pipes, etc. may be led through cargo oil tanks subject to the approval by the Society.

(4) Ballast pipes and other pipes such as sounding and vent pipes to ballast tanks are not to pass through cargo oil tanks. However, these pipes may pass through the cargo oil tanks provided that these pipes in cargo oil tanks are of short length and the connections of these pipes are of welded joints or flanged joints which have no risk of leakage.

(5) Notwithstanding preceeding (4), for oil tankers other than double hull tankers, ballast pipes of ballast tanks adjacent to a cargo oil tanks may pass through cargo oil tanks provided that the connections of these pipes are of welded joints or flanged joints which have no risk of leakage. Expansion bends only, not glands, are permitted in these lines within cargo oil tanks.

8. Sounding devices of cargo oil tanks

A suitable sounding device approved by the Society is to be fitted onto any cargo oil tank. The sounding device is to be designed or arranged to prevent any outflow of flammable gases into spaces such as engine room, accommodation spaces, etc. where sources of vapour ignition are normally present.

9. Steam pipes

(1) The cargo oil heating steam supply and return pipes are not to penetrate the cargo oil tank plating, other than at the top of the tank, and the main supply pipes are to be run above the weather deck.

(2) Isolating shut-off valves or cocks are to be provided at the inlet and outlet connections to the heating circuit(s) of each tank.

(3) The cargo oil heating steam return pipes are to be led to an observation tank or other oil detectors in a position well-ventilated and well-lighted part of the space as apart as possible from hot surfaces such as boilers and ignition sources for the detection of contaminated oil in steam drain.

(4) The steam temperature in steam pipes arranged in cargo oil pump rooms and cargo oil heating steam pipes is not to exceed 220°C.

(5) In the cargo oil pump rooms, drain pipes from steam or exhaust pipes or from the steam cylinders of the pumps are to terminate well above the bilge wells.

(6) Each branch connection of cleaning steam pipes of cargo oil tanks or other tanks to which a cargo oil pipe is led is to be provided with a screw-down non-return valve or two stop valves.

10. Heating plants for asphalts cargo

(1) Heating plants for asphalt tanks are to be

arranged.

(2) Heating coils in asphalt tanks are to be sufficient thickness with fully welded joint.

(3) Pumps and valve systems are to be suitable for the type of cargo to be transported.

(4) Heating system for cargo pumps and cargo lines is to be arranged.

(5) Temperature gauges are to be arranged in each cargo tanks enabling the recording of temperatures at bottom, midway between bottom and deck and at deck level in order to prevent overheating of cargo.

1003. Piping systems for cargo oil pump rooms, cofferdams and tanks adjacent to cargo oil tanks

1. Bilge piping systems, etc. for cargo oil pump rooms and cofferdams adjacent to cargo oil tanks

(1) Bilge piping system consisting of a power driven pump or eductor is to be provided to discharge bilge in the cargo oil pump room and cofferdams adjacent to a cargo oil tank. The bilge in these spaces is not to be led to the engine room.

(2) Cargo oil pumps may be used for bilge drainage purpose specified in (1), provided that each bilge suction is provided with a screw-down non-return valve, and a stop valve or cock is fitted on the suction side of the pump and, in addition, a stop valve is fitted between the cargo oil pipe and the overboard discharge valve.

(3) Bilge pipes for a cofferdam adjacent to a cargo oil tank are to be entirely separate from those for spaces not adjacent to a cargo oil tank. However, a common bilge pump (except cargo oil pump) may be used for bilge drainage purpose of these spaces subject to the approval by the Society, provided that the bilge pipe for spaces not adjacent to a cargo oil tank has a non-return valve.

(4) Sounding pipes of cofferdams adjacent to a cargo oil tank is not to be less than 38 mm in internal diameter and unless otherwise approved by the Society to be led to above the weather deck.

(5) The bilge system serving the cargo oil pump room is to be operable from outside the cargo oil pump room.

(6) Intrinsically safe type bilge level alarm devices are to be provided in the bilge well of the cargo oil pump room so as to activate an audible and visible alarm in the cargo control room and on the navigation bridge.

(7) A system for continuously monitoring the concentration of hydrocarbon gases is to be fitted in the cargo oil pump room. Sampling points or detector heads are to be located in suitable positions in order that potentially dangerous leakages are readily detected. Sequential sampling is acceptable as long as it is dedicated for the pump room only, including exhaust ducts, and the sampling time is reasonably to be short. The system is to raise an alarm if the concentration of hydrocarbon gases exceeds 10 percent of the lower flammable limit(LFL). The alarm signals (visual and audible) are to be provided in the cargo control room and on the navigation bridge. However, for the ships having any limitations for their service area, this requirement may be modified.

2. Ballast tanks adjacent to cargo oil tanks

(1) The requirements in this Paragraph are also applied to ballast tanks used as cofferdams at the fore and after ends of cargo oil tanks in accordance with the requirements in **103. 4.** However, other requirements will be applied, if the fore ends of these ballast tanks are located forward of the collision bulkhead.

(2) Ballast pipes of ballast tanks adjacent to a cargo oil tank are to be separated from other pipes and are not to be led to the engine room. For this purpose, an exclusive pump for ballasting and deballasting these tanks is, generally, to be provided in the pump room. However, where specially approved by the Society, the cargo pumps may be used for the purpose of only de-ballasting in an emergency.

(3) Each air pipe to ballast tanks adjacent to a cargo oil tank is to be provided with an easily renewable wire gauze to prevent the passage of flame at their outlets. In case where approved by the Society, the requirement in **Pt 5, Ch 6, 201. 4** (1) for the dimension of the air pipes will be properly modified.

(4) Sounding pipes of ballast tanks adjacent to a cargo oil tank are to be led to above the weather deck, unless otherwise approved by the Society.

3. Fore peak ballast tank

The fore peak ballast tank ballasted with the system serving ballast tanks within the cargo area are to be meet the following requirements:

(1) The vent pipe openings are to be located on open deck 3m away from sources of ignition.

(2) Means are to be provided on the open deck to allow measurement of flammable gas concentrations within the tank by a suitable portable instrument.

(3) The access to the fore peak and sounding arrangements are to be direct from open deck. In case the fore peak tank is separated by cofferdams from the cargo tanks,

an access through a gas tight bolted manhole located in an enclosed space may be accepted. In this case, a warning sign is to be provided at the manhole stating that the tank may only be opened after it has been proven to be gas free or the electrical equipment which is not electrically safe in the enclosed space is isolated.

4. Fuel oil tanks adjacent to cargo oil tanks

Sounding pipes of fuel oil tanks adjacent to a cargo oil tank are to be led to above the weather deck, unless otherwise approved by the Society.

5. Pump arrangement for forward compartment

A pump used for bilge drainage or transfer of ballast water or fuel oil in a compartment forward of the cargo oil tanks is to be exclusive and unless otherwise approved by the Society to be installed in the forward part of the ship. However, where approved by the Society, other suitable pumps than specified above may be used for the bilge drainage or transfer of ballast water in a compartment forward of the cargo oil tanks.

1004. Venting systems of cargo oil tanks

1. The venting systems of cargo oil tanks are to be entirely distinct from the air pipes of the other compartments of the ship.

2. The venting arrangements are to be so designed and operated as to ensure that neither pressure no vacuum in cargo oil tanks is to exceed design parameters and are to be such as to provide for:

(1) the flow of the small volumes of vapour, air or inert gas mixtures caused by thermal variations in a cargo oil tank in all cases through pressure/vacuum valves (hereinafter referred to as "P/V valve");
(2) the passage of large volumes of vapour, air or inert gas mixtures during cargo loading and ballasting, or during discharging.
(3) a secondary means of allowing full flow relief of vapour, air or inert gas mixtures to prevent over-pressure or under-pressure in the event of failure of the arrangements in (2) above. Alternaitively, pressure sensors may be fitted in each tank protected by the arrangement required in (2) above, with a monitoring system in the ship's cargo control room or the position from which cargo operations are normally carried out. Such monitoring equipment is also to provide an alarm facility which is activated by detection of over-pressure or under-pressure conditions within a tank.
(4) If cargo loading and ballasting or discharging of a cargo tank or cargo tank group is intended, which is isolated from a common venting system, that cargo tank or cargo tank group is to be fitted with a means for over-pressure or under-pressure protection as required in (3) above.

3. The venting arrangements in each cargo oil tank may be independent or combined with other cargo oil tanks and may be incorporated into the inert gas piping.

4. Where the arrangements are combined with other cargo oil tanks either stop valves or other acceptable means are to be provided to isolate each cargo oil tank. Where stop valves are fitted, they are to be provided with locking arrangements and a clear visual indication (or other acceptable means) of the operational status of the valves. Any isolation is to continue to permit the flow caused by thermal variations in a cargo tank in accordance with **2** (1).

5. The venting arrangements are to be connected to the top of each cargo oil tank and are to be self-draining to the cargo tanks under all normal conditions of trim and list of the ship. Where it may not be possible to provide self-draining lines permanent arrangements are to be provided to drain the vent lines to a cargo oil tank.

6. The venting system is to be provided with devices to prevent the passage of flame into the cargo oil tanks. The design, testing and locating of these devices are to comply with the requirements which are considered appropriate by the Society.

7. Provision is to be made to guard against liquid rising in the venting system to a height which would exceed the design head of cargo oil tanks. This is to be accomplished by high level alarms or overflow control systems or other equivalent means, together with gauging devices and cargo oil tank filling procedures.

8. Openings for pressure release required by **2** (1) are to:

(1) have as great a height as is practicable above the cargo oil tank deck to obtain maximum dispersal of flammable vapours but in no case less than 2 m above the cargo oil tank deck;
(2) be arranged at the furthest distance practicable but not less than 5 m from the nearest air intakes and openings to enclosed spaces containing a source of ignition and from deck machinery and equipment which may constitute an ignition hazard.

9. P/V valves required by **2** (1) may be provided with a by-pass arrangement when they are located in a vent main or masthead riser. Where such an arrangement is provided there is to be an isolating arrangement with suitable indicators to show whether the by-pass is open or closed.

10. Vent outlets for cargo loading, discharging and ballasting required by **2** (2) are to:

(1) Permit the free flow of vapour mixtures; or

permit the throttling of the discharge of the vapour mixtures to achieve a velocity of not less than 30 *m/sec*;

(2) be so arranged that the vapour mixture is discharged vertically upwards;

(3) where the method is by free flow of vapour mixtures, be such that the outlet is to be not less than 6 *m* above the cargo tank deck or fore and aft gangway if situated within 4 *m* of the gangway and located not less than 10 *m* measured horizontally from the nearest air intakes and openings to enclosed spaces containing a source of ignition and from deck machinery and equipment which may constitute an ignition hazard;

(4) where the method is by high velocity discharge, be located at a height not less than 2 *m* above the cargo tank deck and not less than 10 *m* measured horizontally from the nearest air intakes and openings to enclosed spaces containing a source of ignition and from deck machinery and equipment which may constitute an ignition hazard. These outlets are to be provided with high velocity devices of an approved type;

(5) be designed on the basis of the maximum designed loading rate multiplied by a factor of at least 1.25 to take account of gas evolution, in order to prevent the pressure in any cargo oil tank from exceeding the design pressure. The ship is to be provided with information regarding the maximum permissible loading rate for each cargo oil tank and in the case of combined venting systems, for each group of cargo oil tanks.

1005. Purging and/or gas freeing systems of cargo oil tanks

1. Gas freeing systems capable of introducing fresh air with the object of removing toxic, flammable and inert gases and increasing the oxygen content to 21% by volume are to be provided for the cargo oil tanks.

2. Puring and/or gas freeing systems are to be such as to minimize the hazards due to the dispersal of flammable vapours in the atmosphere and to flammable mixtures in a cargo oil tank, and to comply with the following:

(1) When the ship is provided with an inert gas system, the cargo oil tanks are first to be purged in accordance with the requirements in **1111.** until the concentration of hydrocarbon vapours in the cargo oil tanks has been reduced to less than 2% by volume. Thereafter, venting may be at the cargo oil tank deck level.

(2) When the ship is not provided with an inert gas system, the operation is to be such that the flammable vapour is initially discharged. When the flammable gas concentration in the outlet has been reduced to 30% of the lower flammable limit the discharge of the gas mixture may be at the cargo oil tank deck level:

(a) through the vent outlets as specified in **1004. 10**; or

(b) with a vertical exit velocity of a least 20 *m/sec* through outlets at least 2 *m* above the cargo oil tank deck level and which are protected by suitable devices to prevent the passage of flame.

1006. Ventilation systems in cargo oil pump rooms

1. Ventilation systems of mechanical extraction type are to be provided for the cargo oil pump room. The outlets of exhaust ducts are to be led to the safe position above the open deck and to be fitted with wire mesh screens with mesh of suitable size.

2. The ventiliation systems specified in **Par 1** are to be capable of circulating sufficient air to give at least 20 air changes per *hour* for the total volume of the pump room to prevent accumulation of cargo vapours. The ventilation fan is to be of non-sparking construction.

3. The ducts are to be arranged, to permit ventilation from the vicinity of the pump room bilge, above the transverse floor plate or bottom longitudinals. An emergency intake located nearly 2 *m* above the pump room lower grating is to be arranged to the ducts, and this emergency intake is to have a damper which is capable of being opened or closed from the weather deck and lower grating level.

4. The foregoing exhaust system is to be in association with open grating floor plates to allow the free flow of air.

1007. Venting systems of cofferdams adjacent to cargo oil tanks

Effective venting systems are to be provided to cofferdams adjacent to a cargo oil tank. Where air pipes are provided for this purpose, each air pipe is to be provided with an easily renewable wire gauze to prevent the passage of flame at their outlets, and they are not to be less than 50 *mm* in internal diameter. Where ventilation system is provided, the construction of the ventilation fan and the wire mesh screens fitted on the exhaust ducts are to comply with the requirements in **1006.** Air holes are to be cut in every part of the structure where there might be a change of gases being pocketed.

1008. Positions of openings of machinery spaces, deck houses, etc. and electrical equipment, etc.

The arrangement of ventilation inlets and outlets and other deckhouse and superstructure boundary space openings is to be such as to complement the requirements in **1004.** Such vents especially for machinery spaces are to be situated as far aft as practicable. Due consideration in this regard is to be given when the ship is equipped to load or discharge at the stern. Sources of ignition such as electrical equipment are to be so arranged as to avoid an explosion hazard.

1009. Venting systems for double hull and double bottom spaces

Double hull and double bottom spaces are to be fitted with suitable connections for the supply of air.

1010. Inert gas system for double hull spaces

Oil tankers required to be fitted with inert gas systems are to be in accordance with the following requirements.

(1) Double hull spaces are to be fitted with suitable connections for the supply of inert gas.
(2) Where such connections specified in (1) above are connected to a permanently fitted inert gas distribution system, means are to be provided to prevent hydrocarbon gases from the cargo tanks entering the double hull spaces through the system.
(3) Where such connections specified in (1) above are not permanently connected to an inert gas distribution system, appropriate means are to be provided to allow connection to the inert gas main.

1011. Gas detection

1. Suitable portable instruments for measuring oxygen and flammable vapour concentrations, together with a sufficient set of spares, are to be provided. Suitable means is to be provided for the calibration of such instruments. Portable instruments required in **1112. 1** may be used as these instruments.

2. Where atmosphere in double hull spaces cannot be reliably measured using flexible gas sampling hoses, such spaces are to be fitted with permanent gas sampling lines. The configuration of such line systems are to be adapted to the design of such spaces.

3. The materials of construction and the dimensions of gas sampling lines are to be such as to prevent restriction. Where plastic materials are used, they are to be electrically conductive.

1012. Tankers carrying only oils having a flash point exceeding 60°C

For tankers intended only for the carriage of oils having a flash point exceeding 60°C the requirements in this Section may be modified as follows:

(1) The requirements in **1002. 2** to **9** may be properly modified.
(2) Bilges of the cargo oil pump room and cofferdams adjacent to a cargo oil tank may be led to the engine room (See **1003. 2** (1)).
(3) Ballast pipes of ballast tanks adjacent to a cargo oil tank may be led to the engine room (See **1003. 2**(2)). The wire gauze to prevent the passage of flame required for the outlets of the air pipes to the ballast tanks may be omitted (See **1003. 2**(3)). The sounding pipes of these tanks may be arranged to have openings below the weather deck (See **1003. 2**(4)).
(4) The sounding pipes of fuel oil tanks adjacent to a cargo oil tank may not be led to above the weather deck (See **1003. 3**).
(5) For the venting systems, purging systems and gas freeing systems, the requirements in **1004.** may be properly modified.

1013. Testing and inspection

After the manufacture of piping systems and ventilating systems of oil carriers, the following tests are to be conducted in addition to the requirements in **Pt 5, Ch 6, Sec 12.**

(1) Tests on board
  (a) Cargo oil pipes, after the completion of their piping, are to be subjected to a leak test at a pressure of 1.25 times the design pressure or greater.
  (b) Heating pipes inside cargo oil tanks are to be subjected to a leak test at a pressure of 1.5 times the design pressure or greater.
(2) After installation inboard, auxiliaries and piping systems are to be subjected to the following tests:
  (a) A test on the functioning of cargo oil pumps.
  (b) A test on the functioning of ventilating systems.
  (c) A test on the functioning of various systems concerning safety measures specified in this Section.

SECTION 11
Inert Gas System

1101. Application

1. The requirements in this Section apply to inert gas systems using flue gases. Special consideration will be given by the Society to other types of inert gas systems, which are to comply with the requirements in this Section.

2. Inert gas system using stored carbon dioxide will not be permitted unless the Society is satisfied that there is no risk of ignition from generation of static electricity by the system itself.

1102. Drawings and data

Following drawings and data regarding the ship's inert gas system are to be submitted for approval. Where, however, the system is the one already approved by the Society, they may be omitted from submission.

(1) Drawings
  - (a) General arrangements and piping diagrams of inert gas systems.
  - (b) Details of each component consisting of inert gas systems.
  - (c) Arrangement of piping system for the distribution of inert gas (diagram).
  - (d) plans and documents considered necessary by the Society.

(2) Data
  - (a) Instructions and operation manual of the inert gas system (including the matter to be attended to the safety of the operators).
  - (b) Other drawings and data considered necessary by the Society.

(3) The instructions and operation manual specified in (2) (a) are to be carried on board the ship.

1103. General requirements for inert gas systems

1. The inert gas system is to be capable of inerting empty cargo oil tanks by reducing the oxygen content of the atmosphere in each tank to a level at which combustion cannot be supported.

2. The inert gas system is to be capable of maintaining the atmosphere in any part of any cargo oil tank with an oxygen content not exceeding 8% by volume and at a positive pressure at all times in port and at sea except when it is necessary for such a tank to be gas free.

3. The inert gas system is to be capable of eliminating the need for air to enter a tank during normal operations except when it is necessary for such a tank to be gas free. If the blowers of the inert gas system is to be used for gas freeing, each air inlet is to be provided with a blanking flange or a shut-off valve with an indicator to show whether it is open or closed.

4. The inert gas system is to be capable of purging empty cargo tanks of hydrocarbon gas, so that subsequent gas freeing operations will at no time create a flammable atmosphere within the tank.

5. The inert gas system is to be capable of delivering inert gas to the cargo oil tanks at a rate of at least 125% of the maximum rate of discharge capacity of the ship expressed as a volume.

6. The inert gas system is to be capable of delivering inert gas with an oxygen content of not more than 5% by volume in the inert gas supply main to the cargo oil tanks at any required rate of flow.

7. Means are to be provided to protect cargo oil tanks against the effect of overpressure or vacuum caused by thermal variations when the cargo oil tanks are isolated from the inert gas mains.

8. Special consideration is to be given to the design and location of the gas generator, scrubber and blowers with relevant piping and fittings in order to prevent flue gas leakages into enclosed spaces.

9. Materials used in inert gas systems are to be suitable for their intended purpose. In particular those parts or scrubbers, blowers, non-return devices, scrubber effluent and other drain pipes which may be subjected to corrosive action of the gases and/or liquids are to be either constructed of corrosion resistant material or lined with rubber, glass fiber epoxy resin or other equivalent coating material.

1104. Source of inert gas supply

1. The inert gas system is to be capable of supplying an adequate quantity of inert gas to ensure effective inerting of the tanks during navigating, cargo handling, tank cleaning, gas freeing, etc. which require the supply of inert gas under the normal condition.

2. The inert gas may be treated flue gas from the main or auxiliary boiler(s) or from a separate inert gas generator. In case where inert gas is supplied from only one boiler, the boiler is to be fitted with two or more units of burning pumps and fuel oil heaters, respectively.

3. Where inert gas is supplied from a separate inert gas generator, the separate inert gas generator is to be provided with two or more fuel oil pumps and to be of suitable construction and provided with equipment considered necessary by the Society. However, the Society may permit only one fuel oil pump on condition that sufficient spares for the fuel oil pump and its prime mover are carried on board to enable any failure of the fuel oil pump and its prime mover to be easily rectified by the ship's crew.

4. Arrangements are to be made to vent the inert gas from inert gas generators to the atmosphere when the inert gas produced is offspecification, e.g. during starting-up or in the event of equipment failure.

5. Automatic combustion control capable of producing suitable inert gas under all service conditions is to be fitted to the inert gas generators. For the separate inert gas generators, automatic shut-down of the oil fuel supply is to be arranged on predetermined limits being reached in respect of low water pressure or low water flow rate to the cooling and scrubbing arrangement and in respect of high gas temperature.

6. Flue gas isolating valves are to be fitted in the inert gas supply mains between the boiler uptakes and the flue gas scrubber. These valves are to be provided with indicators to show whether they are open or shut. Precautions are to be taken to maintain the gas isolating valves specified above gastight and keep the seatings clear of soot. Arrangements are to be made to ensure that boiler soot blowers cannot be operated when the corresponding flue gas isolating valves is open.

1105. Gas scrubbers

1. A flue gas scrubber is to be fitted which will effectively cool the volume of flue gas and remove solids and sulpher combustion products. The scrubber is generally to be installed on a suction side of the inert gas blowers except where a separate inert gas generator is provided.
2. The cooling water arrangements for the scrubber (including the precooler) are to be such that an adequate supply of water will, under the inert gas system being used, be available without interfering with any essential services on the ship.
3. A stand-by cooling water pump is to be included in the cooling water arrangements specified in **Par 2.** This pump may be used for other purposes.
4. Demisters or equivalent devices are to be fitted in or just after the scrubber to minimize the amount of water carried over to the inert gas blowers.
5. The scrubber is to located aft of all cargo oil tanks, cargo oil pump rooms and cofferdams separating these spaces from machinery spaces of category *A*.
6. To permit safe maintenance, an additional water seal or other effective means of preventing flue gas leakage is to be fitted between the flue gas isolating valves and scrubber or incorporated in the gas entry to the scrubber.

1106. Inert gas blowers

1. The inert gas system is to be provided with two or more sets of inert gas blowers which are together to be capable of delivering to the cargo oil tanks at least the volume of inert gas required by **1103. 5.** In the system with a separate inert gas generator, the Society may permit only one blower where this blower is installed before the burning system and if that system is capable of delivering the total volume of inert gas required by **1103. 5** to the protected cargo oil tanks, provided that sufficient spares for the blower and its prime mover are carried on board to enable any failure of the blower and its prime mover to be rectified by the ship's crew.
2. The inert gas blowers are to be so designed that the maximum pressure which can be exerted on any cargo oil tank will not exceed the test pressure of any cargo oil tank.
3. Suitable shut-off arrangements are to be provided on the suction and discharge connections of each blower. However, in the system with a separate inert gas generator and where the blower(s) is installed before the generator, the shut off valve on the suction side of the blower may be omitted.
4. Arrangements are to be provided to enable the functioning of the inert gas system to be stabilized before commencing cargo discharge.
5. The inert gas blowers are to be located aft of all cargo oil tanks, cargo oil pump rooms and cofferdams separating these spaces from machinery spaces of category *A*.

1107. Inert gas regulating valves

1. An inert gas regulating valve with an indicator to show whether it is open or closed is to be fitted in the inert gas supply main. This valve is to be automatically controlled to close as required in **1112. 3** (1) and (2). It is also to be capable of automatically regulating the flow of inert gas to the cargo oil tanks unless means are provided to automatically control the speed of the inert gas blowers required in **1106.**
2. The valve referred to in **Par 1** is to be located at the forward bulkhead of the forwardmost gas safe space (Gas safe space means a space in which the entry of hydrocarbon gases would produce hazards with regard to flammability or toxicity. The same is referred hereinafter.) through which the inert gas supply main passes.

1108. Non-return devices

1. At least two non-return devices, one of which is to be a water seal, are to be fitted in the inert gas supply main, in order to prevent the return of hydrocarbon vapour to the machinery space uptakes or to any gas safe spaces. They are to be located between the inert gas regulating valve required by **1107. 1** and the aftermost connection to any cargo oil tank or cargo oil pipeline.
2. The non-return devices are to be effective under all normal conditions including trim, list and motion of the ship.
3. The non-return devices are to be located in the cargo tank area on deck.
4. The water seal specified in **Par 1** is to comply with the following requirements.
   (1) The water seal is to be capable of being supplied by two separate pumps, each of which is to be capable of maintaining an adequate supply at all times.

(2) The arrangement of the seal and its associated fittings is to be such that it will prevent back-flow of hydrocarbon vapours and will ensure the proper functioning of the seal under operating conditions.
(3) Provision is to be made to ensure that the water seal is protected against freezing, in such a way that the integrity of seal is not impaired by overheating.
(4) A water loop or other approved arrangement is to be fitted to each associated water supply and drain pipe and each venting or pressuresensing pipe leading to gas safe spaces. Means are to be provided to prevent such loops from being emptied by vacuum.
(5) The deck water seal and all loop arrangements are to be capable of preventing return of hydrocarbon vapours at a pressure equal to the test pressure of the cargo oil tanks.

5. As for the non-return devices specified in **Par 1,** the non-return device other than water seal is:

(1) to be a non-return valve or equivalent capable of preventing the return of vapours or liquids;
(2) to be fitted forward of the deck water seal required in **Par 1**; and
(3) to be provided with positive means of closure. As an alternative to the positive means of closure, an additional valve having such means of closure may be provided forward of the non-return valve to isolate the deck water seal from the inert gas main to the cargo oil tanks.

6. As an additional safeguard against the possible leakage of hydrocarbon liquids or vapours back from the deck main, means are to be provided to permit this section of the line between the valve having positive means of closure referred to in **Par 5** and the inert gas regulating valve referred to in **1107. 1** to be vented in a safe manner when the first of these valves is closed.

1109. Inert gas distribution lines

1. The inert gas main may be divided into two or more branches forward of the non-return devices required by **1108.**

2. The inert gas supply mains are to be fitted with branch piping leading to each cargo tank. Branch piping for inert gas is to be fitted with either stop valves or equivalent means of control for isolating each tank. The control system operated is to provide positive indication of the operational status of such valves.

3. The stop valves specified in **Par 2** are to be provided with locking arrangements.

4. In combination carriers, the arrangement to isolate the slop tanks containing oil or oil residues from other tanks is to be provided consisting of blank flanges which will remain in position at all times when cargoes other than oil are being carried except where approved by the Society.

5. Piping systems are to be so designed as to prevent the accumulation of cargo or water in the pipelines under all normal conditions.

6. Suitable arrangements are to be provided to enable the inert gas main to be connected to an external supply of inert gas.

7. Where inert gas distribution lines are used for the venting of all vapours displaced from the cargo oil tanks during loading and ballasting, the arrangements are to comply with the requirements in **1004.** and are to consist of either one or more masthead risers, or a number of high velocity vents.

1110. Safety measures during cargo handling

1. One or more pressure-vacuum breaking devices are to be provided on the inert gas supply main to prevent the cargo oil tanks from being subject to:

(1) a positive pressure in excess of the test pressure of the cargo oil tank if the cargo were to be loaded at the maximum rated capacity and all other outlets were left shut; or
(2) a negative pressure in excess of 700 mm water gauge if cargo were to be discharged at the maximum rated capacity of the cargo oil pumps and the inert gas blowers were to fail.

2. The location and design of the devices referred to in **Par 1** are to comply with the requirements in **1004.**

1111. Safety measures during inerting, purging or gas freeing of empty tanks

The arrangements for inerting, purging or gas freeing of empty tanks are to be subjected to the approval by the Society and to comply with the following requirements:

(1) The accumulation of hydrocarbon vapours in pockets formed by the internal structural members in a tank is to be minimized.
(2) On individual cargo oil tanks the gas outlet pipe, if fitted, is to be positioned as far as practicable from the inert gas/air inlet and in accordance with the requirements in **1004.** The inlet of such outlet pipes may be located either at deck level or at not more than 1 m above the bottom of the tank.
(3) The cross sectional area of such gas outlet pipe referred to in (2) is to be such that an exit velocity of at least 20 m/sec can be maintained when any three tanks are being simultaneously supplied with inert gas. Their outlets are to extend not less than 2 m above deck

level.

(4) Each gas outlet referred to in (3) is to be fitted with suitable blanking arrangements.

(5) If a connection is fitted between the inert gas supply mains and the cargo oil piping system for the effective gas freeing arrangements are to be provided consisting of two shut-off valve with an arrangement to vent the space between the valves in a safe manner or an arrangement consisting of a spool-piece with associated blanks.

(6) The valve required by (5) separating the inert gas supply main from the cargo oil main and which is on the cargo oil main side is to be a non-return valve with a positive means of closure.

1112. Means for measuring and controlling

1. Measuring devices

(1) Means are to be provided for continuously indicating the temperature and pressure of the inert gas at the discharge side of the inert gas blowers, whenever the blowers are operating. In the system with a separate inert gas generator, the temperature and pressure of the inert gas may be measured at the outlet side of the scrubber.

(2) Instrumentation is to be fitted for continuously indicating and permanently recording the pressure and oxygen content in (a) and (b), when the inert gas is being supplied. These devices are to be placed in the cargo oil control room where provided. But where no cargo oil control room is provided, they are to be placed in a position easily accessible during cargo operations.
   (a) The pressure of the inert gas supply mains forward of the non-return devices required by **1108. 1**; and
   (b) The oxygen content of the inert gas in the inert gas supply mains on the discharge side of the inert gas blowers. In the system with a separate inert gas generator, the oxygen content may be measured at the outlet side of the scrubber.

(3) Portable instruments for measuring oxygen and flammable vapour concentration are to be provided. In addition, suitable arrangement is to be made on each cargo oil tank such that the condition of the tank atmosphere can be determined using these portable instruments.

(4) In addition to (1), meters are to be fitted:
   (a) in the navigating bridge to indicate at all times the pressure referred to in (2) (a) and the pressure in the slop tanks of combination carriers, whenever those tanks are isolated from the inert gas supply main; and
   (b) in the machinery control room or in the machinery space to indicate the oxygen content referred to in (2) (b).

(5) Suitable means are to be provided for the zero and span calibration of both fixed and portable gas concentration measurement instruments, referred to in (1) to (4).

2. Alarm devices

(1) Audible and visual alarms are to be provided to indicate the following. The alarms required in (e), (f) and (h) are to be fitted in the machinery space and cargo oil control room, where provided, but in each case in such a position that they are immediately received by the crew.
   (a) low water pressure or low water flow rate to the scrubber;
   (b) high water level in the scrubber;
   (c) high gas temperature as referred to in **1** (1);
   (d) failure of the inert gas blowers;
   (e) oxygen content in excess of 8% by volume as referred to in **1** (2) (b);
   (f) failure of the power supply to the automatic control system for the inert gas regulating valve and to the indicating devices as referred to in **1** (2).
   (g) low water level in the water seal;
   (h) gas pressure less than 100 mm water gauge as referred to in **1** (2) (a). The alarm arrangement is to be such as to ensure that the pressure in slop tanks in combination carriers can be monitored at all times;
   (i) high gas pressure as referred to in **1** (2) (a); and

(2) In the system with a separate inert gas generator audible and visual alarms are to be provided to indicate:
   (a) the conditions referred to in (1) (a), (c) and (e) to (j);
   (b) insufficient fuel oil supply;
   (c) failure of the power supply to the gas generator; (d) failure to the power supply to the automatic control system for the gas generator.

3. Safety devices

(1) Automatic shut-down of the inert gas blowers and inert gas regulating valve is to be arranged on predetermined limits being reached in respect of **2** (1) (a) to (c).

(2) Automatic shut-down of the inert gas regulating valve is to be arranged in respect of **2** (1) (d). In the system with a separate inert gas generator, automatic shutdown of the inert gas regulating valve is also to be arranged in respect of **2** (2) (c).

(3) In respect of **2** (1) (e), when the oxygen content of the inert gas exceeds 8% by volume, immediate action is to be taken to improve the gas quality. Unless the quality of the gas improves, all cargo oil tank operations are to be suspended so as to

avoid air being drawn in to the tanks and the isolation valve referred to in **1108. 5** is to be closed.

(4) Automatic stoppage of cooling water supply to the scrubber is to be arranged in respect of **2** (1) (b).

(5) In respect of **2** (1) (g), safety measures are to be taken for the maintenance of an adequate reserve of water at all times and the integrity of the arrangements to permit the automatic formation of the water seal when the gas flow ceases. The audible and visible alarm on the low level of water in the water seal is to operate when the inert gas is not being supplied.

(6) An audible alarm system independent of that required in **2** (1) (h) or automatic shut-down of cargo oil pumps is to be provided to operate on predetermined limits of low pressure in the inert gas mains being reached.

1113. Testing and inspection

After the manufacture of inert gas systems of oil carriers, the following tests are to be conducted in addition to the requirements in **Pt 5, Ch 6, Sec 12.**

(1) Tests on board
With respect to inert gas systems, their equipment are to be subjected to a functioning test and their control, safety and alarm devices are to be subjected to an effectiveness test.

(2) After installation inboard, auxiliaries and piping systems are to be subjected to the following tests.
   (a) An airtight test of inert gas systems.
   (b) A test on the functioning of various systems concerning safety measures specified in this Section.

SECTION 12
Electrical Equipment for Oil Tankers

1201. General

1. Application

Electrical equipment for ships carrying oil having a flash point not exceeding 60°C (hereinafter referred to as **"tankers"** in this Section.) is to comply with the requirements in this Section and all applicable requirements in **Pt 6, Ch 1.**

2. Dangerous spaces

In tankers, the following spaces and zones are to be considered as dangerous spaces.

(1) Cargo tanks,
(2) Cofferdams, double bottoms and duct-keels adjoining cargo tanks.
(3) Enclosed or semi enclosed spaces immediately above cargo tanks (e.g. between decks) or having bulkheads above and in line with cargo tank bulkheads,
(4) Other spaces adjoining cargo tanks than those specified in (2) and (3) above,
(5) Cargo pump rooms,
(6) Enclosed or semi-enclosed spaces in which cargo pipes are fitted,
(7) Compartments for cargo hoses,
(8) Zones on open deck, or semi-enclosed spaces on open deck, within at least 3 m of any cargo tank outlet or gas or vapour outlets, and spaces within 3m of the manifold. Gas or vapour outlets are to include ventilation openings of cargo pump rooms, cofferdams and the like, and cargo pump rooms entrances,
(9) Zones on open deck within 10 m of ventilation openings of cargo tanks and the zones downward from there to the deck,
(10) Zones on open deck over all cargo tanks (including all ballast tanks within the cargo tank block) and to the full width of the vessel plus 3 m fore and aft on open deck, up to a height of 2.4 m above the deck,
(11) Enclosed and semi-enclosed spaces immediately above cargo pump rooms or above vertical cofferdams adjoining cargo tanks unless separated by a gastight deck and suitably mechanically ventilated.
(12) Enclosed or semi-enclosed spaces having a direct opening into any of the dangerous spaces or zones stipulated in the above.
(13) Fore peak ballast tank ballasted with the system serving ballast tanks within the cargo area.

3. System of supply

(1) The system of power supply is to be one of the following systems:
Two-wire insulated for $d.c.$
Two-wire insulated for single-phase $a.c.$,
Three-wire insulated for three-phase $a.c.$,

(2) Generator circuits, power supply and distribution circuits are not to be earthed, nor to depend on hull return system except the following:
   (a) Impressed current cathodic protection system for outer hull protection only,
   (b) Earth indication devices or other alternative means, however, in no case the circulation current to exceed 30 mA,
   (c) Limited and locally earthed systems, such as starting and ignition systems of internal combustion engines,
   (d) Electrical circuits having no fear of causing hull current in the dangerous spaces, subjected to the approval of the Society.

4. Isolating means

Distribution circuits for the electrical equipments installed in dangerous spaces are to be provided on each circuit with multipole linked isolation switches in a safe space. In addition, the isolation switches are to be clearly labelled to identify the electrical equipment to be connected with, and further effective means are to be provided to avoid danger due to unauthorized operation of the isolation switches.

5. Earth detection

Excluding intrinsically safe circuits, the feeders and distribution circuits to be connected to the electrical equipments in the dangerous spaces or to run through the dangerous spaces are to be provided with such devices that keep monitoring the insulation levels and will give an alarm in case of abnormally low level.

1202. Wirings in dangerous spaces

1. General

Cables are generally not to be installed in the dangerous spaces specified in **1201. 2.** Where installation of cables in such spaces is unavoidable, it is to comply with the following requirements.

2. Selection of cables

Cables are to be one of the following. Where corrosion may be expected, a non-metallic impervious sheath is to be applied over metallic sheath or armour of cables for corrosion protection.

(1) Mineral insulated and metallic sheathed.
(2) Lead sheathed and armoured.
(3) Non-metallic impervious sheathed and armoured.

3. Installation of cables

(1) Cables are to be installed as close to the hull center line as practicable.
(2) Cables are to be installed sufficiently distant from decks, bulkheads, tanks and various kinds of pipes.
(3) Cables which are installed on the fore and aft gangways and the decks are to be protected against mechanical damage. Further, the cables and their supports are to be fitted in such a manner as to withstand expansion and contraction and other effects of the hull structure.
(4) The penetration part of the cables or cable pipes through decks and bulkheads of the dangerous spaces is to be constructed so as to maintain gastightness and liquid-tightness as the case may require.
(5) When mineral insulated cables are used, special precautions are to be taken to ensure sound terminations.

4. Earthing of cables

All metallic protective coverings of power and lighting cables passing through dangerous spaces, or connected to equipment in such spaces, are to be earthed at least at each end.

5. Intrinsically safe circuits

(1) The cables for intrinsically safe circuits associated with intrinsically safe type electrical equipment are to be of exclusive use, being installed separately from cables for general circuits.
(2) Intrinsically safe circuits associated with different kinds of intrinsically safe type electrical equipment are generally to be wired individually using different cables. Where it is necessary to use a multi-core cable in common, a cable which has shields by each core or each pair of cores is to be used, having such shields earthed effectively.

1203. Electrical equipment in dangerous spaces

1. General

(1) Electrical equipment is generally not to be installed in the dangerous spaces specified in **1201. 2.** Where installation of electrical equipment is unavoidable, it is to comply with the following requirements.
(2) Explosion-protected electrical equipment is to comply with the requirements in **Pt 6, Ch 1, Sec 9** and to be suitable for use in the explosive gases and vapours classified into the ignition group G3 and the explosion class 2 as stipulated in *KS C* 0906 (General Rules for the Construction of Explosion-Proof Electrical Equipment) or equivalent thereto.
(3) Electrical measuring, monitoring, control and communication apparatus are to be of intrinsically safe type.
(4) Portable lamps are to be of intrinsically safe or flameproof type with self-contained battery or of air-driven type with pressurized enclosure.
(5) Lighting fittings of increased safety type are to be of a type accepted by the Society for oil tankers.

2. All dangerous spaces specified in 1201. 2

Intrinsically safe type electrical equipment may be installed.

3. Cathodic protection

(1) Impressed current systems are not to be permitted in oil cargo tanks.
(2) Magnesium or magnesium alloy anodes are not to be permitted in oil tanks.
(3) Aluminium anodes are only permitted in cargo tanks of tankers in locations where the potential energy does not exceed 275$N\cdot m$. Aluminium anodes are not to be located under tank hatches or Butterworth openings in order

to avoid any metal parts falling on the fitted anodes, unless protected by adjacent structure.

(4) There is no restriction on the position of zinc anodes.

(5) The anodes are to have steel cores and these are to be sufficiently rigid to avoid resonance in the anode support and be designed so that they retain the anode even when it is wasted.

(6) The steel inserts are to be attached to the structure by means of a continuous weld of adequate section. Alternatively they may be attached to separate supports by bolting, provided a minimum of two bolts with locknuts are used. However, approved mechanical means of clamping will be accepted.

(7) The supports at each end of an anode are not to be attached to separate items which are likely to move independently.

(8) When anode inserts or supports are welded to the structure, they are to be arranged so that the welds are clear of stress raisers.

4. Dangerous spaces specified in 1201. 2 (2)

(1) The transducers of navigation instruments such as electric depth sounding devices may be installed. The transducers are to be of totally-enclosed type and to be housed in a gastight enclosure clear of the cargo tank. The cables to the transducers are to be installed in heavy gauge galvanized steel pipes with gastight joints up to the main deck.

(2) Where the anodes or electrodes and the cables of an impressed current cathodic protection system for outer hull protection are installed in such spaces, the requirements in the preceding (1) are to be applied.

(3) Lighting fittings of flameproof type or of air-driven type with pressurized enclosure may be installed in double bottoms and ductkeels equipped with machinery which is to be manned for operation and watch. The lighting fittings are to be arranged on at least two independent circuits.

5. Dangerous spaces specified in 1201. 2 (3)

(1) Lighting fittings of flameproof type or of air-driven type with pressurized enclosure may be installed. Lighting fittings in the spaces which are normally attended by the personnel are to be supplied by at least two independent circuits.

(2) Cables may be run through in these spaces.

6. Dangerous spaces specified in 1202. 2 (4)

(1) Electrical equipment specified in **Par 3** may be installed.

(2) Lighting fittings of flameproof type or air-driven type with pressurized enclosure may be installed in the spaces equipped with machinery which is to be manned for operation and watch.

(3) Through-runs of cables are to be subjected to the approval of the Society.

7. Dangerous spaces specified in 1201. 2 (5)

(1) Electrical equipment specified in **Par 3** may be installed.

(2) Lighting fittings of flameproof type of air-driven type with pressurized enclosure may be installed. Lighting fittings are to be arranged on at least two independent circuits.

(3) Where cables are run through cargo pump room entrances, they are to be installed in heavy gauge steel pipes or steel ducts with gastight joints.

8. Dangerous spaces specified in 1201. 2 (6) and (7)

(1) Lighting fittings of flameproof type or air-driven type with pressurized enclosure may be installed.

(2) Where cables are run through these spaces, they are to be installed in heavy gauge steel pipes or steel ducts with gastight joints.

9. Dangerous spaces specified in 1201. 2 (8) to (11)

(1) Electrical equipment of flameproof type, pressurized protected type and increased safety type may be installed.

(2) Cables may be run through the spaces. However, no cable expansion bends are to be provided in th e spaces specified in **1201. 2** (8) as far as practicable.

10. Dangerous spaces specified in 1201. 2 (12)

These spaces are to be taken as equivalent to the adjacent dangerous spaces having direct openings, and the electrical installations are to be in compliance with the corresponding requirements in the preceding **Pars 1** to **8.**

11. Electric motors driving equipment in cargo pump room

Electric motors driving equipment located in cargo pump room spaces are to be installed in the space partitioned from these spaces by a gastight bulkhead and deck. In addition, suitable stuffing boxes are to be fitted where shafts pass through gastight bulkheads and decks.

12. Lighting in dangerous spaces

(1) Where dangerous spaces are illuminated through glazed ports, these are to be effectively protected from mechanical damage and are to have strong covers secured from the side of the safe spaces. Glazed ports are to be so constructed that glass and sealing will not be impaired by the working of the ship.

(2) The glass and the protection of the light fitting in the preceding (1) are not to impair the integrity of the bulkhead and are to be of

equivalent strength. The fitting is to have the same resistance to fire and smoke as the unpierced bulkhead.

(3) To discourage personnel from entering the cargo pump room when the ventilation is not in operation, one of the following means is to be applied.

(A) Lightings in cargo pump room are to be interlocked with ventilation system such that ventilation systems are to be in operation to energize the lighting. Failure of the ventilation systems should not cause the lighting to go out. Emergency lighting, if fitted, is not to be interlocked.

(B) Audible and visible alarms located at the door to the cargo pump room are to provide a warning if the door is opened when the cargo pump room ventilation is not in operation. A notice is to be prominently displayed on or adjacent to the pump room door to the effect that the alarms indicate that the pump room ventilation is not in operation, that the pump room atmosphere may therefore be hazardous, and that the pump room is not to be entered until verified safe. The audible alarm is also to sound on the navigation bridge. Reset of the alarm is to be provided from the navigation bridge only.

13. Electric motors driving ventilators for dangerous spaces

Electric motors driving the ventilators for cargo pump rooms and the exhaust ventilators for other dangerous spaces are not to be installed in the ventilation ducts.

1204. Earthing and bonding of cargo tanks, process plant and piping systems for the control of static electricity

1. Bonding straps are required for cargo tanks and process plant, piping systems which are not permanently connected to the hull of the ship as the followings.

(1) Independent cargo tanks

(2) Cargo tanks and piping systems which are electrically separated from the hull of the ship

(3) Pipe connections arranged for the removal of spool pieces

2. Where bonding straps are required, they are to comply with the followings.

(1) The bonding straps are to be clearly visible so that any shortcomings can be clearly detected.

(2) The bonding straps are to be designed and sited so that they are protected against mechanical damage and, as far as possible, they are not affected by high resistivity contamination(corrosive products or paint).

(3) The bonding straps are to be easy to install and replace. ⚓

CHAPTER 2
ORE CARRIERS

SECTION 1
General

101. Application

1. The construction and equipment of ships intended to be registered and classed as "Ore Carriers" are to be in accordance with the requirements in this Chapter or equivalent thereto.
2. Except where specially required in this Chapter, the general requirements for the construction and equipment of steel ships are to be applied.
3. The requirements in this Chapter are framed for ships not less than 120 m and up to 230 m in length and of usual form, having single deck, machinery aft, two rows of longitudinal watertight bulkheads, and also having double bottoms under ore holds, decks and bottoms with longitudinal framing.
4. Ore carriers which are different construction from the scope of application given above and to which the requirements in this Chapter are not applicable, are to be at the discretion of the Society.

102. Direct calculation

Where approved by the Society, the scantlings of structural members may be determined basing upon direct calculation defined in **Pt 3, Ch 1, 206.**

103. Drainage

1. In general, one bilge suction opening is to be provided on each side of the ship at the after end of the each hold. Where the length of ore hold in ships having only one hold exceeds 66 *meters*, additional bilge suction opening is to be arranged in a suitable position in the forward half-length of the hold.
2. Bilge wells are to be provided at suitable positions so as to protect the cover plates from the direct strike of ore and to be provided with rose boxes or other suitable means so that the suction openings may not be choked by ore dust, etc.
3. Where bilge pipes are led through double bottoms, side tanks or void spaces, non-return valves, or stop valves capable of being closed from a readily accessible position, are to be provided at their open ends.
4. Bilge suction branch pipes may be of inside diameter obtained from the formula in **Pt 5, Ch 6, 404. 2,** taking B as the mean breadth of the ore hold.

SECTION 2
Construction and Dimension

201. Subdivision

1. The distance between longitudinal watertight bulkheads and ship's side is not to be less than that obtained from the following formula even at the narrow parts at the ends of the ship:

$$l = 4L + 500 \quad (mm)$$

2. At least one transverse watertight bulkhead is to be provided between longitudinal watertight bulkheads at a position somewhat forward of the middle of the length of the ore cargo space, except where the Society is satisfied with the omission of such bulkhead.

202. Double bottoms

1. The height of double bottoms is to be determined in such a manner that the centre of gravity of the ship is sufficiently high in full load condition. The standard height is to be $0.2D$ (m).
2. The thickness of centre girders is not to be less than that obtained from the following formula:

$$t = 0.04L + 6.0 \quad (mm)$$

3. Floor plates or bottom transverses are to be arranged at the positions of bulkheads or transverses in side tanks or void spaces.
4. Where longitudinal framing is adopted in the inner bottom, the thickness of the floor plates is not to be less than that obtained from the following formula. The sum of the depth of lightening holes,

slots, etc. is not to exceed a half of the depth of the floor at the part $b/4$ or more from the ends of the floor and a quarter of the depth of the floor at $b/8$ from the ends of the floor. Where suitable reinforcement is provided, lightening holes over the preceding limits may be permitted.

$$t = 62.5\,K\,\frac{SbH}{d_0} + 1.5 \quad (mm)$$

where:

S = spacing of floor plates (m).
b = breadth of floor plates (m).
H = value obtained from the following formulae:
Where floor plates only are arranged.

$H = 2h - d \ (m)$

Where one transverse is ar ranged between adjacent floor plates to support inner bottom longitudinals.

$H = 1.6h - d \ (m)$

h = vertical distance from the upper surface of inner bottom plates to the upper deck measured at the centre line of the ship (m).
d_0 = depth of floor plates (mm).

5. Stiffeners are to be provided on the centre girder plates and floor plates in the spacing not greater than that obtained from the following formula:

$$l = 100\,t - 250 \quad (mm)$$

where:

t = thickness of centre girders or floor plates (mm).

6. The thickness of inner bottom plates is not to be less than that obtained from the following formulae, whichever is the greater:

$$t_1 = 6.6\,S\sqrt{Kh} + 4.0 \quad (mm)$$
$$t_2 = 19\sqrt{S} + 4.0 \quad (mm)$$

where:

S = spacing of inner bottom longitudinals (m).
h = as specified in **Par 4.**

7. The section modulus of inner bottom longitudinals is not to be less than that obtained from the following formula:

$$Z = 21\,Shl^2 \quad (cm^3)$$

where:

S = spacing of inner bottom longitudinals (m).
h = as specified in **Par 4.**
l = spacing of floor plates or transverses (m).

203. Construction and scantlings of wing tanks or void spaces

The construction and scantlings of wing tanks or void spaces are to be as required in the following:

(1) Longitudinal frames and beams are to be generally in accordance with the requirements in **Ch 1, Secs 3** and **9.**
(2) Transverses, girders, webs and cross ties are to be generally in accordance with the requirements in **Ch 1, Secs 4** and **9** and are also to be in accordance with the requirements in **Ch 1, 108** (4).
(3) The construction and scantlings of bulkheads are to be in accordance with the requirements in **Ch 1.** However, h is the distance given by (a) and (b) below, whichever is the greater:
  (a) The distance in *metres*, from the lower point of h for structural members concerned specified in **Ch 1** to the top of hatches or to the mid-point between the top of tanks and the top of overflow pipes, whichever is the greater.
  (b) 0.7 times the distance in *metres*, from the lower point of h for structural members concerned specified in **Ch 1** to the point of 2.0 *metres* above the top of overflow pipes.
(4) Horizontal stiffeners provided at the upper and lower parts of longitudinal watertight bulkheads are to be of increased scantlings over those specified in (3).
(5) The breadth and thickness of the lowest and the uppermost strakes of longitudinal watertight bulkheads are to be in accordance with **Ch 1, 502. 2.** The thickness of longitudinal watertight bulkhead plating at the lower part of the ore hold is to be properly increased in relation to the thickness of inner bottom plating.
(6) The thickness of longitudinal watertight bulkheads is to be in accordance with the requirements in **Pt 3, Ch 3, 301.** and **402.**

204. Transverse bulkheads in ore holds

1. The scantlings of the members of the transverse bulkheads in ore holds are to be in accordance with the requirements in **Pt 3, Ch 15, Sec 2.** Where, however, in application of these requirements, h in the formula is to be substituted for $0.72h'$, h' is to be in accordance with the following.

(1) Bulkhead platings:
Vertical distance (m) from the lower edge of the bulkhead plate to the upper deck at the centre line of the ship.
(2) Stiffeners:
Vertical distance (m) from the midpoint of l for vertical stiffeners or from the midpoint of distance between the adjacent stiffeners for horizontal stiffeners to the upper deck at centre line. Where, however, the distance is less than 6 *metres*, h' is to be at least 0.8 times the distance plus 1.2 m, l is as specified in **Pt 3, Ch 15, 203.**
(3) Girders:
Vertical distance (m) from the mid-point of l

for vertical girders or from the mid-point of S for horizontal girders, to the upper deck at centre line. Where, however, the distance is less than 6 $metres$, h' is to be at least 0.8 times the distance plus 1.2 m, l and S are as specified in **Pt 3, Ch 15, 204.**

2. Notwithstanding the requirements in **Par 1,** the thickness of the transverse bulkhead platings is not to be less than 7 mm.

3. The thickness of the lowest strake of bulkhead plating is to be appropriately increased referring to the thickness of inner bottom plating.

205. Relative deformation of wing tanks

As for wing tanks, where the value obtained from the following formula exceeds 0.18, a special consideration is to be given to the structure of the wing tanks:

$$\delta = \frac{2h - 0.65d}{n_b K_b + n_s \eta_s K_s + n_t \eta_t K_t} \cdot \frac{a}{b} l$$

where:

h = vertical distance between the top of inner bottom plating and the upper deck at the centre line of the ship (m).

l = length of one ore hold (m).

a, b, n_b, n_S, n_t, η_S, η_t, K_b, K_S, K_t = values to be obtained by applying the requirements in **Ch 1, 601,** respectively.

206. Ore/Oil carriers

1. Such ore carriers as intended to carry oils in the ore holds and/or wing tanks (hereinafter referred to as “ore/oil carriers”) are to comply with the relevant requirements in **Ch 1,** in addition to those in this Section.

2. In addition to the requirements in this Section, special requirements may be given as deemed necessary for ore/oil carriers by the Society.

207. Slop tanks in ore/oil carriers

1. Cofferdams are to be provided between slop tanks and machinery spaces in accordance with the requirements of **Ch 1, 103.** In addition, cofferdams are to be provided between slop tanks and ore holds, except where the slop tanks are cleaned and gas freed at any time prior to loading ore cargoes.

2. The cofferdams specified in **Par 1** are to be capable of being flooded, except where the cofferdams are used concurrently as pump rooms, fuel oil tanks or water ballast tanks, or cargo oil tanks (in case of cofferdams between slop tanks and ore holds only).

3. Adequate ventilation is to be provided for the spaces surrounding the slop tanks.

4. Notice boards are to be errected at suitable points detailing the precautions to be observed prior to loading or unloading, or whilst carrying ore cargo with oily water in the slop tanks.

5. It is recommended to provide an inert gas system for the slop tanks. ⚓

CHAPTER 3
BULK CARRIERS

SECTION 1
General

101. Application

1. The construction and equipment of ships intended to be registered as "Bulk Carriers" are to be in accordance with the requirements in this Chapter or equivalent thereto.
2. Except where specially required in this Chapter, the general requirements for the construction and equipment of steel ships are to be applied.
3. The requirements in this Chapter are framed for ships not less than 100 m and up to 250 m in length and of usual form, having single deck, machinery aft, bilge hopper tanks and topside tanks, and also double bottoms under cargo holds, and decks and bottoms with longitudinal framing.
4. Ships with different construction from the scope of application given above or larger ships to which the requirements in this Chapter are not applicable, are to be at the discretion of the Society.
5. Bulk carriers, which were contracted for construction before 1 July 1998, and the keels of which were laid or which were at a similar stage of construction before 1 July 1999, are to be determined at the discretion of the Society.

102. Plans and documents for approval

Plans and documents submitted for approval are to indicate kinds of cargo and/or ballast, loading capacity, level of liquid, etc in each of the holds at service.

103. Direct calculation

Where approved by the Society, the scantlings of structural members may be determined basing upon direct calculation specified in **Pt 3, Ch 1, 206.**

104. Drainage of bulk holds

1. In general, one bilge suction opening is to be arranged on each side of the ship at the after end of the each hold.
2. Bilge wells are to be arranged at suitable positions so as to protect the cover plates from the direct strike of bulk cargoes and to be provided with mud boxes or other suitable means so that the suction openings may not be choked by bulk dust, etc.
3. Where bilge pipes are led through double bottoms, side tanks or void spaces, non-return valves or stop valves capable of being closed from a readily accessible position, are to be provided at their open ends.
4. Where scupper pipes on topside tanks are led over board, stop valves capable of being operated at deck and automatic non-return valves attached to shell plating are to be provided.

105. Coal transportation

For ships intended for transport of coal, care is to be taken to the following:

(1) Structure between holds and other compartments is to be airtight.
(2) Trimming hatches are recommended to be provided outside superstructures and deckhouses.
(3) Ventilation of holds is to be made by a venti-

lation system provided on the weather part.

106. Minimum thickness

1. The thickness of inner bottom plating, bulkhead plates, floor plates, girders and bracket plates in double bottom bilge hopper tanks, topside tanks, side tanks, hold tanks etc. are not to be less than those required by **Table 7.3.1** according to the length of ships.

Table 7.3.1 Minimum Thickness

Length of ships(m)	Minimum thickness(mm)
L 〈 105	8.0
105 ≤ L 〈 120	8.5
120 ≤ L 〈 135	9.0
135 ≤ L 〈 150	9.5
150 ≤ L 〈 165	10.0
165 ≤ L 〈 180	10.5
180 ≤ L 〈 195	11.0
195 ≤ L 〈 225	11.5
225 ≤ L 〈 275	12.0
275 ≤ L 〈 325	12.5
325 ≤ L 〈 375	13.0
375 ≤ L	13.5

2. The minimum thickness of side shell plating located between hopper and upper wing tanks is not to be less than $t_{\min}$ in mm, given by :

$$t_{\min} = \sqrt{L} \qquad (mm)$$

3. The minimum thickness of frame webs within the cargo area except the foremost cargo hold is not to be less than:

$$t_{min} = 0.03L + 7 \quad (mm)$$

Where L is the length of ships in *meters*, but need not be taken greater than 200m. The thickness of the frame lower bracket is not to be less than the greater of the fitted thickness of the side frame web and t_{min} + 2mm. The thickness of the frame upper bracket is not to be less than the greater of the fitted thickness of the side frame web and t_{min}.

4. The minimum thickness of frame webs in way of the foremost hold is not to be less than 1.15 times of thickness as specified in **Par 3**. The thickness of the frame lower bracket in way of the foremost hold is not to be less than the greater of the fitted thickness of the side frame web and 1.15 t_{min} + 2mm. The thickness of the frame upper bracket is not to be less than the greater of the fitted

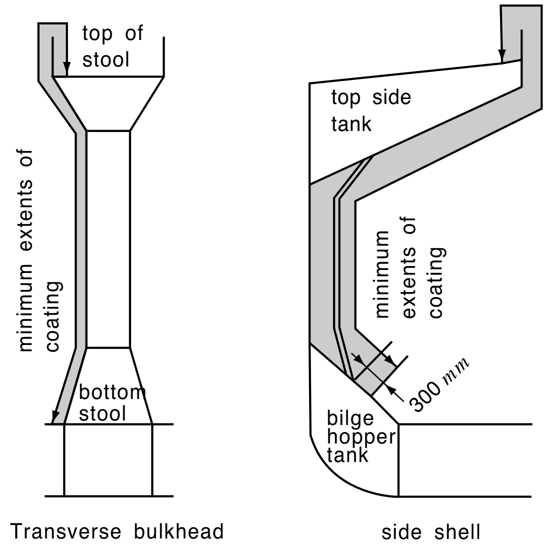


Fig. 7.3.1 Minimum extent of Corrosion Protection Coatings for Cargo Hold

thickness of the side frame web and 1.15 t_{min}.

107. Corrosion protection coatings for cargo hold spaces

All internal and external surfaces of hatch coamings and hatch covers, and all internal surfaces of the cargo holds, excluding the flat tank top areas and the hopper tankers sloping plating approximately 300mm below the side shell frame and brackets, are to have an efficient protective coating (epoxy coating or equivalent) applied in accordance with the manufacturer's recommendation.(See **Fig. 7.3.1**)

SECTION 2
Longitudinal Strength

201. General

1. The longitudinal strength of bulk carriers is to comply with the requirements in **Pt 3**, **Ch 3**.

2. In addition to the requirements in **Par 1**, all bulk carriers of 150m in length and above, intending to carry cargoes having bulk density of 1.0 t/m^3, or above are to be in accordance with the requirements in **Sec 10.**

SECTION 3
Double Bottoms

301. General

1. Except where required in this Section, the require ments in **Pt 3, Ch 7** are to be applied.

2. The scantlings of structural members in double bottom tanks intended to be deep tanks are to be correspondingly in accordance with the requirements in **Pt 3, Ch 7,** as well as the requirements in this Section. However, the thickness of inner bottom plating need not be increased by 1 mm as given in **Pt 3, Ch 15, 208.** for the top plating of deep tanks.

3. Specific gravity of cargoes described in this Section is as defined by the following formula:

$$\gamma = \frac{W}{V}$$

where:

W = mass of cargoes for the hold under consideration (t).

V = volume of the hold excluding its hatchway (m^3)

4. The coefficient specified in **302.** to **304.** is to be obtained from the following formula. Where, however, the angle between hopper plate and horizontal plane, β, is very large, the value of k is to be at the discretion of the Society. (See **Fig. 7.3.2**)

$$k = 2.1 \frac{l l_h}{e^2 \left(1 + \frac{d_1}{d_0}\right)^2}$$

where:

l_h = length of hold (m). Where stools are provided at transverse bulkheads, l_h may be reduced to the distance between the toes.

l = total girth length of hopper plate, side girder and shell plating composing the bilge hopper (m).

e = width of bilge hopper (m)

d_1 = distance from the top of keel to the top of bilge hopper (m).

d_0 = depth of centre girder (m).

5. In addition to the requirements in this **Sec**, all single side skin bulk carriers of 150m in length and above, intending to carry cargoes having bulk density of 1.0t/m^3, or above are to be in accordance with the requirements in **Sec 11**.

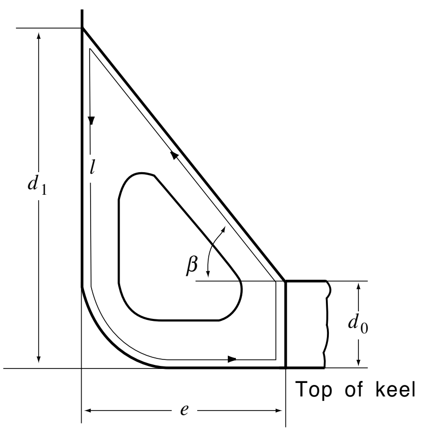


Fig. 7.3.2 Measurement of l, e, d_0, d_1, etc.

302. Centre girders and side girders

1. Side girders are to be provided at the toes of bilge hoppers. In addition, side girders are to be arranged between the centre girder and the side girder at the toe of bilge hoppers at intervals approximately not exceeding the distance obtained from the given in **Table 7.3.2.** Where, however, the value given by the formula exceeds 4.6 $metres$, the distance is to be taken as 4.6 $metres$.

2. Except where specially approved by the Society, the thickness and depth of centre girders are not to be less than those obtained from the formula given in **Table 7.3.2.** In any case, however, the depth is not to be less than $B/20$.

3. Where duct keels are provided, their spacing is not to be larger than 1.8 m. Sufficient consideration is to be paid to strength continuity of solid floors and stiffness of shell plating and inner bottom plating between duct keels.

4. Where the distance from the top of inner bottom plating to the top of overflow pipes is more than 15 m, brackets are to be provided at both ends of vertical stiffeners on watertight side girders and to be connected with inner bottom plating and bottom longitudinals.

303. Floor plates

1. Solid floors are to be provided with spacing not more than that obtained from the formulae given in **Table 7.3.3.** However, the spacing is to be 3.65 m even if the value obtained exceeds 3.65 m, and the spacing may be 2.5 m where the value obtained is less than 2.5 m. Solid floors are to be provided at the foot of the sloping plates of lower stools attached to transverse bulkhead .

2. The thickness of solid floors is not to be less than that obtained from the formula given in **Table 7.3.3.**

304. Inner bottom plating

1. The thickness of inner bottom plating is not to be less than that obtained from the following formulae, whichever is the greater:

$$t_1 = C_3 K \frac{B^2 d}{d_0} + 1.5 \quad (mm)$$

$$t_2 = C_3 S \sqrt{hK} + 1.5 \quad (mm)$$

where:

d_0 = height of centre girders (mm).

S = spacing of inner bottom longitudinals (m).

h = vertical distance from the top of inner bottom plating to the upper deck at centre line (m).

C_3 = coefficient given by the following formula. However, for adjacent holds simulta-

Table 7.3.2 Dimension of Centre Girders and Side Gilrders

Item	Scantlings
(1) Spacing of side girders	(a) For loaded holds $l = 5.7 - 1.6\gamma \ (m)$ (b) For empty holds when the ship is fully loaded $l = 3.5 \ (m)$
(2) Depth of centre girders	$H = 15\sqrt{\frac{L_h BD}{m}} \ (mm)$
(3) Thickness of centre girders and side girders	The thickness obtained from the following formula according to the location in the hold, whichever is the greater: $t_1 = \frac{C_1 KSBd}{d_0 - d_1}\left(2.6\frac{x}{l_h} - 0.17\right)\cdot\left\{1 - 4\left(\frac{y}{B}\right)^2\right\} + 1.5 \ (mm)$ $t_2 = \frac{C_1' d_2}{1000\sqrt{K}} + 1.5 \ (mm)$

γ = as specified in **301. 3.**
L_h = total length of all cargo holds, excluding pump rooms and cofferdams (m).
m = number of holds
S = distance between the centres of two adjacent spaces from the centre or side girder under consideration to the adjacent longitudinal girders (m).
d_0 = depth of the centre or side girder under consideration (mm).
d_1 = depth of the opening at the point under consideration (mm).
d_2 = depth of the girder at the point under consideration (mm). Where, however, horizontal stiffeners are provided in way of the depth of girder, d_0 is the distance from the horizontal stiffener to the bottom shell plating or inner bottom plating or the distance between the horizontal stiffeners (mm).
l_h = length defined in **301. 4.**
x = longitudinal distance between the centre of l_h of each hold and the point under consideration (m). Where, however, x is less than 0.2 l_h, x is to be taken as 0.2 l_h, and where x exceeds 0.45 l_h, x may be taken as 0.45 l_h.
y = transverse distance from the centre line of ship to the longitudinal girder (m).
S_1 = spacing of the brackets or stiffeners provided on the centre girders or the side girders under consideration (m).
C_1' = coefficient given in the following table according to S_1/d_2. For intermediate values of S_1/d_2, C'_1 is to be obtained by linear interpolation.

S_1/d_2	C_1'	
	Centre girder	Side girder
0.3 and under	4.4	3.6
0.4	5.4	4.4
0.5	6.3	5.1
0.6	7.1	5.8
0.7	7.7	6.3
0.8	8.2	6.7
0.9	8.6	7.0
1.0	8.9	7.3
1.2	9.3	7.6
1.4	9.6	7.9
1.6 and over	9.7	8.0

$C_1 = nab$
n = coefficient given by the following table.

Location	n
For adjacent holds simultaneously loaded or empty, and specially short holds such as pump room located in the area of cargo holds	$\frac{1}{3}\left(7 - 2\frac{B}{l_h}\right)^{(*1)}$
For other holds	1.0

(*1) B/l_h exceeds 1.8, B/l_h is to be taken as 1.8, and where B/l_h is under 0.5, B/l_h is to be taken as 0.5.

a = coefficient given by the following table.

Position	hr/d	a
For loaded holds	$\frac{hr}{d} < 0.55$	$0.026\frac{L'}{d} - \frac{hr}{d} + 1$
	$0.55 \le \frac{hr}{d} \le 1.45$	$0.026\frac{L'}{d} + 0.45$
	$\frac{hr}{d} > 1.45$	$0.026\frac{L'}{d} + \frac{hr}{d} - 1$
For empty holds under full load condition		$0.026\frac{L'}{d} + 1$

h = vertical distance from the top of inner bottom plating to the upper deck at centre line (m).
L' = length of ship (m). Where, however, L exceeds 230 m, L' is to be taken as 230 m.
b = value given in the following table, depending on k and B/l_h specified in **301. 4.** For intermediate values of k, b is to be obtained by linear interpolation.

k \ B/l_h	and over / less than 1.4	1.4 / 1.6	1.6 / 1.8	1.8 / 2.0	2.0 / 2.2	2.2 / 2.4	2.4
10.0 and over	17	16	15	14	13	12	11
5.0	16	15	14	13	12	11	11
2.0	15	15	14	13	12	11	11
1.0	14	14	14	13	12	11	11
0	13	13	13	12	12	11	11

NOTE:
Where a partial intermediate side girder with suitable thickness is provided at a location between a transverse bulkhead, or a stool in case where it is provided at the lower part of a bulkhead and the solid floor located at a position 20% or more of the hold length far from the end of the hold, 35% each of its sectional area of the intermediate side girder may be added to the sectional area of the adiacent girders respectively. Where a stool is provided at the lower part of a transverse bulkhead, a side girder is to be provided under the stool to counter-balance this partial intermediate side girder.

Table 7.3.3 Spacing and Thickness of Floor Platas

Item	Scantlings
(1) Spacing of floor plates	(a) For loaded holds $l = 5.6 - 2.8\,\gamma$ (m)
	(b) For empty holds under full loaded condition $l = 2.5$ (m)
(2) Thickness of solid floors	The thickness obtained from the following formula according to the location in the hold, whichever is the greater: $t_1 = \frac{C_2 K S B' d}{d_0 - d_1}\left(\frac{2y}{B''}\right)\left\{1 - 2\left(\frac{x}{l_h}\right)^2\right\} + 1.5\ (mm)$ $t_2 = 0.086\sqrt[3]{\frac{H^2 {d_0}^2}{C_2' K}}\left(t_1 - 1.5\right) + 1.5\ (mm)$

γ = as specified in **301. 3.**

S = spacing of solid floors (m).

B' = distance between the lines of bilge hoppers at the top of inner bottom plating at the midship part (m).

B'' = distance between the lines of toes of bilge hoppers at the top of inner bottom plating at the position of the solid floor under consideration (m).

l_h = length defined in **301. 4.**

y = transverse distance from the centre line of ship to the point under consideration at the position of the solid floor under consideration (m). Where, however, y is less than $B''/4$, y is to be taken as $B''/4$, and where y exceeds $B''/2$, y may be taken as $B''/2$.

x = longitudinal distance from the middle of l_h of the respective hold to the floor under consideration (m).

d_0 = depth of the solid floor at the point under consideration (mm).

d_1 = depth of the opening at the point under consideration (mm).

C_2 = coefficient obtained from the following table.

Position	C_2
For cargo hold	ab
For adjacent holds simultaneously loaded or empty	$0.9ab$

a = coefficient specified in **Table 7.3.2.**

b = value given in the following table, according to k and B/l_h which are defined in **301. 4.** For intermediate values of k, the value of b is to be determined by linear interpolation

C_2' = coefficient given in the following table, according to the ratio of the spacing of stiffeners S_1 (mm) to d_0. For intermediate values of S_1/d_0, C_2' is to be determined by linear interpolation.

S_1/d_0	0.3 and under	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.4 and over
C_2'	64	38	25	19	15	12	10	9	8	7

H = value obtained from the following table.

Kinds	H
(a) Where slots without reinforcement are provided on solid floors	$\sqrt{4.0\frac{d_2}{S_1} - 1.0}$ (*1)
(b) Where openings without reinforcement are provided on solid floors	$0.5\frac{\phi}{d_0} + 1$
(c) Where slots and openings without reinforcement are provided on solid floors	Product of the values given by (a) and (b).
(d) Except for (a), (b) and (c)	1.0

(*1) Where d_2/S_1 is less than 0.5, H is to be taken as 1.0.

d_2 = depth of slots without reinforcement provided at the upper and lower parts of solid floors (mm), whichever is the greater.

ϕ = major diameter of the openings (mm).

k \ B/l_h	and over less than 0.4	0.4 0.6	0.6 0.8	0.8 1.0	1.0 1.2	1.2 1.4	1.4 1.6	1.6 1.8	1.8 2.0	2.0 2.2	2.2 2.4	2.4
10.0 and over	40	38	34	31	26	23	21	18	16	15	14	12
5.0	40	40	37	33	30	26	24	22	18	18	16	15
2.0	41	40	38	35	33	30	28	25	23	21	18	17
1.0	41	40	40	39	37	34	32	29	26	24	23	21
0	41	41	41	41	41	40	37	33	32	30	26	25

NOTE:
Where a partial intermediate solid floor with suitable thickness is provided between the outermost side girder and the side girder located not less than 20% of B'' far from the former, 35% each of its sectional area may be added to the sectional area of the adjacent solid f!oors respectively. In this case, diaphragms, girders or brackets are to be provided in the bilge hopper tank to counter-balance this partial intermediate solid floor.

neously loaded or empty, and specially short holds, the value obtained from the following formula is to be multiplied by 1.2:

$$C_3 = ab$$

a = as specified in **Table 7.3.2.**

b = b_0 or αb_1 given below according to the value of B/l_h.

b_0 for $\dfrac{B}{l_h} < 0.8$

b_0 or αb_1, whichever is the greater

for $0.8 \le \dfrac{B}{l_h} < 1.2$

αb_1 for $1.2 \le \dfrac{B}{l_h}$

b_0, b_1 = as given in **Table 7.3.4** according to the values of k and B/l_h.
k, l_h =as specified in **301. 4** respectively.
α = as given by the following formula:

$$\alpha = \frac{13.8}{24 - 10.6\, f_B K}$$

C_3' = coefficient obtained from the following formulae, depending on the value of l/S:

$$\left(0.46\frac{l}{S} + 2.64\right)\sqrt{\gamma} \quad \text{for} \quad 1 \le \frac{l}{S} < 3.5$$

$$4.25\sqrt{\gamma} \quad \text{for} \quad 3.5 \le \frac{l}{S}$$

l = distance between floors (m).
γ = as specified in **301. 3.** However, the value of γ is not to be less than 1.2 times the ratio of the designed deadweight (t) to the total capacity of all holds (m^3).

Table 7.3.4 Coefficient b_0 or b_1

B/l_h and over	less than	b_0 or b_1 \ k	10.0 and over	5.0	2.0	1.0	0
	0.4	b_0	4.6	3.9	3.3	2.7	2.0
0.4	0.6	b_0	4.1	3.5	3.0	2.4	2.0
0.6	0.8	b_0	3.4	2.9	2.4	2.1	1.9
0.8	1.0	b_0	2.3	2.1	1.9	1.7	1.5
		b_1	2.3	2.0	1.7	1.4	1.4
1.0	1.2	b_0	1.7	1.5	1.5	1.4	1.3
		b_1	2.2	1.9	1.7	1.6	1.3
1.2	1.4	b_1	2.0	1.8	1.6	1.4	1.3
1.4	1.6	b_1	1.8	1.6	1.5	1.4	1.2
1.6	1.8	b_1	1.5	1.4	1.4	1.3	1.2
1.8	2.0	b_1	1.3	1.2	1.2	1.2	1.2
2.0	2.2	b_1	1.1	1.1	1.1	1.1	1.1
2.2		b_1	1.0	1.0	1.0	1.0	1.0

NOTE:
For intermediate values of k, b_0, and b_1 are to be obtained by linear interpolation.

2. The thickness of inner bottom plating under hatchway, where no ceiling is provided, is to be 2 mm greater than that obtained from the second formula in **Par 1,** except where **Par 3** is applied.

3. In ships in which cargoes are handled by grabs or similar mechanical appliances, thickness of inner bottom plating is to be 2.5 mm greater than that specified in **Par 1,** except where ceiling is provided.

305. Longitudinals

The section modulus of bottom and inner bottom longitudinals is not to be less than that obtained from the formulae given in **Table 7.3.5,** respectively.

306. Vertical struts

1. Where vertical struts are provided, they are to be rolled sections other than flat bars or bulb plates

Table 7.3.5 Section Modulus of Bottom and Inner Bottom Longitudinals

Longitudinals	Section modulus (cm^3)
Bottom longitudinals	$Z_b = \dfrac{CKSl^2}{24 - 15.0 f_B K}(d + 0.026 L')$
Inner bottom longitudinals	$Z_i = \dfrac{CKShl^2}{24 - 11.4 f_B K}$ (However, Z_{min} = 0.75 Z_b)

γ = as specified in **301. 3.**
l = spacing of solid floors (m).
S = spacing of bottom longitudinals or inner bottom longitudinals (m).
L' = length of ship (m). Where, however, L exceeds 230 m, L is to be taken as 230 m.
h = as specified in **304.1.**
C = coefficient given in the following table.

Case	C: Bottom longitudinals	C: Inner bottom longitudinals
In case where no strut specified in **307.** is provided midway between floors	100	100 γ (However, $C \ge 90$)
In case where a strut specified in **307.** is provided midway between floors	a) Lower part of the holds which become empty in a fully loaded condition and that of deep tanks: 62.5	60 γ (However, $C \ge 54$)
	b) Elsewhere: 30 γ + 20 (However, C $\ge$ 50)	
	And further, where the width of vertical stiffeners provided on floors and that of struts are specially large, the coefficient may be properly reduced.	

and to be well overlapped with the webs of bottom and inner bottom longitudinals.

2. The sectional area of the above-mentioned vertical struts is not to be less than that obtained from the following formula. Where the double bottom is deep, sufficient care is to be taken against buckling.

$$A = 1.8\,CKSbh \quad (cm^2)$$

where:

S = spacing of longitudinals (m).
b = breadth of the area supported by the strut (m).
h = as obtained from the following formula. In no case is h to be less than d.

$$h = \frac{d + 0.026\,L' + h_i}{2} \quad (m)$$

L' = as specified in **Table 7.3.2.**
h_i = γ times the value of h specified in **304. 1** (m). However, under deep tanks, h is not to be less than the vertical distance from the upper surface of inner bottom to the mid-point between the top of overflow pipe and the top of inner bottom or 0.7 times the vertical distance from the upper surface of inner bottom to the point of 2.0 *metres* above the top of overflow pipe, whichever is the greater (m).
γ = as specified in **301. 3.**
C = coefficient obtained from the following for mula. In no case is the value of coefficient to be less than 1.43.

$$C = \frac{1}{1 - 0.5\dfrac{l_s}{k\sqrt{K}}}$$

l_S = length of strut (m).
k = minimum radius of gyration of vertical struts, obtained from the following formula (cm).

$$k = \sqrt{\frac{I}{A}}$$

I = the least moment of inertia of the strut (cm^4).
A = sectional area of the strut (cm^2).

307. Double bottom structure under lower stools at bulkheads

The inner bottom plating, centre girders, side girders and bottom longitudinals under lower stools at bulkheads are to be connected with those of holds just before and behind the bulkheads properly extending them. The floor are to be equivalent to those of holds.

SECTION 4
Hopper Tanks

401. General

1. Compartments of hopper tanks are to be in coincidence with those of holds as fas as practicable.

2. Special care is to be taken for the continuity of strength at fore and aft ends of hopper tank structure.

3. The scantlings of structural members in hopper tanks are to be in accordance with the requirements in this Section and also those in **Pt 3, Ch 15.**

402. Thickness of hopper plates

1. The thickness of hopper plates of hopper tanks is not to be less than that obtained from the following formula.

$$t = CS\sqrt{hK} + 1.5 \quad (mm)$$

where:

S = length of the shorter side of the panel enclosed by stiffeners, etc. (m)
h = vertical distance from the lower end of the hopper plate to the upper deck at centre line (m).
C = coefficient obtained from the following formula. However, in no case is it to be less than 3.2.

$$C = 4.25\,C_1 C_2 \sqrt{\gamma}$$

C_1 = coefficient obtained from the following formula

where $1 \le \dfrac{l}{S} < 3.5$ $\quad C_1 = \left(0.11\dfrac{l}{S} + 0.615\right)$

where $3.5 \le \dfrac{l}{S}$ $\quad C_1 = 1$

l = length of the longer side of the panel enclosed by stiffeners, etc. (m)
C_2 = coefficient obtained from the formula in **Table 7.3.6.**

Table 7.3.6 Coefficient C_2

Angle β (degree)	C_2
$\beta \le 40°$	1.0
$40° < \beta < 80°$	1.4 − 0.01β
$\beta \ge 80°$	0.6

γ = as specified in **301. 3.** However, in no case is the value of γ to be less than 1.2 times the ratio of the designed total cargo mass (t) to the total volume of all cargo holds (including hatchways) (m^3).

2. In ships in which cargoes are handled by grabs or similar mechanical appliances, the thickness of hopper plate is to be increased by following thickness above that determined in the preceding 1 or determined by **401. 3,** whichever is the grater.

Hopper plate under hatchway -----------2.5 mm
Hopper plate other than the above----1.0 mm

3. Where transverse stiffeners are provided on the hopper plates is to be sufficient against buckling.

403. Stiffeners

1. The section modulus of longitudinal stiffeners provided on the hopper plates is not to be less than that obtained from the following formula:

$$Z = CKShl^2 \quad (cm^3)$$

where:

S = spacing of stiffeners (m).
h = vertical distance from the stiffener to the upper deck at centre line (m).
l = length of longitudinal stiffener between transverse webs (m).
C = coefficient obtained from the following formula:

$$C = \frac{\alpha}{24 - 15.0\, f_B\, K \dfrac{y}{y_B}}$$

α = coefficient obtained from the formula given in **Table 7.3.7** according to β, acute angle between the hopper plate and the horizontal plate and γ specified in **301. 3.**

Table 7.3.7 Coefficient α

Angle β (degree)	α
$\beta \le 40°$	130γ
$40° < \beta < 80°$	$(214-2.1\beta)\gamma$
$\beta \ge 80°$	46γ

y = vertical distance from the neutral axis of transverse section of hull to the longitudinal stiffener concerned (m).
y_B = vertical distance from the neutral axis of transverse section of hull to the top of keel (m).

2. The section modulus of transverse stiffeners provided on hopper plates is not to be less than that obtained from the following formula:

$$Z = CKShl^2 \quad (cm^3)$$

where:

S = spacing of transverse stiffeners (m).
l = distance between the supports of stiffeners (m).
h = vertical distance from the mid-point of l to the upper deck at centre line (m).
C = coefficient obtained from the formula given in **Table 7.3.8.** according to β, acute angle between the hopper plate and the horizontal plate and γ specified in **301. 3.**

Table 7.3.8 Coefficient C

Angle β (degree)	C
$\beta \le 40°$	7.8γ
$40° < \beta < 80°$	$(12.8-0.125\beta)\gamma$
$\beta \ge 80°$	2.8γ

3. Bottom longitudinals in bilge hopper tanks are to be in accordance with the requirements in **Pt 3, Ch 7, 403.** Side longitudinals are to be in accordance with the requirements in **Pt 3, Ch 8, 401. 1,** in which case l in the formula is to be taken as the distance between transverse webs in *metres*. The section modulus of bilge longitudinals need not exceed that specified for bottom longitudinals.

404. Transverse webs

1. In hopper tanks, a transverse web or diaphragm is to be provided at every solid floor.

2. The scantlings of transverse webs provided on hopper plates are not to be less than those obtained from the formulae given in **Table 7.3.9.**

3. Flat bar stiffeners are to be provided on transverse webs or diaphragms at the positions through which longitudinals pass and tripping brackets are to be provided at a spacing of approximately 3 *metres* as well.

SECTION 5
Topside Tanks

501. General

1. Compartments of topside tanks are to be in coincidence with those of holds as fas as practicable. Except for the foremost hold, however, adjacent two compartments may be made one compartment.

2. Special care is to be taken for the continuity of strength at the fore and after ends of topside tank structure.

3. The scantlings of members in topside tanks are

Table 7.3.9 Scantlings of Transverse Webs

Transverse webs		Scantlings
(1) Webs	Depth	$l/5$ or 2.5 times the depth of slot for longitudinal stiffener, whichever is the greater.
	Thickness	The thickness obtained from the following formulae, whichever is the greater. $t_1 = 0.01\,d_0 + 1.5\,(mm)$ $t_2 = \dfrac{C_1 KShl}{d_0 - a} + 1.5\,(mm)$ within 0.2l from ends $t_3 = 0.0502\sqrt[3]{\dfrac{CShlS_1^2}{d_0 - a}} + 1.5\,(mm)$
(2) Section modulus		$Z = C_2 KShl^2\ (cm^3)$
(3) Face bars	Breadth	$d = 2.7\sqrt{d_0 l_1}\ (mm)$
	Thickness	Above formulae t_1 or t_2, whichever is the greater.

d_0 = depth of transverse webs (mm).
a = depth of slots (mm). Where effective collar plates are provided within 0.25l from each end of l, a may be modified depending on the size of collar plates, a may be taken as zero for 0.5l at the middle part of l.
S = breadth of the area supported by transverse webs (m).
h = vertical distance from the mid-point of l to the upper deck at centre line (m).
l = overall length of transverse web (m). Where the transverse webs are connected with effective brackets at ends. l may be modified in accordance with the requirements in **Pt 3, Ch 1, 605.**
l_1 = distance between supports of transverse web (m). Where, however, effective tripping brackets are provided, they may be taken as supports.
S_1 = the spacing of stiffeners of transverse webs or depth of web(m), whichever is smaller.
C_1, C_2 = coefficient obtained from the formulae given in the following table according to β, acute angle between the hopper plate and the horizontal plane and γ specified in **301. 3.** Where γ is less than 0.7, γ is to be taken as 0.7.

Angle (β)	C_1(*1)	C_2(*2)
$\beta \le 40°$	41.7 γ	7.1 γ
$40° < \beta < 80°$	$(68.5 - 0.67\,\beta)\,\gamma$	$(11.5 - 0.11\,\beta)\,\gamma$
$\beta \ge 80°$	14.9 γ	2.7 γ

(*1) Where the value, C_1, obtained from the above formula is less than 27.8, C_1 is to be taken as 27.8.
(*2) Where the value, C_2, obtained from the above formula is less than 4.75, C_2 is to be taken as 4.75. Where an effective support is provided at the mid-point of girder, one-half of C_2 obtained from the above formula may be taken as C_2.

not to be less than those specified in **Pt 3, Ch 15,** where h is not to be less than a half of the breadth of tanks at midship section.

4. As for the flat bars used for longitudinal stiffeners, the ratio of the depth to the thickness is not to be greater than 15. As for longitudinals near the strength deck, the slenderness ratio is not to exceed 60 as far as possible at the midship part of the ships.

502. Thickness of sloping plates.

1. The thickness of sloping plates of topside tanks is not to be less than that obtained from the following formula:

$$t = 4.6\,S\sqrt{Kh} + 1.5 \quad (mm)$$

where:
S = spacing of longitudinal or transverse stiffeners (m).
h = distance from the lower edge of sloping plate to the top of over-flow pipe or a half of the breadth of topside tank at midship part, whichever is the greater (m).

2. Where transverse stiffeners are provided on the sloping plates of topside tanks, the thickness of sloping plates is to be sufficient against buckling.

503. Stiffeners provided on sloping plates

1. The section modulus of longitudinal stiffeners provided on the sloping plates of topside tanks is not to be less than that obtained from the following formula:

$$Z = CKShl^2 \quad (cm^3)$$

where:
S = spacing of longitudinal stiffeners (m).
h = vertical distance from the stiffener to the top of overflow pipe or one-half of the breadth of topside tank at midship part, whichever is the greater (m).

l = length of longitudinal stiffeners between transverse webs (m).

C = coefficient obtained from the following formula:

$$C = \frac{100}{24 - 15 f_D K \dfrac{y}{y_D}}$$

y_D = vertical distance from the neutral axis of transverse section of hull to the top of beams at side (m).

y = vertical distance from the neutral axis of transverse section of hull to the longitudinal stiffener concerned (m).

2. The section modulus of transverse stiffeners provided on the sloping plates of topside tanks is not to be less than that obtained from the following formula:

$$Z = 6.8\, KShl^2 \quad (cm^3)$$

where:

S = spacing of transverse stiffeners (m).

l = unsupported length of stiffener (m).

h = vertical distance from the mid-point of l to the top of overflow pipe or one-half of the breadth of topside tank at midship part, whichever is the greater (m).

504. Longitudinal beams

The section modulus of longitudinal beams in topside tnks is not to be less than that obtained from the requirement in **Pt 3, Ch 10, 303.** Where, h is the deck load (kN/m^2) specified in **Pt 3, Ch 10, Sec 2** or one-half of the breadth of topside tank at midship part multiplied by 9.81, whichever is the greater (m).

505. Side frames

1. The section modulus of side longitudinals in topside tanks is not to be less than that obtained from the formula in **Pt 3, Ch 8, 401. 1,** taking l and h as follows:

l = distance between transverse webs (m).

h = as specified in **Pt 3, Ch 8, 401. 1,** but is not to be less than one-half of the breadth of topside tank at midship part (m).

2. Where transverse frames are provided on the side shell plating in way of topside tanks, the section modulus is not to be less than that obtained from the following formula:

$$Z = 6\, KShl^2 \quad (cm^3)$$

where:

S = spacing of frames (m).

l = vertical distance from the bottom of sloping plate of topside tank to the upper deck at side (m).

h = vertical distance from the mid-point of l to the point $d + 0.038L'$ above the top of keel, or one-half of the breadth of topside tank at midship part, whichever is the greater (m). Where, however, the value is less than $0.3\sqrt{L}$ (m), h is to be taken as $0.3\sqrt{L}$ (m).

L' = length of ship (m). Where, however, L exceeds 230 m, L' is to be taken as 230 m.

506. Transverse webs

1. Transverse webs or diaphragms are to be provided at a spacing not exceeding 5 m in topside tanks.

2. The scantlings of transverse webs are not to be less than those obtained from the formulae in **Table 7.3.10.**

3. Flat bar stiffeners are to be provided on transverse webs or diaphragms at the positions through which longitudinal frames or longitudinal stiffeners pass and brackets are to be provided at a spacing of approximately 3 *metres* as well.

4. Where heavy cargoes are loaded on the deck, web plates or diaphragms are to be suitably reinforced.

507. Large topside tanks

1. Where topside tanks are large, special consideration is to be given to the structure such as providing longitudinal diaphragms at around the mid-point of the breadth of topside tanks.

2. The thickness of longitudinal diaphragms, where provided, is not to be less than that specified in **106.,** or that obtained from the following formula, whichever is the greater. However, value of f_D is not to be less 1.0.

$$t = 19.8\, S\sqrt{\frac{y f_D}{D}} + 1.5 \quad (mm)$$

where:

S = spacing of longitudinals (m).

y = vertical distance from $D/2$ at midship section to the mid-point of panel between the stiffeners under consideration (m).

3. Where longitudinal stiffeners are provided on longitudinal diaphragms, depth of stiffeners is not to be less than $0.06\, l$, where l is the distance between the girders provided on the longitudinal diaphragms. Where longitudinal stiffeners are connected with tripping brackets at ends, depth of the stiffeners may be properly reduced.

4. Where transverse stiffeners are provided on longitudinal diaphragms, the thickness of longitudinal diaphragms is to be sufficient against buckling. The scantlings of the stiffeners are to be equivalent to those specified in **Pt 3.**

Table 7.3.10 Scantlings of Transverse Webs

Transverse webs		Scantlings
(1) Webs	Depth	(a) Where struts are provided at an intermediate position of transverse webs : $l/6$ (b) Elsewhere : $l/5$ or 2.5 times the depth of slots through which longitudinals pass, whichever is the greater.
	Thickness	The thickness obtained from the following formulae, whichever is the greater: $t_1 = 0.01 d_0 + 1.5\ (mm)$ $t_2 = 41.7 K \dfrac{Shl}{d_0 - a} + 1.5\ (mm)$ within $0.2l$ from ends $t_3 = 0.174 \sqrt[3]{\dfrac{ShlS_1^2}{d_0 - a}} + 1.5\ (mm)$
(2) Section modulus		(a) Where struts are provided at an intermediate position of transverse webs: $Z = 3.57 KShl^2\ (cm^3)$ (b) Elsewhere: $Z = 7.14 KShl^2\ (cm^3)$
(3) Face bars	Breadth	$b = 2.7 \sqrt{d_0 l_1}\ (mm)$
	Thickness	Above formulae t_1 or t_2, whichever is the greater.

d_0 = depth of transverse webs (mm).
a = depth of slots (mm). Where effective collar plates are provided within $0.25l$ from each end of l, a may be modified depending on the size of collar piates. a may be taken as zero for $0.5l$ at the middle part of l.
S = breadth of the area supported by transverse webs (m).
h = vertical distance from the midpoint of l to the top of overflow pipe, or a half of the breadth of topside tank, whichever is the greater (m)
l = overall length of transverse webs (m). Where a longitudinal diaphragm is provided at an intermediate position of transverse webs, l is to be the distance from the longitudinal diaphragm to the heel of bracket provided at the end of transverse webs (m). In any case where effective brackets are provided, l may be modified as specified in **Pt 3, Ch 1, 605.**
l_1 = distance between supports of transverse web (m). Where, however, effective tripping brackets are provided, they may be taken as supports.
S_1 = the spacing of stiffeners of transverse webs or depth of web(m), whichever is smaller.

SECTION 6
Transverse Bulkheads and Stools

601. Transverse bulkheads

1. The scantlings of structural members of transverse bulkheads are to be in accordance with the requirements in **Pt 3, Ch 15, Sec 2.** Where, however, in application of these requirements, h in the formulae is to be substituted by $0.36\gamma h'$, where γ is as specified in **301. 3.** Where, however, γ is less than 1.5, γ is to be taken as 1.5, and h' is to be in accordance with the following:

(1) In case of bulkhead platings, vertical distance from the lower edge of bulkhead plate to the upper deck at centre line of ship (m).

(2) Vertical distance from the mid-point of l for vertical stiffeners on bulkhead or from the mid-point of distance between the adjacent stiffeners for horizontal stiffeners to the upper deck at centre line of ship (m). l is as specified in **Pt 3, Ch 15, 203.**

(3) Vertical distance from the mid-point of l for vertical webs supporting stiffeners or from the midpoint of S for horizontal girders to the upper deck at centre line of ship (m). l and S are as specified in **Pt 3, Ch 15, 204.**

2. Notwithstanding the requirements in **Par 1,** the scantlings of structural members of transverse bulkheads are not to be less than those specified in **Pt 3, Ch 14.**

3. For transverse bulkhead without lower stool, the thickness of the lowest strake of bulkhead plating is to be appropriately increased referring to the thickness of inner bottom plating.

4. Plating of transverse bulkheads to which the sloping plates of topside tanks are connected, is to be properly strengthened, by increasing its thickness, or by any other means.

5. In addition to the requirements in this **Sec**, any cargo hold of bulk carriers of 150 m in length(L_f) and above, with single deck, topside tanks and hopper tanks, intending to carry solid bulk cargoes having a density of 1.0 t/m^3, or above, with vertically corrugated transverse watertight bulkheads, which are contracted for construction on or after 1 July 1998, except as stipulated in **1001. 1.** (1) to (3) is to be in accordance with the requirements in **Sec 12**.

602. Lower and upper stools at transverse bulkheads

1. The thickness of hopper plate of the lower stool of transverse bulkhead is not to be less than that obtained from the formula in **402. 1.** using the value of coefficient C reduced by 10%. In ships in which cargoes are handled by grabs or similar mechanical appliances, the thickness is to be increased by 1 mm.

2. The section modulus of horizontal stiffeners provided on sloping plates of lower stool is not to be less than that obtained from the formula for stiffeners or hopper plates given in **403. 1,** where the coefficient C of the first term is to be reduced by 10%. Where vertical stiffeners are provided, the section modulus is not to be less than that specified in **403. 2.**

3. Girders are to be provided in lower stools in the positions of centre girders and side girders in double bottoms. Scantlings of girders are not to be less than those specified in **404.**

4. Where holds are so designed as to be loaded with ballast water, cargo oil or heavy cargo, girders specified in the preceding Paragraph are to be sufficient against shear, for instance, by adopting diaphragms.

5. The scantlings of the members of upper stools are not to be less than those specified in **Pt 3, Ch 14.**

6. In addition to the requirements in this **Sec**, any cargo hold of bulk carriers of 150 m in length(L_f) and above, with single deck, topside tanks and hopper tanks, intending to carry solid bulk cargoes having a density of 1.0 t/m^3, or above, with vertically corrugated transverse watertight bulkheads, which are contracted for construction on or after 1 July 1998, except as stipulated in **1001. 1.** (1) to (3) is to be in accordance with the requirements in **Sec 12.**

SECTION 7 Hold Frames

701. Hold frames

1. The section modulus of hold frames is not to be less than that obtained from the formulae given in **Table 7.3.11.**

2. The thickness of webs near the top and bottom end connections of hold frames is to be sufficient against shearing.

3. For holds loaded with cargoes of specially large specific gravity, special care is to be taken such as increasing scantlings of hold frames specified in **Pars 1** and **2.**

4. Frames are to be fabricated symmetrical sections with integral upper and lower brackets and are to be arranged with soft toes.

5. In ships less than 190m in length, mild steel frames may be asymmetric and fitted with separate brackets. The face plate or flange of the bracket is to be sniped at both ends. Brackets are to be arranged with soft toes.

Table 7.3.11 Section Modulus of Hold Frames

Location	Section modulus (cm^3)
Between 0.15 L from the fore end and the after peak bulkhead	$Z = CKShl^2$
Between 0.15 L from the fore end and the collision bulkhead	$Z = 1.25\,KCShl^2$

S = spacing of frames (m).
h = vertical distance from a point $d + 0.038L'$ above the top of keel to the top of bilge hopper at side (m).
L' = length of ship (m). Where, however, L exceeds 230 m, L' is to be taken as 230 m.
l = distance between the top of bilge hopper at side and the bottom of top side tank (m). (See **Fig.7.3.3**).
C = coefficient obtained from the following formula:

$$C = \left(3.3 - 2.5\frac{l}{h}\right) + (25.7\lambda_1 + 44.5)\alpha\frac{d}{h}$$

$$\lambda_1 = \frac{l_1}{l}$$

l_1 = vertical distance from the mid-point of depth of centre girder to the top of bilge hopper at side (m). (See **Fig. 7.3.3**)
α = coefficient given in the following table. For intermediate values of B/l_h the value of α are to be determined by linear interpolation. For the holds which are empty in fully loaded condition, the value of α is to be 1.8 times the value determined from the table.

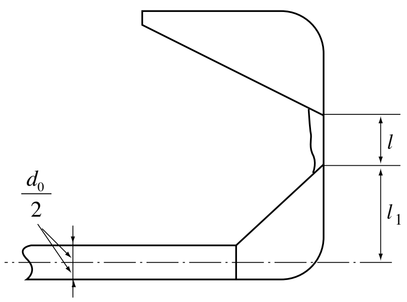


Fig. 7.3.3 Measurement of l, l_1, etc.

B/l_h	α	B/l_h	α
0.4 and under	0.0288	1.2	0.0069
0.6	0.0207	1.4	0.0048
0.8	0.0144	1.6	0.0034
1.0	0.0099	1.8 and over	0.0025

6. The side frame flange is to be curved (not knuckled) at the connection with the end brackets. The radius of curvature is not to be less than r, given by: (See, **Fig. 7.3.4**)

$$r = \frac{0.4 b_f^2}{t_f} \qquad (mm)$$

b_f = flange width of the brackets (mm).
t_f = thickness of the brackets (mm).

7. The web depth to thickness ratio of frames is not to exceed the following values.

(1) Symmetrical flanged frames : $60\sqrt{K}$

(2) Asymmetrical flanged frames : $50\sqrt{K}$

K is the material factor, as specified in **Pt 3**, **Ch 1**, **Sec 4**, **Table 3.1.2**.

8. The outstanding flange is not to be exceed $10\sqrt{K}$ times the flange thickness.

702. Top and bottom end connections of frames

1. The toes of brackets connecting frames with hopper plates and topside tank sloping plates are not to coincide with bracket ends in the tanks.

2. The section modulus of the frame and bracket or integral bracket, and associate shell plating, at the locations shown in **Fig. 7.3.4**, is not to be less than twice the section modulus required for the frame midspan area. The dimensions of the lower and upper brackets are not to be less than those shown in **Fig. 7.3.6**.

3. Structural continuity with the upper and lower end connection of side frames is to be ensured with-

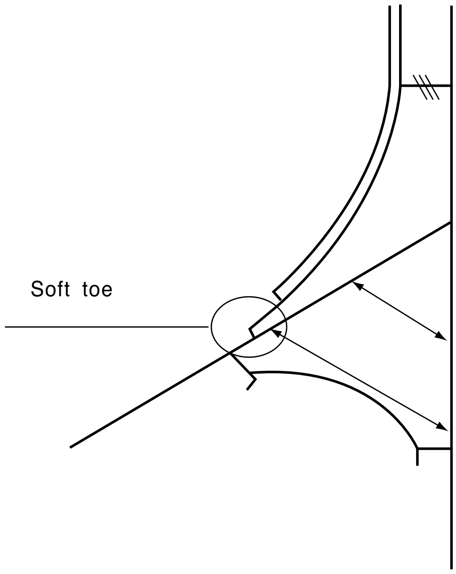


Fig. 7.3.5 Bracket

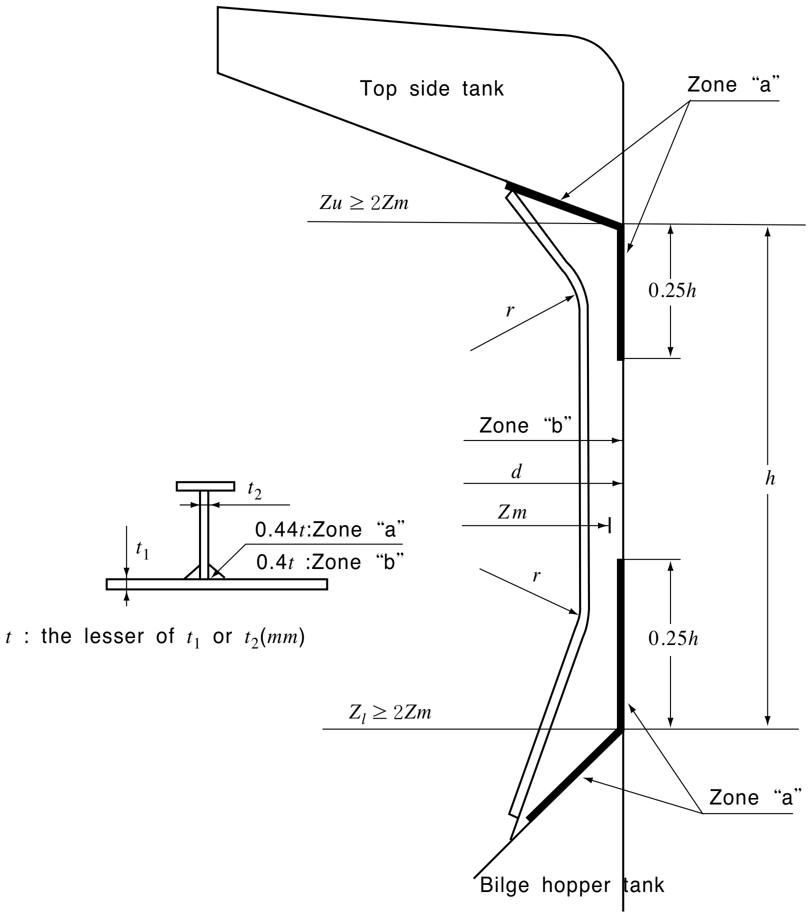


Fig. 7.3.4 Figure of frame and bracket

in topside and hopper tanks by connecting brackets as shown in **Fig. 7.3.5**. The brackets are to be stiffened against buckling.

4. Double continuous welding is to be adopted for the connections of frames and brackets to side shell, hopper and hopper wing tank plating and web to face plate. For this purpose, the weld throat is to be : (See, **Fig. 7.3.4**)

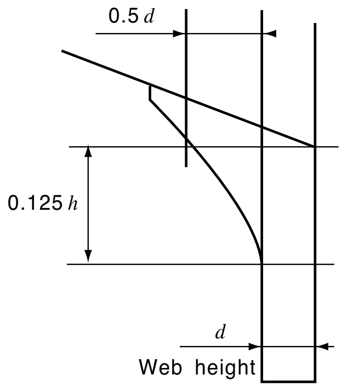
Zone "a" : $0.44t$, Zone "b" : $0.4t$,

Where, t is the thinner of the two connected members.

5. Where the hull form is such to prohibite an effective fillet weld, edge preparation of the web of frame and bracket may be required, in order to ensure the same efficiency as the weld connection stated in **Par. 4**.

703. Side structure in the foremost hold

The scantlings of side hold frames immediately adjacent to the collision bulkhead are to be increased



h : As shown in **Fig. 7.3.4**

Fig. 7.3.6 The dimension of the lower and upper brackets.

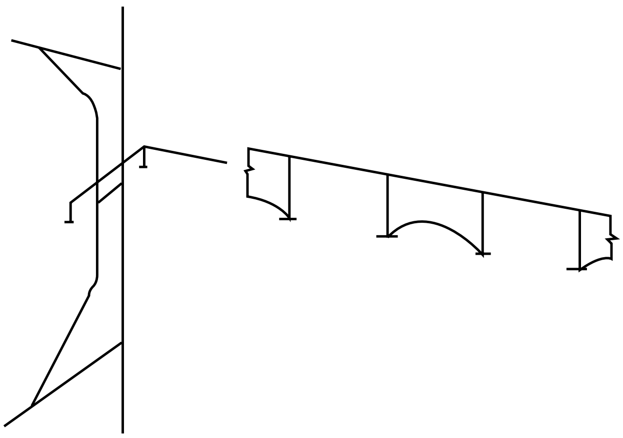


Fig. 7.3.7 Tripping brackets to be fitted in way of foremost hold

in order to prevent excessive imposed deformation on the shell plating. As an alternative, supporting structures are to be fitted which maintain the continuity of forepeak stringers within the foremost hold.

704. Tripping brackets

In way of the foremost hold, side frames of asymmetrical section art to be fitted with tripping brackets at every two frames, as shown in **Fig. 7.3.7**.

SECTION 8
Decks and Shell Platings

801. Deck plating outside the line of openings

The cross sectional area of deck plating outside the line of openings, where topside tanks are not provided, is to determined in consideration of the continuity of longitudinal strength.

802. Deck plating inside the line of openings

1. Hatch end coamings are to be provided in coincidence with the positions of girders in topside tanks. If not coincident, sufficient care is to be taken for the continuity of strength at the connection of hatch end coamings with topside tanks.

2. Deck plating inside the line of openings is recommended to be provided with transverse beams. Where longitudinal beams are provided, special care is to be taken against buckling.

803. Side shell plating

Where a loaded hold and an empty hold are adjacent to each other across a transverse bulkhead, the thickness of side shell plating may be properly reduced from that specified in **Pt 3, Ch 3, 301.** considering that the transverse bulkhead under consideration withstands a part of shear forces on ship's hull in still water.

804. Bottom shell plating

The thickness of bottom shell plating of cargo holds in way of double bottom is not to be less than that obtained from the formula in **Pt 3, Ch 4, 304.** or from the first formula in **304. 1,** whichever is the greater. However, in application of the latter formula, α is to be as given by the following formula:

$$\alpha = \frac{13.8}{24 - 15.0 f_B K}$$

SECTION 9
Hatch Covers of Cargo Holds

901. Application and definitions

1. These requirements apply to the hatch covers on exposed decks of all bulk carriers. And the requirements in **Pt 4**, **Ch 2.** are also applied.
2. In addition to the requirements of **ILLC 1966,** the net minimum scantlings of the hatch covers located forward of 0.25L from the fore perpendicular, are to fulfil the strength criteria given in **903**, adopting the load model given in **902**.
3. The net thicknesses t_{net} are the thicknesses necessary to obtaine the **Par 2** net minimum scantlings. The required thicknesses are obtained by adding the corrosion addition t_s given in **905.** to the net thickness t_{net}.
4. Material for the hatch covers is to be steel according to the requirements in **Pt 3**, **Ch 1**, **Sec 4**.

902. Load model

The pressure (P) to be considered as acting on the hatch covers is given by:

$$P = 19.6\sqrt{H} \qquad (kN/m^2)$$

$$H = 0.14 A_i \sqrt{\frac{VL}{C_b}} - d_h$$

A_i = coefficient depending on the longitudinal position of the hatch cover mid length (see **Table 7.3.2**).
V = ship's design speed, to be taken not less than 13$knots$.
L = length of ship (m).
C_b = block coefficient.
d_h = vertical distance from the summer loadline to the top of the hatch coaming (m).

Table 7.3.12 Coefficient A_i

Distance from the FP [(1)]	A_i
FP	2.70
0.05 L	2.16
0.10 L	1.70
0.15 L	1.43
0.20 L	1.22
0.25 L	1.00

NOTE:
(1) For intermediate positions A_i is obtained by linear interpolation between the table values.

903. Strength criteria

1. Allowable stress

(1) The normal and shear stress σ and τ in the hatch cover secondary stiffeners, primary supporting members and their attached plating are not to exceed the allowable values σ_a and τ_a given by:

$$\sigma_a = 0.80\,\sigma_y \qquad (N/mm^2)$$
$$\tau_a = 0.45\,\sigma_y \qquad (N/mm^2)$$

σ_y = the minimum upper yield stress of the material (N/mm^2).

(2) When calculating the stress σ and τ, the net scantlings are to be used.
(3) For determination of the section modulus of primary supporting members, the effective width of compression panel flange is not to be taken larger than as given in **Par 2**.
(4) In case of stiffeners of variable cross section, the provisions of interpretation in **Pt 4**, **Ch 2**, **Sec 2**, **Table 4.2.3** are to be applied.

2. Effective width of compression panel flanges

The effective width is generally to be taken as given in the following (1) and (2). The effective width is in case of biaxial compression to be determined at the discretion of the Society.

(1) Effective width for primary member parallel to the stiffening direction
The effective width $b_{ef,l}$ of the compression panel is given by:

$$b_{ef,l} = C_{e,l} S \qquad (m)$$

$$C_{e,l} = \frac{1.80}{\beta} - \frac{0.80}{\beta^2} \quad \text{for } \beta > 10$$

$$C_{e,l} = 1.0 \quad \text{for } \beta \le 1.0$$

$$\beta = \frac{S}{t_{net}}\sqrt{\frac{\sigma_y}{E}} \times 10^3$$

t_{net} = net thickness of plate panel (mm)
S = short edge of plate panel (m).
σ_y = minimum upper yield stress of the material (N/mm^2).
E = modulus of elasticity of the material to be assumed equal to 2.06 × 10^5 (N/mm^2) for steel.

(2) Effective width for primary member at right angle to stiffening direction.
The effective width $b_{ef,t}$ of the compression panel is given by:

$$b_{ef,t} = C_{e,t} l \qquad (m)$$

$$C_{e,t} = C_{e,l}\frac{S}{l} + 0.115\left(1-\frac{S}{l}\right)\left(1+\frac{1}{\beta^2}\right)^2 \le 1.0$$

l, S = longer and shorter edges of panel respectively (m).
$C_{e,l}$, β = as given in above (1).

3. Local net plate thickness

The local net plate thickness t_{net} of the hatch cover plating is given by:

$$t_{net} = 14.9 S_f S \sqrt{\frac{P}{\sigma_y}} \quad (mm)$$

S_f = safety factor, to be taken equal to 1.2.
S = stiffener spacing (m).
P = pressure, as defined in **902.**(kN/m^2)
σ_y = minimum upper yield stress of the material (N/mm^2).

904. Local details

1. For ships without forecastle or breakwater, the scantlings of the coamings for the foremost hold are not to be less than that required by **Pt 3**, **Ch 16** for front bulkheads of deckhouses at that position.

2. Unless otherwise stated, weld connections and materials are to be dimensioned and selected in accordance with the descretion of the Society.

905. Corrosion addition and steel renewal

1. For all the structures(plating and stiffeners) of single skin hatch cover, the corrosion addition t_s is to be 2.0mm.

2. For pontoon hatch covers, the corrosion addition is to be taken equal to:

(1) For the top and bottom plating : 2.0mm
(2) For the internal structures : 1.5mm

SECTION 10
Longitudinal Strength of Hull Girder in Flooded Condition for Bulk Carriers

1001. Application

1. These requirements are to be complied with in respect of the flooding of any cargo hold of bulk carriers of 150 m in length(L_f) and above, with single deck, topside tanks and hopper tanks, intending to carry solid bulk cargoes having a density of 1.0 t/m^3, or above, which are contracted for construction on or after 1 July 1998, except as stipulated in (1) to (3). Such ships are to have their hull girder strength checked for specified flooded condition of **1003.**, in each of the cargo and ballast conditions considered in the intact longitudinal strength calculation.

(1) Cargo holds of double side skin construction in ships, the keels of which were laid, or which were at a similar stage of construction, before 1 July 1999,
(2) Cargo holds of double side skin construction of not less than 760 mm breadth at any location within the hold length, measured perpendicular to the side shell in ships, the keels of which were laid, or which were at a similar stage of construction, before 1 January 2000,
(3) Cargo holds of double side skin construction of not less than 1000 mm breadth at any location within the hold length, measured perpendicular to the side shell in ships, the keels of which are laid, or which are at a similar stage of construction, on or after 1 January 2000.

1002. Flooding criteria

1. To calculating the weight of ingressed water, the following assumptions are to be made.

(1) The permeability of empty cargo spaces and volume left in loaded cargo spaces above any cargo is to be taken as 0.95.
(2) Appropriate permeabilities and bulk densities are to be used for any cargo carried.
(a) Iron ore : bulk density = 3.0t/m^3, permeability = 0.3
(b) Cement : bulk density = 1.3t/m^3, permeability = 0.3
(3) "permeability" for solid cargo means the ratio of the floodable volume between the particles, granules or any larger pieces of the cargo, to the gross volume of the bulk cargo.

2. For packed cargo conditions (such as steel mill products), the actual density of the cargo should be used with a permeability of zero.

3. The still water loads in flooded conditions are to be calculated for the cargo and ballast conditions on which the design of the ship has been based.

1003. Flooding conditions

Each cargo hold, except where excluded by **1001. 1** (1) to (3), is to be considered individually flooded up to the equilibrium waterline. The wave loads in the flooded conditions are assumed to be equal to 80% of the most probable maximum lifetime wave load, as given in **Pt 3**, **Ch 3**, **Sec 2**, **Table 3.3.1.** and **Sec 3, 301.1**.

1004. Stress assessment

1. The actual hull girder bending stress σ_{fld} at any location is given by:

$$\sigma_{fld} = \frac{M_{sf} + 0.8 M_w}{Z} \times 10^3 \qquad (N/mm^2)$$

M_{sf} = still water bending moment in the flooded conditions for the section under consideration ($kN \cdot m$).
M_w = wave bending moment as given in **Pt 3**, **Ch 3**, **Table 3.3.1**.
Z = section modulus for the corresponding location in the hull girder (cm^3).

2. The actual hull girder shear stress σ_{fld} at any location is given by:

$$\tau_{fld} = \frac{0.5(F_{sf}C + 0.8 F_w)Q}{It} \times 10^2 \qquad (N/mm^2)$$

F_{sf} = still water shear force in the flood conditions for the section under consideration (kN).
F_w = wave shear force as given in **Pt 3**, **Ch 3**, **Table 3.3.1** and **Pt 3**, **Ch 3**, **301**.
C = still water shear force correction factor for alternate loading condition to be determined at the discretion of Society.
Q and I = as defined in **Pt 3**, **Ch 3**, **301**.
t = thickness of plating (mm).

1005. Strength criteria

The damaged structure is assumed to remain fully effective in resisting the applied loading. Permissible stress and axial stress buckling strength are to be in accordance with **Pt 3**, **Ch 3**, **Table 3.3.1** and **Pt 3**, **Ch 3**, **301**.

SECTION 11
Evaluation of Allowable Hold Loading for Bulk Carriers Considering Hold Flooding

1101. Application

1. These requirements are to be complied with in respect of the flooding of any cargo hold of bulk carriers of 150 m in length(L_f) and above, with single deck, topside tanks and hopper tanks, intending to carry solid bulk cargoes having a density of 1.0 t/m^3, or above, which are contracted for construction on or after 1 July 1998, except as stipulated in **1001. 1** (1) to (3).

2. The loading in each hold is not to exceed the allowable hold loading in flooded condition, calculated as per **1104.**, using the loads given in **1102.** and the shear capacity of the double bottom given in **1103.**

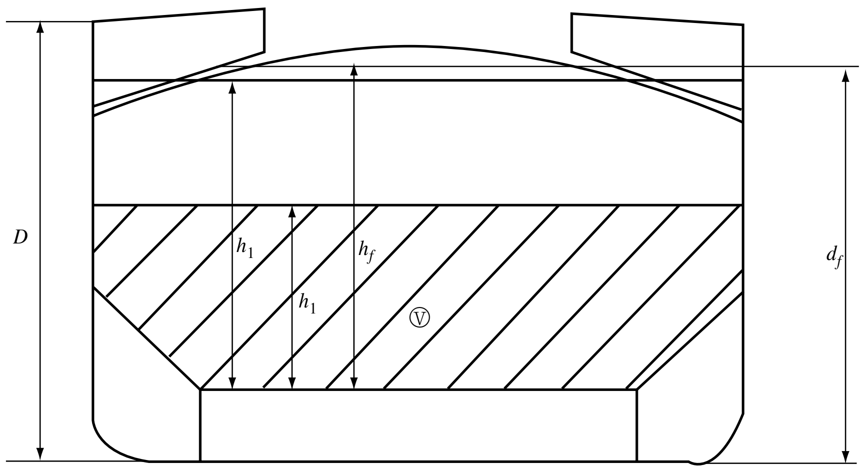
3. In no case is the allowable hold loading, considering flooding, to be taken greater than the design hold loading in intact condition.

1102. Loading model

1. General

(1) The loads to be considered as acting on the double bottom are those given by follows.
   (a) External sea pressures
   (b) Combination of the cargo loads with those induced by the flooding of the hold which the double bottom belongs to.

(2) The most severe combinations of cargo induced loads and flooding loads are to be used, depending on the loading conditions included in the loading manual:
   (a) Homogeneous loading condition.
   (b) Non-homogeneous loading condition.



V : Volume of cargo

Fig. 7.3.8 Measurement of d_1, d_f, h_1 and h_f

(c) Packed cargo conditions (such as steel mill products).

(3) For each loading condition, the maximum bulk cargo density to be carried is to be considered in calculating the allowable hold loading limit.

2. Inner bottom flooding head

The flooding head h_f is the distance measured vertically with the ship in the upright position, from the inner bottom to a level located at a distance d_f (m) from the baseline equal to:

(1) For ships less than 50,000 tonnes deadweight with Type B freeboard:
(a) For the foremost hold : d_f = 0.95D
(b) For the other holds : d_f = 0.85D

(2) In general
(a) For the foremost hold : d_f = 1.0D
(b) For the other holds : d_f = 0.9D

1103. Shear capacity of the double bottom

1. The shear capacity C of the double bottom is defined as the sum of the shear strength at each end of:

(1) All floors adjacent to both hoppers, less one half of the strength of the two floors adjacent to each stool or transverse bulkhead if no stool is fitted (See **Fig. 7.3.9**).

(2) All double bottom girders adjacent to both stools, or transverse bulkheads if no stool is fitted.

2. Where in the end holds, girders or floors run out and are not directly attached to the boundary stool or hopper girder, their strength is to be evaluated for the one end only.

3. Note that the floors and girders to be considered are those inside the hold boundaries formed by the hoppers and stools (or transverse bulkheads if no stool is fitted). The hopper side girders and the floors directly below the connection of the bulkhead stools (or transverse bulkheads if no stool is fitted) to the inner bottom are not to be included.

4. When the geometry and/or the structural arrangement of the double bottom are such to make the above assumptions inadequate, the shear capacity C of double bottom is to be calculated according to the Society's discretion.

5. In calculating the shear strength, the net thickness of floors and girders is to be used. The net thickness t_{net} is given by:

$$t_{net} = t - 2.5 \ (mm)$$

t = thickness of floors and girders (mm).

6. Floor shear strength

The floor shear strength in way of the floor panel adjacent to hoppers S_{f1} (kN) and the floor shear strength in way of the openings in the outmost

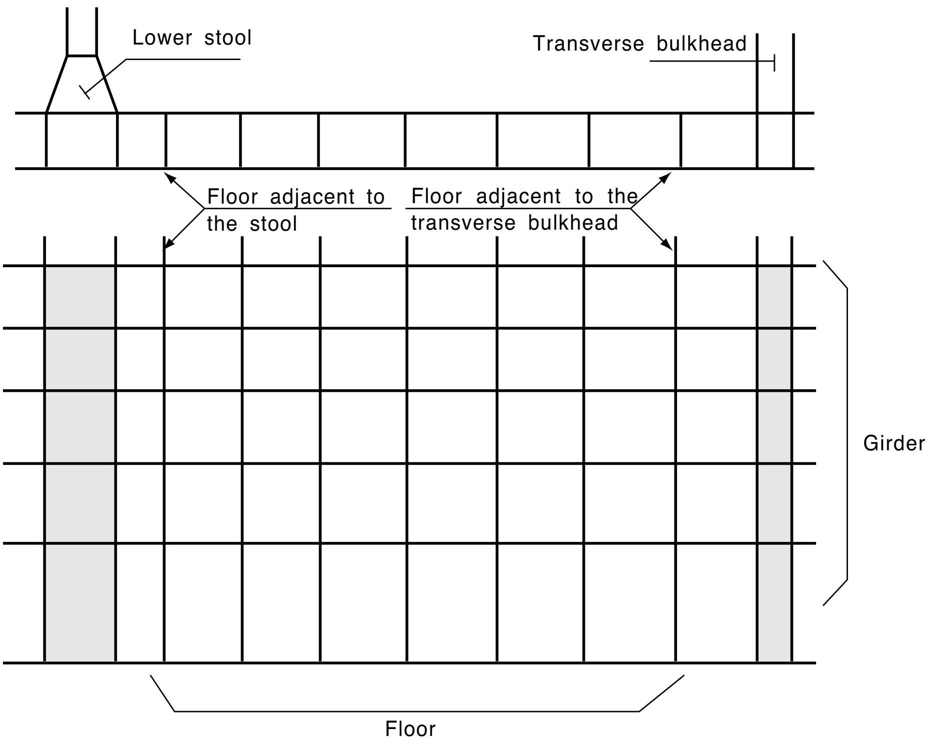


Fig. 7.3.9 Floor and Girder

bay (i.e. that bay which is closer to hopper) S_{f2} (kN), are given by:

$$S_{l1} = A_f \frac{\tau_a}{\eta_1} \times 10^{-3} \qquad (kN)$$

$$S_{l2} = A_{f,h} \frac{\tau_a}{\eta_2} \times 10^{-3} \qquad (kN)$$

A_f = sectional area of the floor panel adjacent to hoppers (mm^2).

$A_{f,h}$ = net sectional area of the floor panels in way of the openings in the outmost bay (i.e. that bay which is closer to hopper) (mm^2).

τ_a = the allowable shear stress to be taken equal to the lesser of following formulae (N/mm^2).

$$\tau_{a1} = \frac{162\sigma_y^{0.6}}{(S/t_{net})^{0.8}} \qquad (N/mm^2)$$

$$\tau_{a1} = \frac{\sigma_y}{\sqrt{3}} \qquad (N/mm^2)$$

For floors adjacent to the stools or transverse bulkheads, τ_a may be taken as $\frac{\sigma_y}{\sqrt{3}}$

σ_y = minimum upper yield stress of the material (N/mm^2).

S = spacing of stiffening members of panel under consideration (mm).

η_1 = 1.1

η_2 = 1.20, may be reduced, to the Society's discretion, down to 1.1, where appropriate reinforcements are fitted to the Society's satisfaction.

7. Girder shear strength

The girder shear strength in way of the girder panel adjacent to stools (or transverse bulkheads, if no stool is fitted) S_{g1}, and the girder shear strength in way of the largest opening in the outmost bay (i.e. that bay which is closer to stool, or transverse bulkhead, if no stool is fitted) S_{g2} are given by:

$$S_{g1} = A_g \frac{\tau_a}{\eta_1} \times 10^{-3} \qquad (kN)$$

$$S_{g2} = A_{g,h} \frac{\tau_a}{\eta_2} \times 10^{-3} \qquad (kN)$$

A_g = minimum sectional area of the girder panel adjacent to stools (or transverse bulkheads, if no stool is fitted) (mm^2).

$A_{g,h}$ =net sectional area of the girder panel in way of the largest opening in the outmost bay (i. e. that bay which is closer to stool, or transverse bulkhead, if no stool is fitted) (mm^2).

τ_a = allowable shear stress as given in **Par 6** (N/mm^2).

η_1 = 1.1

η_2 = 1.15, may be reduced, to the Society's discretion, down to 1.1 where appropriate reinforcements are fitted to the Society's satisfaction.

1104. Allowable hold loading

The allowable hold loading W is given by:

$$W = \rho_c V \frac{1}{F} \qquad (ton)$$

F = 1.1 in general, and may be 1.05 for steel mill products.

ρ_c = Bulk cargo density (t/m^3).

V = Volume (m^3), occupied by cargo at a level h_1.

$$h_1 = \frac{X}{\rho_c g}$$

X = for bulk cargoes, the lesser of X_1 and X_2 given by:

$$X_1 = \frac{Z + \rho g (E - h_f)}{1 + \frac{\rho}{\rho_c}(perm - 1)}$$

$$X_2 = Z + \rho g (E - h_f perm)$$

X = X_1 using perm=0, for steel products

ρ = sea water density (t/m^3).

g = gravity acceleration (= 9.81m/s^2).

E = ship immersion (m), for flooded hold condition = d_f − 0.1D

d_f = as given in **1102. Par 2.**

h_f = flooding head as defined in **1102. Par 2** (m).

$perm$ =cargo permeability, defined in **1002. Par 1.** it needs not be taken greater than 0.3 and is to be taken equal to zero for steel mill products.

Z = the lesser of Z_1 and Z_2 given by:

$$Z_1 = \frac{C_h}{A_{DB,h}}$$

$$Z_2 = \frac{C_e}{A_{DB,e}}$$

C_h = shear capacity of the double bottom, as defined in **1103.** considering, for each floor, the lesser of the shear strengths S_{f1} and S_{f2} (See **1103. Par 6**) and for each girder, the lesser of the shear strengths S_{g1} and S_{g2} (See **1103. Par 7**) (kN).

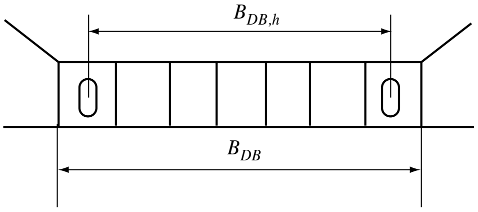


Fig. 7.3.10 Measurement $B_{DB,h}$ and B_{DB}

C_e = shear capacity of the double bottom as defined in **1103.** considering, for each floor, the shear strength S_{f1} (See **1103. Par 6**) and, for each girder, the lesser of the shear strengths S_{g1} and S_{g2} (See **1103. Par 7**) (kN).

$$A_{DB,h} = \sum_{i=1}^{i=n} S_i B_{DB,i}$$

$$A_{DB,e} = \sum_{i=1}^{i=n} S_i (B_{DB} - S_l)$$

n = number of floors between stools (or transverse bulkheads, if no stool is fitted)

S_i = space of ith-floor (m).

$B_{DB,i}$ = $B_{DB} - S_l$, for floors whose shear strength is given by S_{f1}.
= $B_{DB,h}$, for floors whose shear strength is given by S_{f2}

B_{DB} = breadth of double bottom between hoppers (m) (See **Fig. 7.3.10**).

$B_{DB,h}$ = distance between the two considered opening (m) (See **Fig. 7.3.10**).

S_l = spacing of double bottom longitudinals adjacent to hoppers (m).

SECTION 12
Evaluation of Scantlings of Corrugated Transverse Watertight Bulkheads in Bulk Carriers Considering Hold Flooding

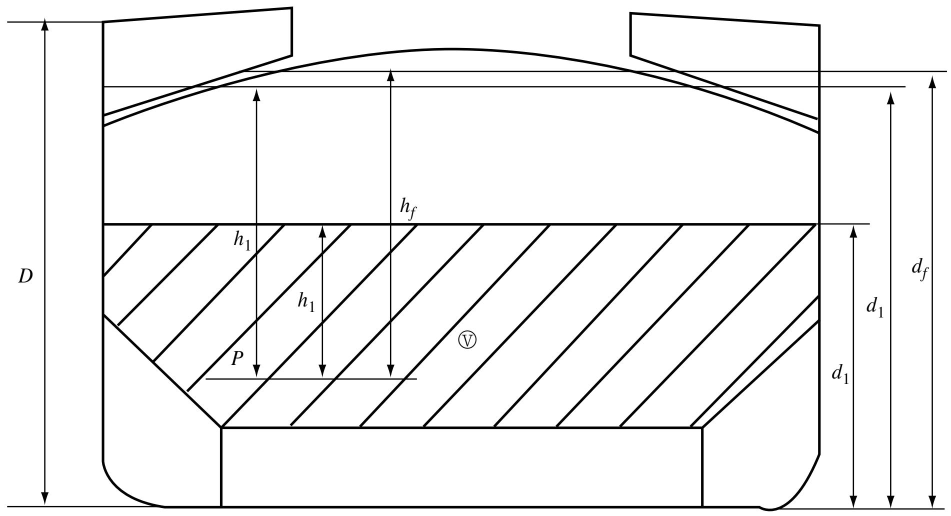
1201. Application and definitions

1. These requirements are to be complied with in respect of the flooding of any cargo hold of bulk carriers of 150 m in length(L_f) and above, with single deck, topside tanks and hopper tanks, intending to carry solid bulk cargoes having a density of 1.0 t/m^3, or above, with vertically corrugated transverse watertight bulkheads, which are contracted for construction on or after 1 July 1998, except as stipulated in **1001. 1** (1) to (3).

2. The net thickness t_{net} is the thickness obtained by applying the strength criteria given in **1204.**

3. The required thickness is obtained by adding the corrosion addition t_s, given in **1206.** to the net thickness t_{net}.

4. In this requirement homogeneous loading condition means a loading condition in which the ratio between the highest and the lowest filling ratio, evaluated for each hold, does not exceed 1.2 to be corrected for different cargo densities (See, **Fig. 7.3.11**).



V : Volume of cargo
P : Calculation point

Fig. 7.3.11 Measurement of d_1, d_f, h_1 and h_f

1202. Load model

1. General

(1) The loads to be considered as acting on the bulkheads are those given by the combination of the cargo loads with those induced by the flooding of one hold adjacent to the bulkhead under examination. In any case, the pressure due to the flooding water alone is to be considered.

(2) The most severe combinations of cargo induced loads and flooding loads are to be used for the check of the scantlings of each bulkhead, depending on the loading conditions included in the loading manual:
(a) homogeneous loading conditions;
(b) non-homogeneous loading conditions;
Considering the individual flooding of both loaded and empty holds.

(3) The specified design load limits for the cargo holds are to be represented by loading conditions defined by the Designer in the loading manual.

(4) Non-homogeneous part loading conditions associated with multiport loading and unloading operations for homogeneous loading conditions need not to be considered according to these requirements.

(5) Holds carrying packed cargoes are to be considered as empty holds for this application.

(6) Unless the ship is intended to carry, in non homogeneous conditions, only iron ore or cargo having bulk density equal or greater than 1.78t/m^3, the maximum mass of cargo which may be carried in the hold shall also be considered to fill that hold volume up to the upper deck level at centreline.

2. Bulkhead corrugation flooding head

The flooding head h_f (See **Fig. 7.3.11**) is the distance (m) measured vertically with the ship in the upright position, from the calculation point to a level located at a distance d_f (m) from the baseline equal to:

(1) For ships less than 50,000 tonnes deadweight with Type B freeboard
(a) for the foremost transverse corrugated bulkhead : d_f = 0.95D
(b) for the other bulkheads : d_f = 0.85D

(2) For ships less than 50,000 tonnes deadweight with Type B freeboard and the ship is to carry cargoes having bulk density less than l.78t/m^3 in non homogeneous loading conditions.
(a) for the foremost transverse corrugated bulkhead : d_f = 0.9D
(b) for the other bulkheads : d_f = 0.8D

(3) In general
(a) for the foremost transverse corrugated bulkhead : d_f = D
(b) for the other bulkheads : d_f = 0.9D

(4) In (3), where the ship is to carry cargoes having bulk density less than 1.78t/m^3 in non homogeneous loading conditions.
(a) for the foremost transverse corrugated bulkhead : d_f = 0.95D
(b) for the other bulkheads : d_f = 0.85D

3. Pressure in the non-flooded bulk cargo loaded holds

(1) At each point of the bulkhead, the pressure P_c is given by:

$$P_c = \rho_c g h_1 tan^2\gamma \qquad (kN/m^2)$$

ρ_c = bulk cargo density (t/m^3).
g = gravity acceleration (=9,8l m/s^2).
h_1 = vertical distance (m), from the calculation point to horizontal plane corresponding to the level height of the cargo (See **Fig. 7.3.11**), located at a distance d_1, (m) from the baseline.
γ = 45° - (ϕ/2)
ϕ = angle of repose of the cargo, that may generally be taken as 35° for iron ore and 25° for cement.

(2) The force F_c acting on a corrugation is given by:

$$F_c = \rho_c\, g\, S_1 \frac{(d_1 - h_{DB} - h_{LS})^2}{2} \tan^2\gamma \qquad (kN)$$

ρ_c, d_1, g and γ = as given above (1).
S_1 = spacing of corrugations (m) (See **Fig. 7.3.12**).
h_{LS} = mean height of the lower stool from the inner bottom (m).
h_{DB} = height of the double bottom (m).

4. Pressure in the flooded holds

(1) Bulk cargo holds
Two cases are to be considered, depending on the values of dl and d_f.
(a) $d_f \geq d_1$
(i) At each point of the bulkhead located at a distance between d_l and d_f from the baseline, the pressure P_{cf} is given:

$$P_{cf} = \rho g h_f \qquad (kN/m^2)$$

ρ_c = sea water density (t/m^3).
g = as defined in **1202. Par 3.** (1).
h_f = flooding head as defined in **1202. Par 2.**

(ii) At each point of the bulkhead located at a distance lower than d_1 from the baseline, the pressure P_{cf} is given by:

$$P_{cf} = \rho g h_f + [\rho_c - \rho(1 - perm)]\ g h_1 \tan^2\gamma \quad (kN/m^2)$$

ρ and h_f = as defined in above (a).
ρ_c, g, h_1 and γ = as defined in **1202. Par 3.**

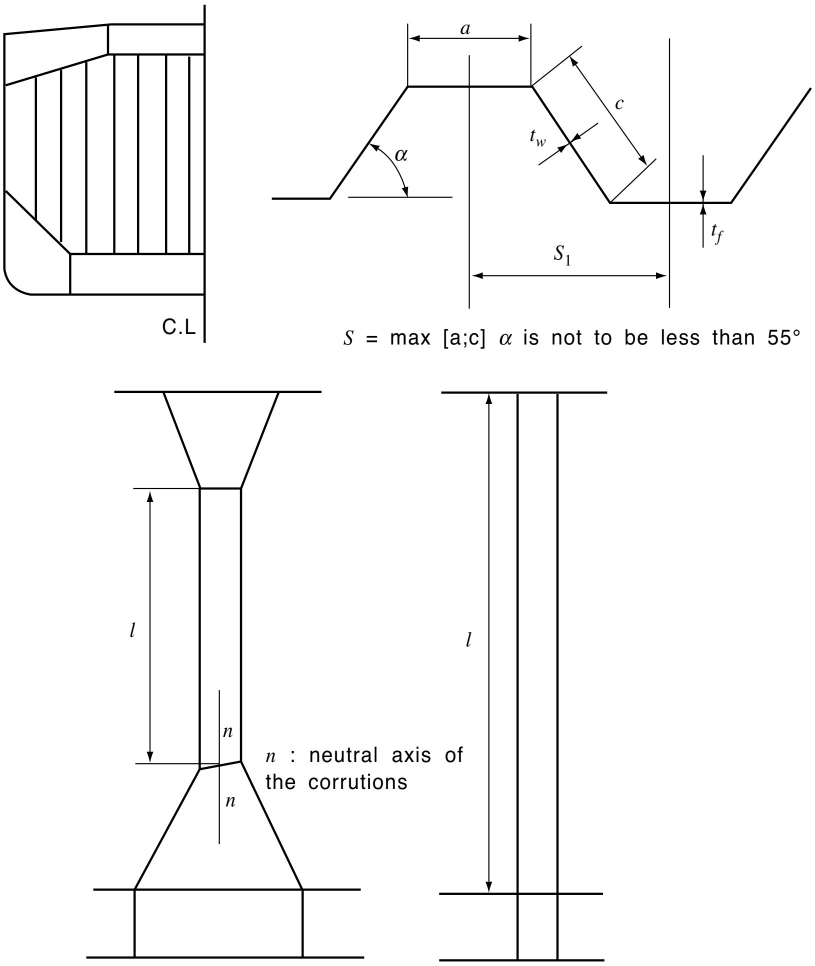


Fig. 7.3.12 Measurement of S and l

$perm$ = permeability of cargo, as defined in **1202. Par 1.**

(iii) The force F_{cf} acting on a corrugation is given by:

$$F_{c,f} = S_1\left[\frac{\rho g(d_f - d_1)^2}{2} + \frac{\rho g(d_f - d_1) + (P_{c,f})_{le}}{2}(d_1 - h_{DB} - h_{LS})\right] \quad (kN)$$

ρ = as defined in (a).

S_1, g, d_1, h_{LS} and h_{DB} = as given in **Par 3.**

d_f = as given in **Par 2.**

$(P_{c,f})_{le}$ = pressure at the lower end of the corrugation (kN/m^2).

(b) $d_f < d_1$

(i) At each point of the bulkhead located at a distance between d_1 and d_f from the baseline, the pressure $P_{c,f}$ is given by:

$$P_{cf} = \rho_c g h_1 \tan^2\gamma \quad (kN/m^2)$$

ρ_c, g, h_1 and γ = as given in above **Par 3.**

(ii) At each point of the bulkhead located at a distance lower than d_f from the baseline, the pressure $P_{c,f}$, is given by:

$$P_{cf} = \rho g h_f + [\rho_c h_1 - \rho(1 - perm)h_f]\, g \tan^2\gamma \quad (kN/m^2)$$

ρ, h_f and $perm$ = as given in above (a).

ρ_c, g, h_1 and γ = as given in above **Par 3.**

(iii) The force $F_{c,f}$, acting on a corrugation is given by:

$$F_{c,f} = S_1\left[\frac{\rho_c g(d_1 - d_f)^2}{2}\tan^2\gamma + \frac{\rho_c g(d_1 - d_f)\tan^2\gamma + (P_{c,f})_{le}}{2}(d_f - h_{DB} - h_{LS})\right] \quad (kN)$$

ρ_c, S_1, g, d_1, γ, h_{DB} and h_{LS} = as given by above **Par 3.**

d_f = as given by above **Par 2.**
$(P_{cf})_{le}$ = pressure, at the lower end of the corrugation (kN/m^2)

(2) Pressure in empty holds due to flooding water alone

At each point of the bulkhead, the hydrostatic pressure P_f induced by the flooding head h_f is to be considerd. The force F_f, acting on a corrugation is given by:

$$F_f = S_1 \rho g \frac{(d_f - h_{DB} - h_{LS})^2}{2} \quad (kN)$$

ρ = as given by (1), (a), (i).
S_1, g, h_{DB} and h_{LS} = as given by **Par 3.**
d_f = as given by **Par 2.**

5. Resultant pressure and force

(1) Homogeneous loading conditions

(a) At each point of the bulkhead structures, the resultant pressure P to be considered for the scantlings of the bulkhead is given by;

$$P = P_{cf} - 0.8P_c \quad (kN/m^2)$$

(b) The resultant force F, acting on a corrugation is given by;

$$F = F_{cf} - 0.8F_c \quad (kN)$$

(2) Non-homogeneous loading conditions

(a) At each point of the bulkhead structures, the resultant pressure P, to be considered for the scantlings of the bulkhead is given by:

$$P = P_{cf} \quad (kN/m^2)$$

(b) The resultant force F, acting on a corrugation is given by:

$$F = F_{cf} \quad (kN)$$

1203. Bending moment and shear force in the bulkhead corrugations

The bending moment M and the shear force Q in the bulkhead corrugations are given by:

1. Bending moment

$$M = \frac{Fl}{8} \quad (kN \cdot m)$$

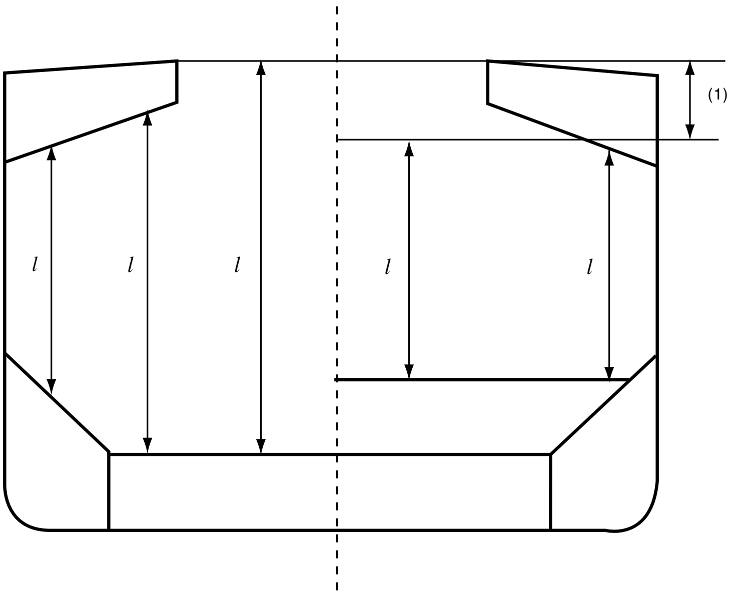
F = resultant force, as given in **1202. Par 5.** (kN).
l = span of the corrugation (m) (See, **Fig 7.3.12** and **Fig 7.3.13**).

2. Shear force

The shear force Q, at the lower end of the bulkhead corrugations is given by:

$$Q = 0.8F \quad (kN)$$

F : as given in above **Par 1.**



(Note) (1) For the definition of l, the internal end of the upper stool is not to be taken more than a distance from the deck at the centerline equal to:
(1) For rectangular stool : 2 times the depth of corrugations.
(2) In general : 3 times the depth of corrugations.

Fig. 7.3.13 Measurement of span l

1204. Strength criteria

1. General

The following criteria are applicable to transverse bulkheads with vertical corrugations (See **Fig 7.3.12**).

(1) For ships of 190m of length and above, these bulkheads are to be fitted with a bottom stool, and generally with a top stool below deck. For smaller ships, corrugations may extend from inner bottom to deck.

(2) The corrugation angle(α) shown in **Fig. 7.3.12** is not to be less than 55°.

(3) Requirements for local net plate thickness, t_{net} are given in **Par 7**. In addition, the criteria given in **Par 2** and **5** are to be complied with.

(4) The thicknesses of the lower part of corrugations considered in the application of **Par 2** and **3** are to be maintained for a distance from the inner bottom(if no lower stool is fitted) or the top of the lower stool not less than 0.15l.

(5) The thicknesses of the middle part of corrugations as considered in the application of **Par 2** and **4** are to be maintained to a distance from the deck or the bottom of the upper stool not greater than 0.3l.

(6) The section modulus of the corrugation in the remaining upper part of the bulkhead is not to be less than 75% of that required for the middle part, corrected for different yield stresses.

(7) Lower stool

(A) The height of the lower stool is generally to be not less than 3 times the depth of the corrugations. The thickness and material of the stool top plate is not to be less than those required for the bulkhead plating above.

(B) The thickness and material of the upper portion of vertical or sloping stool side plating within the depth equal to the corrugation flange width from the stool top is not to be less than the required flange plate thickness and material to meet the bulkhead stiffness requirement at lower end of corrugation.

(C) The thickness of the stool side plating and the section modulus of the stool side stiffeners is not to be less than the value given by the following formulae.

(a) The thickness of the stool side plating

(i) $d_f \geq d_1$

$$t = C S \sqrt{h_1' K} + 2.5 \qquad (mm)$$

(ii) $d_f < d_1$

$$t = C S \sqrt{h_2' K} + 2.5 \qquad (mm)$$

C = coefficient given by the following formula.

$$C = 3.825\ C_1$$

C_1 = coefficient given below formula according to the value l/S.

$$1 \leq \frac{l}{S} < 3.5 \qquad : \left(0.11\frac{l}{S} + 0.615\right)$$

$$3.5 \leq \frac{l}{S} \qquad : 1.0$$

S = length of the shorter side of the panel enclosed by stiffeners, etc.

l = length of the longer side of the panel enclosed by stiffeners, etc.

h_1' and h_2' = as given in following formulae.

$$h_1' = h_f + \left\{\left(\frac{\rho_c}{\rho}\right) - (1 - perm)\right\} h_1 (\sin^2\beta \tan^2\gamma + \cos^2\beta)$$

$$h_2' = h_f + \left\{\left(\frac{\rho_c}{\rho}\right) h_1 - (1 - perm)\right\} h_f (\sin^2\beta \tan^2\gamma + \cos^2\beta)$$

β = slope angle of stool side plate (deg).

h_f = as given in **1202. Par 2.**

ρ_c, h_1 and γ = as given in **1202. Par 3.**

ρ = as given in **1202. Par 4.**

$perm$ = permeability of cargo, as defined in **1002. Par 1**, (3).

(b) The section modulus of the stool side vertical stiffeners

(i) $d_f \geq d_1$

$$Z = 7.8KSh'_1 l^2 \qquad (cm^3)$$

(ii) $d_f < d_1$

$$Z = 7.8KSh'_2 l^2 \qquad (cm^3)$$

S = spacing of stiffeners (m).

l = unsupported length of stiffener (m).

h_1' and h_2' = as given in (a).

(D) The distance from the edge of the stool top plate to the surface of the corrugation flange is to be in accordance with **Fig. 7.3.14.**

(E) The stool bottom is to be installed in line with double bottom floors and is to have a width not less than 2.5 times the mean depth of the corrugation. The stool is to be fitted with diaphragms in line with the longitudinal double bottom girders for effective support of the corrugated bulkhead. Scallops in the brackets and diaphragms in way of the connections to the stool top plate are to be avoided.

(F) Where corrugations are cut at the bottom stool, corrugated bulkhead plating is to

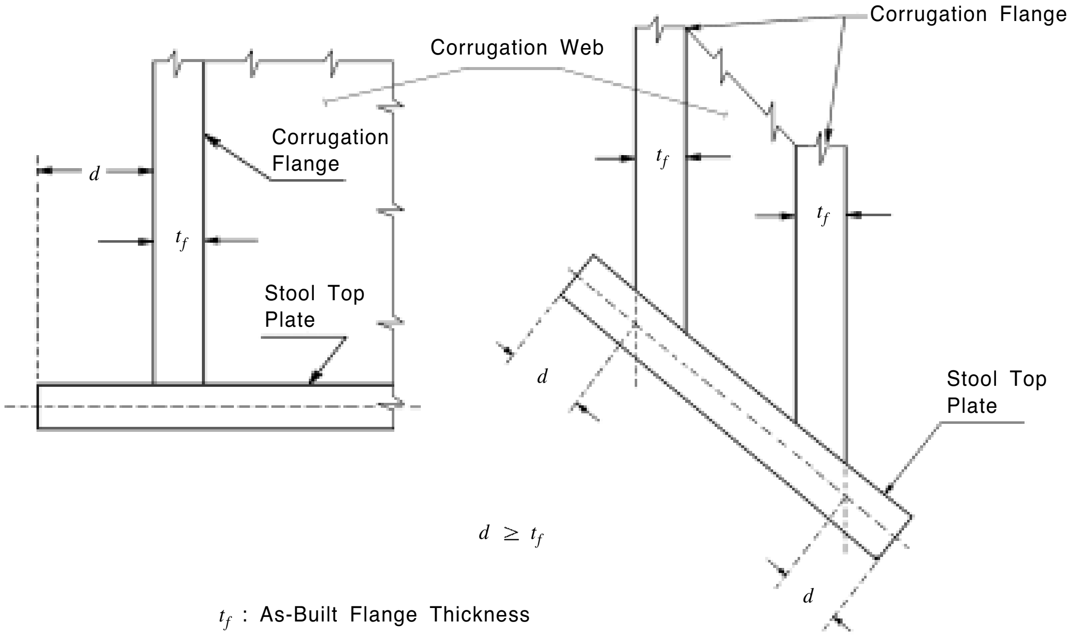


Fig. 7.3.14 Permitted distance, *d*, from edge of stool top plate to surface of corrugation flange

be connected to the stool top plate by full penetration welds. The stool side plating is to be connected to the stool top plate and the inner bottom plating by either full penetration or deep penetration welds.(See **Fig. 7.3.16**) The supporting floors are to be connected to the inner bottom by either full penetration or deep penetration welds.(See **Fig. 7.3.16**)

(G) The plating of the lower stool and supporting floors is generally to be connected to the inner bottom by full penetration welds.

(8) Upper stool

(A) The upper stool, where fitted, is to have a height generally between 2 and 3 times the depth of corrugations. Rectangu1ar stools are to have a height generally equal to 2 times the depth of corrugations, measured from the deck level and at hatch side girder.

(B) The upper stool is to be properly supported by girders or deep brackets between the adjacent hatch-end beams.

(C) The width of the stool bottom plate is generally to be the same as that of the lower stool top plate. The stool top of non rectangular stools is to have a width not less then 2 times the depth of corrugations. The thickness and material of the stool bottom plate are to be the same as those of the bulkhead plating below.

(D) The thickness of the lower portion of stool side plating is not to be less than 80% of that required for the upper part of the bulkhead plating where the same material is used.

(E) The thickness of the stool side plating and the section modulus of the stool side stiffeners is not to be less than those required by Society on the basis of the load model in (7), (C). The ends of stool side stiffener are to be attached to brackets at upper and lower end of the stool.

(F) Diaphragms are to be fitted inside the stool in line with and effectively attached to longitudinal deck girders extending to the hatch end coaming girders for effective support of the corrugated bulkhead. Scallops in the brackets and diaphragms in way of the connection to the stool bottom plate are to be avoided.

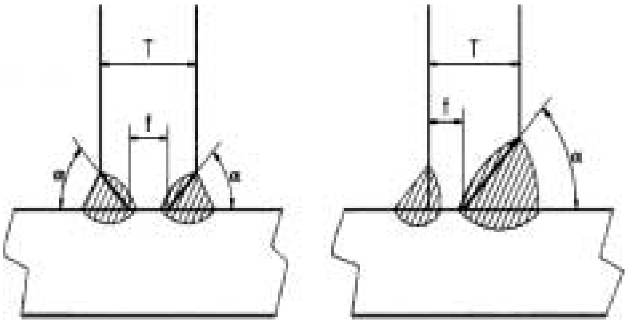
(9) Alignment

(A) At deck, if no stool is fitted, two transverse reinforced beams are to be fitted in line with the corrugation flanges.

(B) At bottom, if no stool is fitted, the corrugation flanges are to be in line with the supporting floors. Corrugated bulkhead plating is to be connected to the inner bottom plating by full penetration welds. The plating of supporting floors is to be connected to the inner bottom by either full penetration or deep penetration welds. (See **Fig. 7.3.16**)

(C) The thickness and material properties of the supporting floors are to be at least equal to those provided for the corrugation flanges. Moreover, the cut-outs for connections of the inner bottom longitudinal to double bottom floors are to be closed by collar plates.

(D) The supporting floors are to be connected to each other by suitably designed shear plates, as deemed appropriate by the Soci-



Root Face(f) : 3 mm to T/3mm
Groove Angle(α) : 40° to 60°

Fig. 7.3.16 Welding methods

ety.

(F) Stool side plating is to align with the corrugation flanges and stool side vertical stiffeners and their brackets in lower stool are to align with the inner bottom longitudinals to provide appropriate load transmission between these stiffening members. Stool side plating is not to be knuckled anywhere between the inner bottom plating and the stool top.

2. Bending capacity and shear stress τ

(1) The bending capacity is to be comply with the following relationship:

$$\frac{M}{0.5\,Z_{le}\,\sigma_{a,le}+Z_m\,\sigma_{a,m}}\times 10^3 \le 0.95$$

M = bending moment, as given in **1203. Par 1** ($kN\cdot m$).

Z_{le} = section modulus of one half pitch corrugation, at the lower end of corrugations, as given in **Par 3** (cm^3).

Z_m = section modulus of one half pitch corrugation, at the mid-span of corrugations, as given in **Par 4** (cm^3).

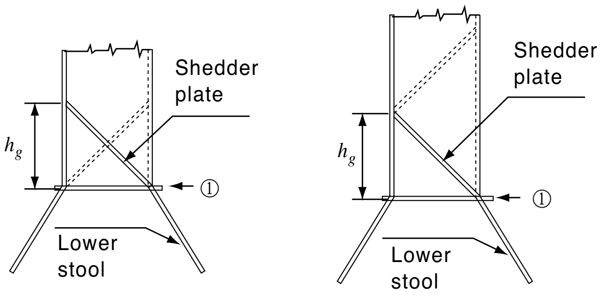
$\sigma_{a,le}$ = allowable stress, as given in **Par 5**, for the lower end of corrugations (N/mm^2).

$\sigma_{a,m}$ = allowable stress, as given in **Par 5**, for the mid-span of corrugations (N/mm^2).

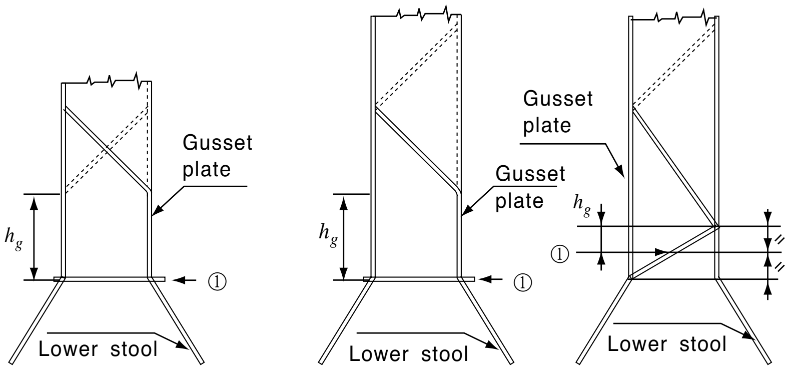
(A) In no case Z_m is to be taken greater than the lesser of 1.15Z_{le} and 1.15Z'_{le} for calculation of the bending capacity, Z'_{le} being defined below.

(a) In case shedders plates are fitted which:
- are not knuckled;
- are welded to the corrugations and the top of the lower stool by one side penetration weld or equivalent;
- are fitted with a minimum slope of 45° and their lower edge is in line with the stool side plating;
- have thicknesses not less than 75% of that provided by the corrugation flange;
- and material properties at least equal to those provided by the flanges.

(b) Or gusset plates are fitted which:
- are in combination with shedder plates having thickness, material properties and welded connections in accordance with



(1) Symmetric shedder plates (2) Asymmetric shedder plates



(3) Symmetric gusset/shedder plates (4) Asymmetric gusset/shedder plates

Fig. 7.3.15 Shedder plate and gusset plate

the above requirements;
- have a height not less than half of the flange width;
- are fitted in line with the stool side plating;
- are generally welded to the top of the lower stool by full penetration welds, and to the corrugations and shedder plates by one side penetration welds or equivalent.
- have thickness and material properties at least equal to those provided for the flanges.

(B) The section modulus Z_{le}, is to be taken not larger than the value Z'_{le}, given by:

$$Z'_{le} = Z_g + \frac{Q\ h_g - 0.5 h_g^2 S_1 P_g}{\sigma_a} \times 10^3 \qquad (cm^3)$$

Z_g = section modulus of one half pitch corrogation calculated, according to **Par 4**. in way of the upper end of shedder or gusset plates, as applicable (cm^3).

Q = shear force, as given in **1203. Par 2.** (kN).

h_g = height of shedders or gusset plates (m), as applicable (See **Fig. 7.3.15** (1), (2), (3) and (4)).

S_1 = as given in **1202. Par 3**.

P_g = resultant pressure, as defined in **1202. Par 5.** calculated in way of the middle of the shedders or gusset plates (kN/m^2), as applicable.

σ_a = allowable stress, as given in **Par 5.** (kN/m^2).

(2) Shear stress τ is obtained by dividing the shear force Q by the shear area. The shear area is to be reduced in order to account for possible non-perpendicularity between the corrugation webs and flanges. In general, the reduced shear area may be obtained by multiplying the web sectional area by (sin α), α being the angle between the web and the flange.

(3) When calculating the section modulus and the shear area, the net plate thicknesses are to be used.

(4) The section modulus of corrugations are to be calculated on the basis of the following requirements given in **Par 3** and **4**.

3. Section modulus at the lower end of corrugations

The section modulus is to be calculated with the compression flange having an effective flange width, bef, not larger than as given in **Par 6**. If the corrugation webs are not supported by local brackets below the stool top (or below the inner bottom) in the lower part, the section modulus of the corrugations is to be calculated considering the corrugation webs 30% effective.

(1) Provided that effective shedder plates, as defined in above **Par 2** are fitted (See **Fig. 7.3.15** (1) and (2)), when calculating the section modulus of corrugations at the lower end (cross-section ① in **Fig. 7.3.15** (1) and (2)), the area of flange plates may be increased by ($2.5a\sqrt{t_f t_{sh}}$) (not to be taken greater than $2.5at_f$).

a = width of the corrugation flange (m) (See **Fig. 7.3.12**).

t_{sh} = net shedder plate thickness (mm).

t_f = net flange thickness (mm).

(2) Provided that effective gusset plates, as defined in above **Par 2** are fitted (See **Fig. 7.3.15** (3) and (4)), when calculating the section modulus of corrugations at the lower end (cross-section ① in **Fig. 7.3.15** (3) and (4)), the area of flange plates may be increased by $7h_g t_f$.

h_g = height of gusset plate (m), see **Fig. 7.3.15** (3) and (4), not to be taken greater than $\frac{10}{7}S_{gu}$

S_{gu} = width of the gusset plates (m).

t_f = net flange thickness based on the as built condition (mm).

(3) If the corrugation webs are welded to a sloping stool top plate, which have an angle not less than 45° with the horizontal plane, the section modulus of the corrugations may be calculated considering the corrugation webs fully effective. In case effective gusset plates are fitted, when calculating the section modulus of corrugations the area of flange plates may be increased as specified in above (2). No credit can be given to shedder plates only. For angles less than 45°, the effectiveness of the web may be obtained by linear interpolation between 30% for 0° and 100% for 45°.

4. Section modulus of corrugations at cross-sections other than the lower end

The section modulus is to be calculated with the corrugation webs considered effective and the compression flange having an effective flange width, b_{cf}, not larger than as given in **Par 6**.

5. Allowable stress check

The normal and shear stresses σ and τ are not to exceed the allowable values σ_a and τ_a given by:

$$\sigma_a = \sigma_y \qquad (N/mm^2)$$
$$\tau_a = 0.5\sigma_y \qquad (N/mm^2)$$

σ_y = the minimum upper yield stress of the material (N/mm^2).

6. Effective compression flange width and shear

buckling checks

(1) Effective width of the compression flange of corrugations

The effective width bef of the corrugation flange is given by:

$$b_{ef} = C_e \alpha \quad (m)$$

$$\beta > 1.25 \; : \; C_e = \frac{2.25}{\beta} - \frac{1.25}{\beta^2}$$

$$\beta \leq 1.25 \; : \; C_e = 1.0$$

$$\beta = \frac{a}{t_f}\sqrt{\frac{\sigma_y}{E}} \times 10^3$$

t_f = net flange thickness (mm).

a = width of the corrugation flange (m) (See **Fig. 7.3.12**)

σ_y = the minimum upper yield stress of the material (N/mm^2).

E = modulus of elasticity of the material (N/mm^2) to be assumed equal to 2.06 × 10^5 for steel.

(2) Shear

The buckling check is to be performed for the web plates at the corrugation ends. The shear stress τ is not to exceed the critical value τ_c , as given by the following formulae.

$$\tau_c = \tau_E \qquad : \tau_c \leq 0.5\tau_y$$

$$\tau_c = \tau_y\left(1 - \frac{\tau_y}{4\tau_E}\right) \qquad : \tau_c > 0.5\tau_y$$

τ_y = shear stress of material, in N/mm^2, τ_y is to be determined as $\sigma_y / \sqrt{3}$

τ_E = ideal elastic buckling stress is determined as following:

$$\tau_E = 0.9 k_t E\left(\frac{t}{1000c}\right)^2 \qquad (N/mm^2)$$

k_t=6.34

t = net thickness of corrugation web (mm).

c = width of corrugation web (m). (See, **Fig. 7.3.12**)

σ_y, and E = as given in above (1).

7. Local net plate thickness

(1) The bulkhead local net plate thickness t_{net} is given by:

$$t_{net} = 14.9 S_w \sqrt{\frac{1.05P}{\sigma_y}} \quad (mm)$$

S_w = plate width, to be taken equal to the width of the corrugation flange or web, whichever is the greater (m) (See **Fig. 7.3.12**).

P = resultant pressure as defined in **1202. Par 5**, at the bottom of each strake of plating, in all cases, the net thickness of the lowest strake is to be determined using the resultant pressure at the top of the lower stool, or at the inner bottom, if no lower stool is fitted or at the top of sheddres, if shedders or gusset/shedder plates are fitted (kN/m^2).

σ_y = minimum upper yield stress of the material (kN/m^2).

(2) For built-up corrugation bulkheads, when the thicknesses of the flange and web are different,

(A) The net thickness of the narrower plating is to be not less than t_n, given by:

$$t_n = 14.9 S_n \sqrt{\frac{1.05P}{\sigma_y}} \quad (mm)$$

S_n = the width of the narrow plating (m).

P and σ_y = as given in (1).

(B) The net thickness of the wider plating is not to be taken less than the maximum of the following values:

$$t_{w1} = 14.9 S_w \sqrt{\frac{1.05P}{\sigma_y}} \quad (mm)$$

$$t_{w2} = 14.9 S_w \sqrt{\frac{440 S_w^2 1.05P}{\sigma_y} - t_{np}^2} \quad (mm)$$

t_{np} = not to be more than the smaller value of the actual net thickness of the narrower plating and t_{w1}.

S_w = the breath of the wider plating (m).

P and σ_y = as given in (1).

1205. Local details

1. As applicable, the design of local details is to be designed such that transferring the corrugated bulkhead forces and moments to the boundary structures, in particular to the double bottom and cross-deck structures, is sufficient.

2. In particular, the thickness and stiffening of effective gusset and shedder plates is to comply with the Society requirement, on the basis of the load model in **1204. Par 2**.

1206. Corrosion addition

The corrosion addition t_s is to be taken equal to 3.5mm.

SECTION 13
Supplementary Provisions for Carriage of Liquid in Holds

1301. General

1. Bulk carriers whose holds are loaded with cargo oil (hereinafter referred to as "B/O Carriers") are to be in accordance with the requirements in this Chapter and also those for oil tankers.
2. Other important items required for B/O carriers than those specified in this Chapter are to be at the discretion of the Society.
3. Where holds are loaded with cargo oil or ballast water, the scantlings of plates, stiffeners and girders composing bilge hopper tanks, topside tanks, transverse bulkheads and their stools as well as side structures are not to be less than those obtained from the relevant formulae, where the value of h specified in **Pt 3, Ch 15, 105.** is applied. The scantlings of structural members of double bottom under holds loaded with ballast are to be at the discretion of the Society.
4. When ships are designed to transport alternatively oil having a flash point below 60°C (closed cup test) or dry cargoes, openings which may be used for cargo operations are not permitted in bulkheads and decks separating oil cargo spaces from other spaces not designed and equipped for the carriage of oil cargoes unless alternative approved means are provided to ensure equivalent integrity.

1302. Holds half-loaded with cargo oils

Where holds are half-loaded with cargo oils, special care is to be taken to avoid synchronization of the natural period of oscillation of liquid in the holds with the natural periods of rolling and pitching of the ship. Where synchronization is not avoidable, plating, stiffeners and girders of transverse bulkheads and topside tanks are to be specially strengthened.

SECTION 14
Electrical Equipment of Coal Carriers

1401. General

The requirements in this Section apply to the electrical equipment installed in the cargo holds and the compartments adjacent thereto of coal carriers.

1402. Electrical equipment

1. Electrical equipment in cargo hold

In principle no electrical equipment is to be installed in the cargo holds. Where it is inevitable to install electrical equipment in the holds, the equipment is to comply with the following requirements:

(1) Switches and socket-outlets are not to be installed except those connected to intrinsically safe circuits.
(2) In case where other electrical equipment than those specified in (1) above is inevitably installed, the equipment and its associated cables are to be installed so as to be kept from mechanical damage. In addition, the feeder circuits for the equipment are to be provided with multipole linked isolating switches situated outside the holds, so deviced as to have the equipment usually locked with the switch in "off" position.
(3) The cables passing through the cargo holds are to be led in gastight heavy gauge steel pipes, and the both ends of the pipes are to be sealed using cable glands and the like in way of the boundaries of the cargo holds.

2. Electrical equipment in the compartments adjacent to cargo holds

(1) The electrical equipment which is installed in the compartments adjacent to the cargo holds and having an opening such as non-gastight door, hatch and like in their bulkheads and decks is to be of explosion protected type accepted by the Society.
(2) No electrical equipment except those of explosion protected type is to be installed in the vicinity of ventilation openings of the cargo holds.

3. Cargo lamps

Cargo lamps to be led and used in the cargo holds are to be the types accepted by the Society. ⚓

CHAPTER 4
CONTAINER SHIPS

Section

SECTION 1
General

101. Application

1. The construction and equipment of ships intended to be registered and classed as "Container Ship" are to be in accordance with the requirements in this Chapter, where, "Container Ship" means a ship designed exclusively for the carriage of containers in holds and on deck.

2. Except where specially required in this Chapter, the general requirements for the construction and equipment of steel ships are to be applied.

3. The requirements in this Chapter apply to ships which are single deckers having double bottoms in cargo holds and having decks and bottoms framed longitudinally.

4. The container ships with different type from that specified in **Par 3** to which the requirements in this Chapter are not applicable, are to be at the discretion of the Society.

SECTION 2
Longitudinal Strength

201. Bending strength

The section modulus, minimum section modulus and minimum moment of inertia of the transverse sections of the hull throughout $0.4L$ amidships are to be in accordance with the requirements in **Pt 3, Ch 3, 201.** However, the midship moment of inertia for the ship to which the requirements in this Chapter are not applicable with the abrupt changes in shape of the transverse section is to be increased at the discretion of the Society.

202. Torsional strength

Where the width of hatchway at midship exceeds $0.7B$, special considerations are to be paid to the additional stress and the deformation of hatchway openings due to torsion. Where, however, the ship has two or more rows of hatchways, the distance between the outermost lines of hatchway openings is to be taken as the width of hatchway.

SECTION 3
Double Bottoms

301. General

1. The construction of double bottoms in holds which are exclusively loaded with containers is to be in accordance with the requirements of this Section.

2. Side girders or solid floors are to be arranged in the double bottoms under corner fittings. Otherwise, double bottoms are to be effectively strengthened so as to support container loads.

3. Where cargo hold is exclusively used for the stowage of containers, the requirements for ceiling and the increment of inner bottom plating under hatchways specified in **Pt 3, Ch 7, 501.** may not be applied.

302. Longitudinals

The section modulus of bottom or inner bottom longitudinals is not to be less than that obtained from the formula given in **Table 7.4.1,** respectively.

303. Vertical struts

1. Vertical struts are to be of rolled sections other than flat bars or bulb plates and to be overlapped with the webs of bottom and inner bottom longitudinals.

2. The sectional area of the vertical struts is not to be less than that obtained from the following formula:

$$A = 1.8\,CKSbh \quad (cm^2)$$

where:

- S = spacing of longitudinals (m).
- b = breadth of the area supported by the strut (m).
- h = as obtained from the following formula (m).

$$h = \frac{d + 0.026\,L'}{2}$$

- L' = as specified in **Table 7.4.1.**
- C = coefficient obtained from the following formula. In no case is the value of coefficient to be less than 1.43.

$$C = \frac{1}{1 - 0.5\dfrac{l_s}{k\sqrt{K}}}$$

- l_s = length of struts (m).
- k = minimum radius of gyration of struts obtained from the following formula (cm).

$$k = \sqrt{\frac{I}{A}}$$

- I = the least moment of inertia of the struts (cm^4).
- A = sectional area of struts (cm^2).

Table 7.4.1 Section modulus of longitudinals

Item	Section modulus (cm^3)
Bottom longitudinals	$Z_b = \dfrac{CKSl^2}{24 - 15.0 f_B K}(d + 0.026L')$
Inner bottom longitudInals	$Z_i \geq 0.75 Z_b$

L' = length of ship (m). Where, however, L exceeds 230 m, L' is to be taken as 230 m.
l = spacing of solid floors (m).
S = spacing of longitudinals (m).
C = coefficient given in the following table.

Case	C
In case where no strut specified in **303.** is provided midway between floors	100
In case where a strut specified in **303.** is provided midway between floors	62.5

NOTE:
Where, however, the width of vertical stiffeners provided on floors and that of struts are large enough, the coefficient may be properly reduced.

304. Thickness of inner bottom plating

1. The thickness of inner bottom plating is not to be less than that obtained from the following formulae, whichever is the greater:

$$t_1 = \frac{CKB^2d}{d_0} + 1.5 \quad (mm)$$

$$t_2 = C'S\sqrt{hK} + 1.5 \quad (mm)$$

where:

- d_0 = height of centre girder (mm).
- S = spacing of inner bottom longitudinals for longitudinal framing or frame spacing for transverse framing (m).
- h = as given by the following formula.

  $h = 1.13\ (d - 0.001\,d_0)$
- C = coefficient obtained from **Table 3.7.7.** of **Pt 3.**
- C' = coefficient obtained from **Table 3.7.8.** of **Pt 3.**

2. The inner bottom plating with which the lower ends of corner fittings of containers are in contact is to be strengthened by means of doubling or by other appropriate means.

SECTION 4
Double Side Construction

401. General

1. Side construction in holds is to be double hull construction as far as practicable and is to be thoroughly stiffened by providing side transverse girders and side stringers within double hull.

2. Double side construction is to be in accordance with the requirements in **Pt 3, Ch 14** in addition to the requirements of this Section.

3. Double side shell structures which are used as deep tanks are to be in accordance with the requirements in **Pt 3, Ch 15,** in addition to the requirements of this Section.

4. Side stringers are to be provided in a proper spacing considering the depth of holds. And, side transverse girders are to be provided at the location of solid floors in double bottoms.

5. The scantlings in case where the width of double side shell structures changes in bilge parts, are to be at the discretion of the Society.

6. The scantlings in case where the height from the load line to the strength deck is specially large, are to be at the discretion of the Society.

7. Where structures effectively supporting deck structures and side shell structures are provided in the midway of holds, the requirements in this section may be appropriately modified.

8. At the location where the longitudinal bulkheads and the inner bottom plating are combined, considerations are to be paid with regard to their structural arrangement so as not to cause stress concentration.

9. At the fore and aft ends of double side construction, sufficient considerations are to be paid to the continuity of construction and strength.

402. Side transverse and side stringers

The thickness of side transverse and side stringers is not to be less than that obtained from the following formula. However, where deemed necessary by the Society, the thickness of these members is to be determined in consideration of bending and shear strength.

$$t = 8.5\frac{S_2}{\sqrt{K}} + 1.5 \quad (mm)$$

where:

S_2 = S_1 or d_1, whichever is the smaller.

S_1 = spacing of the stiffeners provided in the direction of the depth of transverse on the web of transverse for side transverse or spacing of the stiffeners provided in the direction of the depth of stringer on the web of stringer for side stringer (m), respectively.

d_1 = depth of side transverse or side stringers (m). Where, however, the depth of webs is divided by providing stiffeners in the direction of the length of side transverse on the webs or of side stringer on the webs, d_1 may be taken as the divided depth, respectively.

403. Longitudinal Bulkheads

The thickness of longitudinal bulkheads and the section modulus of longitudinal stiffeners in case where the double side structure is used as deep tanks, are not to be less than those obtained from the following formulae, respectively.

(1) The thickness of longitudinal bulkheads is not to be less than that obtained from the following formula. However, the thickness of longitudinal bulkheads which are not in contact with sea water in service conditions may be reduced from the following requirements by 0.5 mm.

$$t = 3.6\,C_1 S\sqrt{h} + 2.0 \quad (mm)$$

where:

S = spacing of longitudinal stiffeners (m).

h = vertical distance measured from the lower edge of plate to the midpoint of the distance between the top of tanks and the top of overflow pipes (m). However, with respect to the longitudinal bulkheads composing a large tank, appropriate additional water pressure specified in **Pt 3, Ch 15, 204.** is to be taken into account.

C_1 = coefficient obtained from **Table 7.4.2.**

(2) The section modulus of longitudinal stiffeners on longitudinal bulkheads is not to be less than that obtained from the following formula.

$$Z = C_2 C_3 S h l^2 \quad (cm^3)$$

where:

C_2 = coefficient given in **Table 7.4.2.**

C_3 = coefficient given in **Table 7.4.2.**

Table 7.4.2 Coefficients C_1, C_2 and C_3

<table>
<tr><th>Framing</th><th>C_1</th><th>C_2</th><th>C_3</th></tr>
<tr><td>Transverse system</td><td>$27.7\sqrt{\frac{K}{767-\alpha^2 K^2}}$</td><td>$K$</td><td rowspan="2">As specified in Table 3.15.2 of Pt 3.</td></tr>
<tr><td>Longitudinal system</td><td>$3.72\sqrt{\frac{K}{27.7-\alpha K}}$
but C_1 is not to be less than l.0.</td><td>$\frac{24K}{24-\alpha K}$</td></tr>
</table>

α = as obtained from the following formulae, whichever is the greater: However the value of α_1 or α_2 is not to be less than α_3

$$\alpha_1 = 15.0 f_D\left(\frac{y - y_B}{Y'}\right) \quad \text{for} \quad y \geq y_B$$

$$\alpha_2 = 15.0 f_B\left(\frac{y_B - y}{y_B}\right) \quad \text{for} \quad y < y_B$$

$$\alpha_3 = \beta\left(\frac{B - 2b}{B}\right)$$

y = distance (m) from the top of keel to the lower edge of plating when the platings under consideration are under y_B and to the upper edge of plating when the platings under consideration are above y_B, respectively.

y_B = vertical distance from the top of keel to the horizontal neutral axis of transverse section (m).

Y' = the greater of the value specified in **Pt 3, Ch 3, 203.,** (5), (a) or (b).

β = coefficient determined according to values of L as specified below :

$\beta = 6/a$ when L is 230 m and under

$\beta = 10.5/a$ when L is 400 m and above

For intermediate values of L, β is to be obtained by linear interpolation.

a = $\sqrt{K}$ when high tensile steels are used for not less than 80% of side shell plating at the transverse section amidship and 1.0 for other parts.

b = width of double side shell (m).

S = spacing of longitudinal stiffeners (m).

h = vertical distance measured from the mid-point of the distance between the top of tanks and the top of overflow pipes to the lower end being regarded as the mid-point of l for vertical stiffeners and as the mid-point of distance between the adjacent stiffeners for horizontal stiffeners, respectively (m).

l = span between supports of longitudinal stiffeners (m).

404. Brackets

Brackets are to be provided on the upper and lower corners inside the double side structure, at every frame in case where transversely stiffened and at an appropriate spacing between side transverse girders in case where longitudinally stiffened.

SECTION 5
Transverse Bulkheads

501. Construction

1. Transverse bulkheads are to be constructed so as to be sufficiently supported at the location of deck. In case where the width of bulkhead is specially large, the upper parts of transverse bulkheads are to be appropriately strengthened by providing box-shaped structures or by other means.
2. The scantlings of bulkheads and stiffeners are to comply with the requirements in **Pt 3, Ch 14, Sec 3.**

502. Partial Bulkheads

Where non-watertight partial bulkheads are provided in cargo holds, the construction and scantlings are to be made to have sufficient strength and rigidity, considering the size of cargo hold, the depth of bulkheads, etc.

SECTION 6
Deck Construction

601. Construction

1. The thickness of deck plating is to comply with the requirement in **Pt 3, Ch 5, Sec 3.**
2. The scantlings of decks inside the line of deck openings are to be appropriately strengthened in consideration of bending in the plane of deck.

602. Cross ties

1. Where the length of hatchway is large in comparison with the width of hatchway, cross ties are to be provided in the hatchway opening with suitable spacing.
2. Where structures effectively supporting the loads from the side and deck of ship are not provided at the location of cross ties in the holds, special considerations are to be paid to the scantlings of cross ties.

603. Continuity of thickness of deck plating

Consideration is to be paid to the continuity in the thickness of deck plating. Especially, the abrupt change between the thickness inside and outside the line of deck openings is to be avoided.

SECTION 7
Freight Container Securing Arrangement

701. Cell guide

1. The cell guides supporting containers are to be constructed so as to effectively transmit the loads to double bottom structure, side construction and transverse bulkheads.
2. The strength of cell guide is to be sufficient for the loads from the bottom and side of ship and the loads due to container loads.

702. Freight container securing systems

1. For freight container securing systems intended to be registered and classed as specified in **Pt 1, Ch 1, 201.** at the request of owners, plans showing materials, arrangement and scantling, etc. may be submitted for approval of the Society. Where container securing fittings are applied for part container only, this requirements may be suitably applied.
2. Securing devices specified in **Par 1** are to be approved in accordance with the special requirements given by the Society prior to installation on board the ship. ⚓

CHAPTER 5
SHIPS CARRYING LIQUEFIED GASES IN BULK

Section

SECTION 1
General

101. Application (IGC Code 1.1)

1. The requirements in this Chapter apply to ships constructed on or after 1 July 1998. Ships constructed before 1 July 1998 are subject to the requirements of IMO Res. MSC. 5(48) adopted on 17 June 1983 and its additional amendments. Ships constructed before 1 July 1986 are subject to the requirements of IMO Res. A. 328(IX) and its additional amendments and ships constructed before 1 November 1976 are to comply with the requirements of IMO Res. A. 329(IX). **802. 18** and **Sec 15** apply to all ships carrying liquefied gases in bulk regardless of the date of construction. Ships constructed before 1 July 1986 and not having the International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk, are to comply with the special requirements given by the Society.

2. The requirements in this Chapter apply to ships carrying liquefied gases in bulk (hereinafter referred to as a “ship” in this Chapter) intended to be registered and classed with the Society. The term “liquefied gases” means liquefied gases having an absolute vapour pressure exceeding 0.28 MPa at a temperature of 37.8°C, and other similar flammable products as shown in **Sec 19.**

3. The construction and equipment of ships for carriage of such liquefied gases which are not designated in **Sec 19** are to be to the satisfaction of the Society.

4. For ships to be classed for restricted service and ships not provided with propulsive machinery, the requirements may be modified as appropriate.

5. The ship’s hull, machinery and equipment not specified in this Chapter are generally to comply with the requirements in the relevant Chapters of these Rules.

6. When it is intended to carry products covered by this Chapter and products covered by **Ch 6**, the ship should comply with the requirements of both Chapters appropriate to the products carried, except the following (1) and (2).

(1) The requirements of this Chapter should take precedence when a ship is designed and constructed for the carriage of the following products:
  (a) those listed exclusively in **Sec 19**, and
  (b) one or more of the products which are listed both in this Chapter and in **Ch 6** (these products are marked with an asterisk (*) in column “a” in the table of **Sec 19**).

(2) When a ship is intended exclusively to carry one or more of the products noted in (1) (b) above, requirements of **Ch 6** should apply.

7. The Society may be subject to IMO decisions which would be different from the requirements of this Chapter.

102. Approval for plans

For classification survey during construction, the following plans and documents as may be required depending upon the products intended to be loaded, condition of cargo storage, construction of cargo containment system and other design conditions are to be submitted in triplicate before the work is commenced.

1. **Plans and data for approval**

(1) Manufacturing specifications for cargo tanks, insulations and secondary barriers (including welding procedures, inspection and testing procedures for weld and cargo tanks, properties of insulation materials and secondary barriers and their processing manual and working standards)
(2) Details of cargo tank construction
(3) Arrangement of cargo tank accessories including details of fittings inside the tanks
(4) Details of cargo tank supports, deck portions through which cargo tanks penetrate, and their sealing devices
(5) Details of secondary barriers
(6) Specifications and standards of materials (including insulations) used for cargo piping system in connection with design pressure and/or temperature
(7) Specifications and standards of materials of cargo tanks, insulations, secondary barriers and cargo tank supports
(8) Layout and details of attachment for insulations
(9) Constructions of cargo pumps, cargo compressors and their prime movers
(10) Constructions of main parts of refrigeration systems
(11) Piping diagrams of cargo and instrument
(12) Piping diagrams of refrigerant for refrigeration systems
(13) Bilge arrangements and ventilation systems in hold spaces or interbarrier spaces, cargo pump room, cargo compressor room and cargo control room
(14) Arrangement of sensors for gas detectors, temperature indicators, and pressure gauges
(15) Diagrams of inert gas lines and details of pressure adjusting devices, where hold spaces or interbarrier spaces are filled by inert gases
(16) Details of pressure relief devices and drainage systems for leakage of liquefied cargo in hold spaces or interbarrier spaces
(17) Sectional assembly, details of nozzles, fitting arrangement and details of fittings for various pressure vessels
(18) Details of valves for special purpose, cargo hoses, expansion joints, filters, etc., for cargo piping system
(19) Piping diagram, constructions and particulars of utilization units, where cargo is used as fuel
(20) Electric wiring plans and a table of electrical equipment in dangerous spaces
(21) Arrangement of earth connections for cargo tanks, pipe lines, machinery, equipment, etc.
(22) Plans showing dangerous spaces
(23) Fire extinguishing system stipulated in **Sec 11.**

2. **Plans and data for reference**

(1) Principal basic design and technical reports of cargo containment systems
(2) Data of test method and its result, where model test is carried out in compliance with the requirements of **Sec 4.**
(3) Data for notch toughness, corrosiveness, physical and mechanical properties of materials and welded parts at the minimum design temperature and room temperature, where new materials or welding methods are adopted for constructing the cargo tanks, secondary barriers, insulations and others
(4) Data of design loads stipulated in **403.**
(5) Calculation sheets of cargo tanks and supports stipulated in **404.** to **406.**
(6) Data of the test method and the results, where model tests were carried out to demonstrate the strength and performance of cargo tanks, insulations, secondary barriers, cargo tank supports
(7) Calculation sheets of heat transfer on the main parts of cargo tank under various condition of loading, where considered necessary by the Society.
(8) Calculation sheets of the thermal stress on the main parts of cargo tank at the condition of the temperature distribution stipulated in (7), where considered necessary by the Society
(9) Calculation sheets of temperature distribution on hull structure, where considered necessary by the Society
(10) Specifications of cargo handling systems
(11) Composition and physical properties of cargoes (including a saturated vapour pressure diagram within the necessary temperature range)
(12) Calculation sheets of relieving capacity for pressure relief valves of cargo tank (including calculation of the back pressure in cargo vent system)
(13) Calculation sheets for capacity of refrigeration systems
(14) Cargo piping arrangement
(15) Calculation sheets of filling limits for cargo tanks
(16) Arrangement of access manholes stipulated in **305.** in cargo tank area and the guide for access through these manholes.
(17) Operation manual stipulated in **Sec 18.**
(18) Calculation for ship survival capability stipulated in **Sec 2.**
(19) Equipment for personnel protection stipulated in **Sec 14.**

103. Equivalents

The construction and equipment, etc. which do not fall under the provisions of this Chapter but are considered to be equivalent to those required in this Chapter will be accepted by the Society.

104. National regulations

For the construction and equipment of the ship, attention is to be paid to the requirements of the national regulations of the country in which the ship is registered and/or of the port which the ship intendes to visit.

105. Hazards (IGC Code 1.2)

Hazards of gases covered by this Chapter include fire, toxicity, corrosivity, reactivity, low temperature and pressure.

106. Definitions (IGC Code 1.3)

The definitions of terms are to be as specified in the following and **Sec 4**, unless otherwise specified elsewhere.

1. **"Accommodation spaces"** are those spaces used for public spaces, corridors, lavatories, cabins, offices, hospitals, cinemas, games and hobbies rooms, barber shops, pantries containing no cooking appliances and similar spaces. Public spaces are those portions of the accommodation which are used for halls, dining rooms, lounges and similar permanently enclosed spaces.
2. **"A class divisions"** are those divisions formed by bulkheads and decks which comply with the following:
   (1) they are to be constructed of steel or other equivalent material;
   (2) they are to be suitably stiffened;
   (3) they are to be so constructed as to be capable of preventing the passage of smoke and flame to the end of the one hour standard fire test;
   (4) they are to be insulated with approved noncom bustible materials such that the average temperature of the unexposed side will not rise more than 139°C above the original temperature, nor will the temperature at any one point, including any joint, rise more than 180°C above the original temperature, within the time listed below:

Class "A-60"	60 minutes
Class "A-30"	30 minutes
Class "A-15"	15 minutes
Class "A-0"	0 minutes

   (5) the Society may require a test of a prototype bulkhead or deck to ensure that it meets the above requirements for integrity and temperature rise.
3. (1) **"Administration"** means the Government of the State whose flag the ship is entitled to fly.
   (2) **"Port Administration"** means the appropriate authority of the country in the Port of which the ship is loading or unloading.
4. **"Boiling point"** is the temperature at which a product exhibits a vapour pressure equal to the atmospheric pressure.
5. **"Breadth (B)"** means the maximum breadth of the ship, measured amidships to the moulded line of the frame in a ship with a metal shell and to the outer surface of the hull in a ship with a shell of any other material. The breadth (B) should be measured in metres.
6. **"Cargo area"** is that part of the ship which contains the cargo containment system and cargo pump and compressor rooms and includes deck areas over the full length and breadth of the part of the ship over the above-mentioned spaces. Where fitted, the cofferdams, ballast or void spaces at the after end of the aftermost hold space or at the forward end of the forwardmost hold space are excluded from the cargo area.
7. **"Cargo containment system"** is the arrangement for containment of cargo including, where fitted, a primary and secondary barrier, associated insulation and any intervening spaces, and adjacent structure if necessary for the support of these elements. If the secondary barrier is part of the hull structure it may be a boundary of the hold space.
8. **"Cargo control room"** is a space used in the control of cargo handling operations and complying with the requirements of **304.**
9. **"Cargoes"** are products listed in **Sec 19** carried in bulk by ships subject to this Chapter.
10. **"Cargo service spaces"** are spaces within the cargo area used for workshops, lockers and storerooms of more than 2 m^2 in area, used for cargo handling equipment.
11. **"Cargo tank"** is the liquid-tight shell designed to be the primary container of the cargo and includes all such containers whether or not associated with insulation or secondary barriers or both.
12. **"Cofferdam"** is the isolating space between two adjacent steel bulkheads or decks. This space may be a void space or a ballast space.
13. **"Control stations"** are those spaces in which ships' radio or main navigating equipment or the emergency source of power is located or where the fire-recording or fire-control equipment is centralized. This does not include special fire-control equipment which can be most practically located in the cargo area.
14. **"Flammable products"** are those identified by an "F" in column ''f'' in the table of **Sec 19.**
15. **"Flammability limits"** are the conditions defining the state of fuel-oxidant mixture at which application of an adequately strong external ignition source is only just capable of producing flammability in a given test apparatus.
16. **"Gas carrier"** is a cargo ship constructed or

adapted and used for the carriage in bulk of any liquefied gas or other products listed in the table of **Sec 19.**

17. "Gas-dangerous space or zone'' is:

(1) a space in the cargo area which is not arranged or equipped in an approved manner to ensure that its atmosphere is at all times maintained in a gas-safe condition;
(2) an enclosed space outside the cargo area through which any piping containing liquid or gaseous products passes, or within which such piping terminates, unless approved arrangements are installed to prevent any escape of product vapour into the atmosphere of that space;
(3) a cargo containment system and cargo piping;
(4) (a) a hold space where cargo is carried in a cargo containment system requiring a secondary barrier;
(b) a hold space where cargo is carried in a cargo containment system not requiring a secondary barrier;
(5) a space separated from a hold space described in (4) (a) by a single gastight steel boundary;
(6) a cargo pump room and cargo compressor room;
(7) a zone on the open deck, or semi-enclosed space on the open deck, within 3 m of any cargo tank outlet, gas or vapour outlet, cargo pipe flange or cargo valve or of entrances and ventilation openings to cargo pump rooms and cargo compressor rooms;
(8) the open deck over the cargo area and 3m forward and aft of the cargo area on the open deck up to a height of 2.4m above the weather deck;
(9) a zone within 2.4m of the outer surface of a cargo containment system where such surface is exposed to the weather;
(10) an enclosed or semi-enclosed space in which pipes containing products are located. A space which contains gas detection equipment complying with **1306. 5** and a space utilizing boil-off gas as fuel and complying with **Sec 16** are not considered gas-dangerous spaces in this context;
(11) a compartment for cargo hoses; or
(12) an enclosed or semi-enclosed space having a direct opening into any gas-dangerous space or zone.

18. "Gas-safe space" is a space other than a gas-dangerous space.

19. "Hold space" is the space enclosed by the ship's structure in which a cargo containment system is situated.

20. "Independent" means that a piping or venting system, for example, is in no way connected to another system and there are no provisions available for the potential connection to other systems.

21. "Insulation space" is the space, which may or may not be an interbarrier space, occupied wholly or in part by insulation.

22. "Interbarrier space" is the space between a primary and a secondary barrier, whether or not completely or partially occupied by insulation or other material.

23. "Length (L)" means 96% of the total length on a waterline at 85% of the least moulded depth measured from the top of the keel, or the length from the foreside of the stem to the axis of the rudder stock on that waterline, if that be greater. In ships designed with a rake of keel, the waterline on which this length is measured should be parallel to the designed waterline. The length (L) should be measured in metres.

24. "Machinery spaces of category A" are those spaces and trunks to such spaces which contain:

(1) internal combustion machinery used for main propulsion; or
(2) internal combustion machinery used for purposes other than main propulsion where such machinery has in the aggregate a total power output of not less than 375 kW; or
(3) any oil-fired boiler or oil fuel unit.

25. "Machinery spaces" are all machinery spaces of category A and all other spaces containing propelling machinery, boilers, oil fuel units, steam and internal combustion engines, generators and major electrical machinery, oil filling stations, refrigerating, stabilizing, ventilation and air-conditioning machinery, and similar spaces; and trunks to such spaces.

26. "MARVS" is the maximum allowable relief valve setting of a cargo tank.

27. "Oil fuel unit" is the equipment used for the preparation of oil fuel for delivery to an oil-fired boiler, or equipment used for the preparation for delivery of heated oil to an internal combustion engine, and includes any oil pressure pumps, filters and heaters dealing with oil at a pressure of more than 0.18 MPa gauge.

28. "Organization" is the International Maritime Organization (IMO).

29. "Permeability" of a space means the ratio of the volume within that space which is assumed to be occupied by water to the total volume of that space.

30. (1) "**Primary barrier**" is the inner element designed to contain the cargo when the cargo containment system includes two boundaries.
(2) "**Secondary barrier**" is the liquid-resisting outer element of a cargo containment system designed to afford temporary containment of any envisaged leakage of liquid cargo through the primary barrier and to prevent the lowering of the temperature of the ship's structure to an

unsafe level. Types of secondary barrier are more fully defined in **Sec 4.**

31. "Relative density" is the ratio of the mass of a volume of a product to the mass of an equal volume of fresh water.

32. "Separate" means that a cargo piping system or cargo vent system, for example, is not connected to another cargo piping or cargo vent system. This separation may be achieved by the use of design or operational methods. Operational methods should not be used within a cargo tank and should consist of one of the following types:

(1) removing spool pieces or valves and blanking the pipe ends;
(2) arrangement of two spectacle flanges in series with provisions for detecting leak age into the pipe between the two spectacle flanges.

33. "Service spaces" are those spaces used for galleys, pantries containing cooking appliances, lockers, mail and specie rooms, store-rooms, workshops other than those forming part of the machinery spaces and similar spaces and trunks to such spaces.

34. "1974 SOLAS Convention" means the International Convention for the Safety of Life at Sea,1974.

35. "1983 SOLAS amendments" means amendments to the 1974 SOLAS Convention adopted by the Maritime Safety Committee of the Organization at its forty-eighth session on 17 June 1983 by resolution MSC. 6(48).

36. "Tank cover" is the protective structure intended to protect the cargo containment system against damage where it protrudes through the weather deck or to ensure the continuity and integrity of the deck structure.

37. "Tank dome" is the upward extension of a portion of a cargo tank. In the case of below-deck cargo containment systems the tank dome protrudes through the weather deck or through a tank cover.

38. "Toxic products" are those identified by a "T'' in column "f" in the table of **Sec 19.**

39. "Vapour pressure" is the equilibrium pressure of the saturated vapour above the liquid expressed in MPa absolute at a specified temperature.

40. "Void space" is an enclosed space in the cargo area external to a cargo containment system, other than a hold space, ballast space, fuel oil tank, cargo pump or compressor room, or any space in normal use by personnel.

41. "Recognized standards" are applicable international or national standards acceptable to the Society or standards laid down and maintained by the Society which complies with the standards adopted by the organization.

SECTION 2
Ship Survival Capability and Location of Cargo Tanks

201. General (IGC Code 2.1)

1. Ships subject to this Chapter should survive the normal effects of flooding following assumed hull damage caused by some external force. In addition, to safeguard the ship and the environment, the cargo tanks should be protected from penetration in the case of minor damage to the ship resulting, for example, from contact with a jetty or tug, and given a measure of protection from damage in the case of collision or stranding, by locating them at specified minimum distances inboard from the ship's shell plating. Both the damage to be assumed and the proximity of the tanks to the ship's shell should be dependent upon the degree of hazard presented by the product to be carried.

2. Ships subject to this Chapter should be designed to one of the following standards:

(1) A type 1G ship is a gas carrier intended to transport products indicated in **Sec 19** which require maximum preventive measures to preclude the escape of such cargo.
(2) A type 2G ship is a gas carrier intended to transport products indicated in **Sec 19** which require significant preventive measures to preclude the escape of such cargo.
(3) A type 2PG ship is a gas carrier of 150 *m* in length or less intended to transport products indicated in **Sec 19** which require significant preventive measures to preclude escape of such cargo, and where the products are carried in independent type C tanks designed (see **402. 4** (4)) for a MARVS of at least 0.7 MPa gauge and a cargo containment system design temperature of -55°C or above. Note that a ship of this description but over 150 *m* in length is to be considered a type 2G ship.
(4) A type 3G ship is a gas carrier intended to carry products indicated in **Sec 19** which require moderate preventive measures to preclude the escape of such cargo.

Thus a type 1G ship is a gas carrier intended for the transportation of products considered to present the greatest overall hazard and types 2G/2PG and type 3G for products of progressively lesser hazards. Accordingly, a type 1G ship should survive the most severe standard of damage and its cargo tanks should be located at the maximum prescribed distance inboard from the shell plating.

3. The ship type required for individual products is indicated in column "c" in the table of **Sec 19.**

4. If a ship is intended to carry more than one product listed in **Sec 19,** the standard of damage should correspond to that product having the most stringent ship type requirement. The requirements for the location of individual cargo tanks, however, are those for ship types related to the respective products intended to be carried.

202. Freeboard and intact stability (IGC Code 2.2)

1. Ships subject to this Chapter may be assigned the minimum freeboard permitted by the International Convention on Load Lines in force. However, the draught associated with the assignment should not be greater than the maximum draught otherwise permitted by this Chapter.

2. The stability of the ship in all seagoing conditions and during loading and unloading cargo should be to a standard which is acceptable to the Society.

3. When calculating the effect of free surfaces of consumable liquids for loading conditions it should be assumed that, for each type of liquid, at least one transverse pair or a single centre tank has a free surface and the tank or combination of tanks to be taken into account should be those where the effect of free surfaces is the greatest. The free surface effect in undamaged compartments should be calculated by a method acceptable to the Society.

4. Solid ballast should not normally be used in double bottom spaces in the cargo area. Where, however, because of stability considerations, the fitting of solid ballast in such spaces becomes unavoidable, then its disposition should be governed by the need to ensure that the impact loads resulting from bottom damage are not directly transmitted to the cargo tank structure.

5. The master of the ship should be supplied with a Loading and Stability Information booklet. This booklet should contain details of typical service conditions, loading, unloading and ballasting operations, provisions for evaluating other conditions of loading and a summary of the ship's survival capabilities. In addition, the booklet should contain sufficient information to enable the master to load and operate the ship in a safe and seaworthy manner.

203. Shipside discharges below the freeboard deck (IGC Code 2.3)

1. The provision and control of valves fitted to discharges led through the shell from spaces below the freeboard deck or from within the superstructures and deckhouses on the freeboard deck fitted with weathertight doors should comply with the requirements of the relevant regulation of the International Convention on Load Lines in force, except that the choice of valves should be limited to:

(1) one automatic non-return valve with a positive means of closing from above the freeboard deck; or

(2) where the vertical distance from the summer load waterline to the inboard end of the dis-

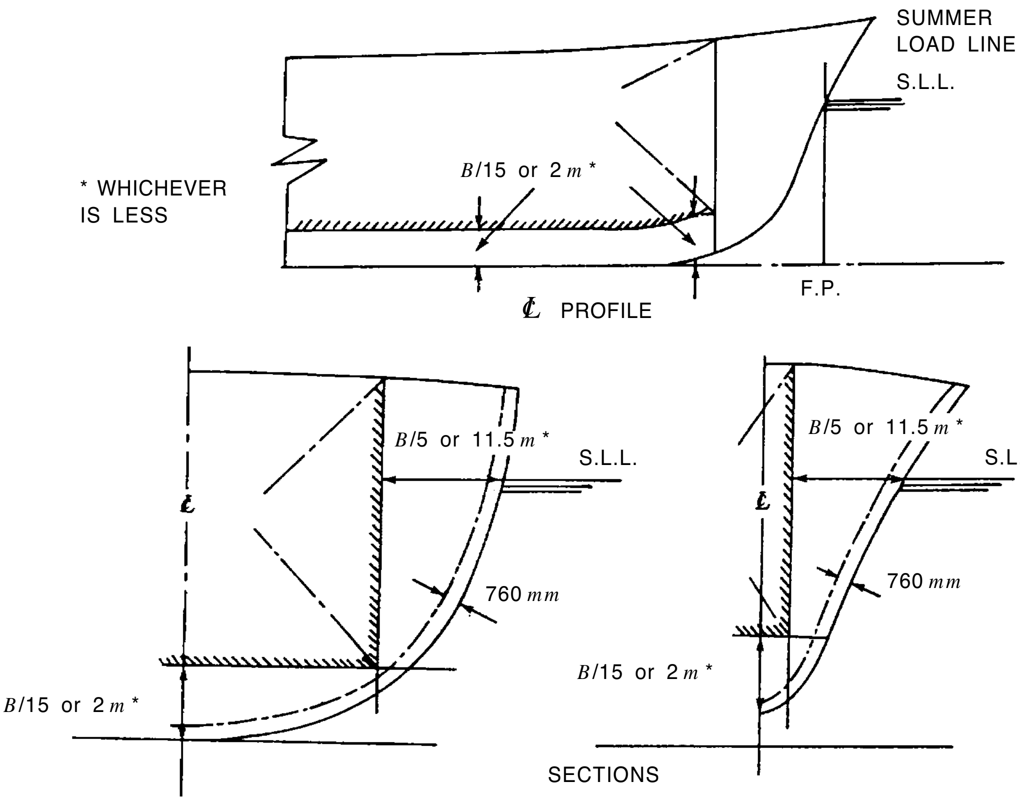


Fig. 7.5.1 Tank location requirements as set out in 206.

charge pipe exceeds 0.01 L, two automatic non-return valves without positive means of closing, provided that the inboard valve is always accessible for examination under service conditions.

2. For the purpose of this Section "**summer load waterline**" and "**freeboard deck**", have the meanings defined in the International Convention on Load Lines in force

3. The automatic non-return valves referred to in **Par 1** (1) and (2) should comply with recognized standards and should fully effective in preventing admission of water into the ship, taking into account the sinkage, trim and heel in survival requirements in **209.**

204. Conditions of loading (IGC Code 2.4)

Damage survival capability should be investigated on the basis of loading information submitted to the Society for all anticipated conditions of loading and variations in draught and trim. The survival requirements need not be applied to the ship when in the ballast condition, provided that any cargo retained on board is solely used for cooling, circulation or fuelling purposes.

205. Damage assumptions (IGC Code 2.5)

1. The assumed maximum extent of damage should be:

(1) Side damage:

(a) Longitudinal extent: $1/3L^{2/3}$ or 14.5 m, whichever is less

(b) Transverse extent: $B/5$ or 11.5 m, whichever is less

measured inboard from the ship's side at right angles to the centreline at the level of the summer load line

(c) Vertical extent: upwards without limit from the moulded line of the bottom shell plating at centreline.

(2) Bottom damage:

	For 0.3 L from the forward perpendicular of the ship	Any other part of the ship
(a) Longitudinal extent:	$1/3L^{2/3}$ or 14.5m ,whichever is less	$1/3L^{2/3}$ or 5m, whichever is less
(b) Transverse extent:	$B/6$ or 10m, whichever is less	$B/6$ or 5m, whichever is less
(c) Vertical extent:	$B/15$ or 2m, whichever is less measured from the moulded line of the bottom shell plating at centreline. (see **206. 3**)	$B/15$ or 2m, whichever is less measured from the moulded line of the bottom shell plating at centreline. (see **206. 3**)

2. Other damage:

(1) If any damage of a lesser extent than the maximum damage specified in **Par 1** would result in a more severe condition, such damage should be assumed.

(2) Local side damage anywhere in the cargo area extending inboard 760mm measured normal to the hull shell should be considered and transverse bulkheads should be assumed damaged when also required by the applicable sub-paragraphs of **208.1.**

206. Location of cargo tanks (IGC Code 2.6)

1. Cargo tanks should be located at the following distances inboard:

(1) Type 1G ships: from the side shell plating not less than the transverse extent of damage specified in **205.1** (1) (b) and from the moulded line of the bottom shell plating at centreline not less than the vertical extent of damage specified in **205.1** (2) (c) and nowhere less than 760 mm from the shell plating.

(2) Types 2G/2PG and 3G ships: from the moulded line of the bottom shell plating at centreline not less than the vertical extent of damage specified in **205. 1** (2) (c) and nowhere less than 760mm from the shell plating.

2. For the purpose of tank location, the vertical extent of bottom damage should be measured to the inner bottom when membrane or semi-membrane tanks are used, otherwise to the bottom of the cargo tanks. The transverse extent of side damage should be measured to the longitudinal bulkhead when membrane or semi-membrane tanks are used, otherwise to the side of the cargo tanks (see **Fig. 7.5.1**). For internal insulation tanks the extent of damage should be measured to the supporting tank plating.

3. Except for type 1G ships, suction wells installed in cargo tanks may protrude into the vertical extent of bottom damage specified in **205.1** (2) (c) provided that such wells are as small as practicable and the protrusion below the inner bottom plating does not exceed 25% of the depth of the double bottom or 350mm, whichever is less. Where there is no double bottom, the protrusion below the upper limit of bottom damage should not exceed 350mm. Suction wells installed in accordance with this paragraph may be ignored in determining the compartments affected by damage.

207. Flooding assumptions (IGC Code 2.7)

1. The requirements of **209.** should be confirmed by calculations which take into consideration the design characteristics of the ship; the arrangements, configuration and contents of the damaged compartments; the distribution, relative densities and the free surface effects of liquids; and the draught

and trim for all conditions of loading.

2. The permeabilities of spaces assumed to be damaged should be as follows:

Spaces	Permeabilities
Appropriated to stores	0.60
Occupied by accommodation	0.95
Occupied by machinery	0.85
Voids	0.95
Intended for consumable liquids	0 to 0.95
Intended for other liquids	0 to 0.95

3. Wherever damage penetrates a tank containing liquids, it should be assumed that the contents are completely lost from that compartment and replaced by salt water up to the level of the final plane of equilibrium.

4. Where the damage between transverse watertight bulkheads is envisaged as specified in **208.1** (4), (5) and (6), transverse bulkheads should be spaced at least at a distance equal to the longitudinal extent of damage specified in **205. 1** (1) (a) in order to be considered effective. Where transverse bulkheads are spaced at a lesser distance, one or more of these bulkheads within such extent of damage should be assumed as non-existent for the purpose of determining flooded compartments. Further, any portion of a transverse bulkhead bounding side compartments or double bottom compartments should be assumed damaged if the watertight bulkhead boudaries are within the extent of vertical or horizontal penetration required by **205.** Also, any transverse bulkhead should be assumed damaged if it contains a step or recess of more than 3 m in length located within the extent of penetration of assumed damage. The step formed by the after peak bulkhead and after peak tank top should not be regarded as a step for the purpose of this paragraph.

5. The ship should be so designed as to keep unsymmetrical flooding to the minimum consistent with efficient arrangements.

6. Equalization arrangements requiring mechanical aids such as valves or cross-levelling pipes, if fitted, should not be considered for the purpose of reducing an angle of heel or attaining the minimum range of residual stability to meet the requirements of **209.1** and sufficient residual stability should be maintained during all stages where equalization is used. Spaces which are linked by ducts of large cross-sectional area may be considered to be common.

7. If pipes, ducts, trunks or tunnels are situated within the assumed extent of damage penetration, as defined in **205.,** arrangements should be such that progressive flooding cannot thereby extend to compartments other than those assumed to be flooded for each case of damage.

8. The buoyancy of any superstructure directly above the side damage should be disregarded. The unflooded parts of superstructures beyond the extent of damage, however, may be taken into consideration provided that:

(1) they are separated from the damaged space by watertight divisions and the requirements of **209. 1** (1) in respect of these intact spaces are complied with; and
(2) openings in such divisions are capable of being closed by remotely operated sliding watertight doors and unprotected openings are not immersed within the minimum range of residual stability required in **209. 2** (1); however the immersion of any other openings capable of being closed weathertight may be permitted.

208. Standard of damage (IGC Code 2.8)

1. Ships should be capable of surviving the damage indicated in **205.** with the flooding assumptions in **207.** to the extent determined by the ship's type according to the following standards:

(1) A type 1G ship should be assumed to sustain damage anywhere in its length;
(2) A type 2G ship of more than 150m in length should be assumed to sustain damage anywhere in its length;
(3) A type 2G ship of 150 m in length or less should be assumed to sustain damage anywhere in its length except involving either of the bulkheads bounding a machinery space located aft;
(4) A type 2PG ship should be assumed to sustain damage anywhere in its length except involving transverse bulkheads spaced further apart than the longitudinal extent of damage as specified in **205. 1** (1) (a);
(5) A type 3G ship of 125m in length or more should be assumed to sustain damage anywhere in its length except involving transverse bulkheads spaced further apart than the longitudinal extent of damage specified in **205. 1** (1) (a);
(6) A type 3G ship less than 125m in length should be assumed to sustain damage anywhere in its length except involving transverse bulkheads spaced further apart than the longitudinal extent of damage specified in **205.1** (1) (a) and except damage involving the machinery space when located aft. However, the ability to survive the flooding of the machinery space should be considered by the Society.

2. In the case of small type 2G/2PG and 3G ships which do not comply in all respects with the appropriate requirements of **Par 1** (3), (4) and (6), special dispensations may only be considered by the Society provided that alternative measures can be taken which maintain the same degree of safety.

The nature of the alternative measures should be approved and clearly stated and be available to the Port Administration. Any such dispensation should be duly noted on the International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk.

209. Survival requirements (IGC Code 2.9)

Ships subject to this Chapter should be capable of surviving the assumed damage specified in **205.** to the standard provided in **208.** in a condition of stable equilibrium and should satisfy the following criteria.

1. In any stage of flooding:

(1) the waterline, taking into account sinkage, heel and trim, should be below the lower edge of any opening through which progressive flooding or downflooding may take place. Such openings should include air pipes and openings which are closed by means of weathertight doors or hatch covers and may exclude those openings closed by menas of watertight manhole covers and watertight flush scuttles, small watertight cargo tank hatch covers which maintain the high integrity of the deck, remotely operated watertight sliding doors, and sidescuttles of the non-opening type;

(2) the maximum angle of heel due to unsymmetrical flooding should not exceed 30°; and

(3) the residual stability during intermediate stages of flooding should be to the satisfaction of the Society. However, it should never be significantly less than that required by **Par 2** (1).

2. At final equilibrium after flooding:

(1) the righting lever curve should have a minimum range of 20° beyond the position of equilibrium in association with a maximum residual righting lever of at least 0.1 m within the 20° range; the area under the curve within this range should not be less than 0.0175m-rad. Unprotected openings should not be immersed within this range unless the space concerned is assumed to be flooded. Within this range, the immersion of any of the openings listed in **Par 1** (1) and other openings capable of being closed weathertight may be permitted; and

(2) the emergency source of power should be capable of operating.

SECTION 3
Ship Arrangements

301. Segregation of the cargo area (IGC Code 3.1)

1. Hold spaces should be segregated from machinery and boiler spaces, accommodation spaces, service spaces and control stations, chain lockers, drinking and domestic water tanks and from stores. Hold spaces should be located forward of machinery spaces of category A, other than those deemed necessary by the Society for the safety or navigation of the ship.

2. Where cargo is carried in a cargo containment system not requiring a secondary barrier, segregation of hold spaces from spaces referred to in **Par 1** or spaces either below or outboard of the hold spaces may be effected by cofferdams, fuel oil tanks or a single gastight bulkhead of all-welded construction forming an A-60 class division. A gastight A-0 class division is satisfactory if there is no source of ignition or fire hazard in the adjoining spaces.

3. Where cargo is carried in a cargo containment system requiring a secondary barrier, segregation of hold spaces from spaces referred to in **Par 1** or spaces either below or outboard of the hold spaces which contain a source of ignition or fire hazard should be effected by cofferdams or fuel oil tanks. If there is no source of ignition or fire hazard in the adjoining space, segregation may be by a single A-0 class division which is gastight.

4. When cargo is carried in a cargo containment system requiring a secondary barrier:

(1) at temperatures below -10°C, hold spaces should be segregated from the sea by a double bottom; and

(2) at temperatures below -55°C, the ship should also have a longitudinal bulkhead forming side tanks.

5. Any piping system which may contain cargo or cargo vapour should:

(1) be segregated from other piping systems, except where inter-connections are required for cargo-related operations such as purging, gas-freeing or inerting. In such cases, precautions should be taken to ensure that cargo or cargo vapour cannot enter such other piping systems through the inter-connections;

(2) except as provided in **Sec 16,** not pass through any accommodation space, service space or control station or through a machinery space other than a cargo pump room or cargo compressor space;

(3) be connected into the cargo containment system directly from the open deck except that pipes installed in a vertical trunk-way or equivalent may be used to traverse void spaces above a cargo containment system and except that pipes for drainage, venting or purging may traverse cofferdams;

(4) except for bow or stern loading and unloading arrangements in accordance with **308.** and emergency cargo jettisoning piping systems in accordance with **Par 6,** and except in accordance with **Sec 16,** be located in the cargo area above the open deck; and

(5) except for thwartship shore connection piping not subject to internal pressure at sea or emergency cargo jettisoning piping systems, be located inboard of the transverse tank location requirements of **206.1.**

6. Any emergency cargo jettisoning piping system should comply with **Par 5** as appropriate and may be led aft externally to accommodation spaces, service spaces or control stations or machinery spaces, but should not pass through them. If an emergency cargo jettisoning piping system is permanently installed a suitable means of isolation from the cargo piping should be provided within the cargo area.

7. Arrangements should be made for sealing the weather decks in way of openings for cargo containment systems.

302. Accommodation, service and machinery spaces and control stations (IGC Code 3.2)

1. No accommodation space, service space or control station should be located within the cargo area. The bulkhead of accommodation spaces, service spaces or control stations which face the cargo area should be so located as to avoid the entry of gas from the hold space to such spaces through a single failure of a deck or bulkhead on a ship having a containment system requiring a secondary barrier.

2. In order to guard against the danger of hazardous vapours, due consideration should be given to the location of air intakes and openings into accommodation, service and machinery spaces and control stations in relation to cargo piping, cargo vent systems and machinery space exhausts from gas burning arrangements.

3. Access through doors, gastight or otherwise, should not be permitted from a gas-safe space to a gas-dangerous space, except for access to service spaces forward of the cargo area through air-locks as permitted by **306. 1** when accommodation spaces are aft.

4. Entrances, air inlets and openings to accommodation spaces, service spaces, machinery spaces and control stations should not face the cargo area. They should be located on the end bulkhead not facing the cargo area or on the outboard side of the superstructure or deckhouse or on both at a distance of at least 4% of the length (L) of the ship but not less than $3m$ from the end of the superstructure or deckhouse facing the cargo area. This distance, however, need not exceed $5\,m$. Windows and sidescuttles facing the cargo area and on the sides of the superstructure or deckhouse within the distance mentioned above should be of the fixed (non-opening) type. Wheelhouse windows may be non-fixed and wheelhouse doors may be located within the above limits so long as they are so designed that a rapid and efficient gas and vapour tightening of the wheelhouse can be ensured. For ships dedicated to the carriage of cargoes which have neither flammable nor toxic hazards, the Society may approve relaxations from the above requirements.

5. Sidescuttles in the shell below the uppermost continuous deck and in the first tier of the superstructure or deckhouse should be of the fixed (non-opening) type.

6. All air intakes and openings into the accommodation spaces, service spaces and control stations should be fitted with closing devices. For toxic gases they should be operated from inside the space.

303. Cargo pump rooms and cargo compressor rooms (IGC Code 3.3)

1. (1) Cargo pump rooms and cargo compressor rooms should be situated above the weather deck and located within the cargo area unless specially approved by the Society. Cargo compressor rooms should be treated as cargo pump rooms for the purpose of fire protection according to regulation II-2/58 of the 1983 SOLAS amendments.

(2) When cargo pump rooms and cargo compressor rooms are permitted to be fitted above or below the weather deck at the after end of the aftermost hold space or at the forward end of the forwardmost hold space, the limits of the cargo area as defined in **106. 6** should be extended to include the cargo pump rooms and cargo compressor rooms for the full breadth and depth of the ship and deck areas above those spaces.

(3) Where the limits of the cargo area are extended by (2), the bulkhead which separates the cargo pump rooms and cargo compressor rooms from accommodation and service spaces, control stations and machinery spaces of category A should be so located as to avoid the entry of gas to these spaces through a single failure of a deck or bulkhead.

2. Where pumps and compressors are driven by shafting passing through a bulkhead or deck, gastight seals with efficient lubrication or other means of ensuring the permanence of the gas seal should be fitted in way of the bulkhead or deck.

3. Arrangements of cargo pump rooms and cargo compressor rooms should be such as to ensure safe unrestricted access for personnel wearing protective clothing and breathing apparatus, and in the event of injury to allow unconscious personnel to be removed. All valves necessary for cargo handling should be readily accessible to personnel wearing protective clothing. Suitable arrangements should be made to deal with drainage of pump and compressor rooms.

304. Cargo control rooms (IGC Code 3.4)

1. Any cargo control room should be above the weather deck and may be located in the cargo area. The cargo control room may be located within the accommodation spaces, service spaces or control stations provided the following conditions are complied with:

(1) the cargo control room is a gas-safe space; and

(2) (a) if the entrance complies with **302. 4,** the control room may have access to the spaces described above;

(b) if the entrance does into comply with **302. 4,** the control room should have no access to the spaces described above and the boundaries to such spaces should be insulated to A-60 class integrity

2. If the cargo control room is designed to be a gas-safe space, instrumentation should, as far as possible, be by indirect reading systems and should in any case be designed to prevent any escape of gas into the atmosphere of that space. Location of the gas detector within the cargo control room will not violate the gas-safe space if installed in accordance with **1306. 5.**

3. If the cargo control room for ships carrying flammable cargoes is a gas-dangerous space, sources of ignition should be excluded. Consideration should be paid to the safety characteristics of any electrical installations.

305. Access to spaces in the cargo area (IGC Code 3.5)

1. Visual inspection should be possible of at least one side of the inner hull structure without the removal of any fixed structure or fitting. If such a visual inspection, whether combined with those inspections required in **Par 2, 407. 7** or **410. 16** or not, is only possible at the outer face of the inner hull, the inner hull should not be a fuel-oil tank boundary wall.

2. Inspection of one side of any insulation in hold spaces should be possible. If the integrity of the insulation system can be verified by inspection of the outside of the hold space boundary when tanks are at service temperature, inspection of one side of the insulation in the hold space need not be required.

3. Arrangements for hold spaces, void spaces and other spaces that could be considered gas-dangerous and cargo tanks should be such as to allow entry and inspection of any such space by personnel wearing protective clothing and breathing apparatus and in the event of injury to allow unconscious personnel to be removed from the space and should comply with the following:

(1) Access should be provided:

(a) to cargo tanks direct from the open deck;

(b) through horizontal openings, hatches or manholes, the dimensions of which should be sufficient to allow a person wearing a breathing apparatus to ascend or descend any ladder without obstruction and also to provide a clear opening to facilitate the hoisting of an injured person from the bottom of the space; the minimum clear opening should be not less than 600 mm by 600 mm; and

(c) through vertical openings, or manholes providing passage through the length and breadth of the space, the minimum clear opening of which should be not less than 600 mm by 800 mm at a height of not more than 600 mm from the bottom plating unless gratings or other footholds are provided.

(2) the dimensions referred to in (1) (b) and (c) may be decreased if the ability to traverse such openings or to remove an injured person can be proved to the satisfaction of the Society.

(3) The requirements of (1) (b) and (c) do not apply to spaces described in **106. 17** (5). Such spaces should be provided only with direct or indirect access from the open weather deck, not including an enclosed gas-safe space.

4. Access from the open weather deck to gas-safe spaces should be located in a gas-safe zone at least 2.4m above the weather deck unless the access is by means of an air-lock in accordance with **306.**

306. Air locks (IGC Code 3.6)

1. An air-lock should only be permitted between a gas-dangerous zone on the open weather deck and a gas-safe space and should consist of two steel doors substantially gastight spaced at least 1.5m but not more than 2.5m apart.

2. The doors should be self-closing and without any holding back arrangements.

3. An audible and visual alarm system to give a warning on both sides of the air lock should be provided to indicate if more than one door is moved from the closed position.

4. In ships carrying flammable products, electrical equipment which is not of the certified safe type in spaces protected by air locks should be de-energized upon loss of overpressure in the space (see also **1002. 5** (4)). Electrical equipment which is not of the certified safe type for manoeuvring, anchoring and mooring equipment as well as the emergency fire pumps should not be located in spaces to be protected by air locks.

5. The air lock space should be mechanically ventilated from a gas-safe space and maintained at an overpressure to the gas-dangerous zone on the open weather deck.

6. The air-lock space should be monitored for cargo vapour.

7. Subject to the requirements of the International Convention on Load Lines in force, the door still should not be less than 300 mm in height.

307. Bilge, ballast and fuel oil arrangements (IGC Code 3.7)

1. (1) Where cargo is carried in a cargo containment system not requiring secondary barrier, hold spaces should be provided with suitable drainage arrangements not connected with the machinery space. Means of detecting any leakage should be provided.

(2) Where there is a secondary barrier, suitable drainage arrangements for dealing with any leakage into the hold or insulation spaces through adjacent ship structure should be provided. The suction should not be led to pumps inside the machinery space. Means of detecting such leakage should be provided.

2. (1) The hold or interbarrier spaces of Type A independent tank ships should be provided with a drainage system suitable for handling liquid cargo in the event of cargo tank leakage or rupture. Such arrangements should provide for the return of any cargo leakage to the liquid cargo piping.

(2) Arrangements referred to in (1) should provided with a removable spool piece. This paragraph applies to ships constructed on or after 1 July 2002.

3. In case of internal insulation tanks, means of detecting leakage and drainage arrangements are not required for interbarrier spaces and spaces between the secondary barrier and the inner hull or independent tank structure which are completely filled by insulation material complying with **409. 7** (2).

4. Ballast spaces, including wet duct keels used as ballast piping, fuel-oil tanks and gas-safe spaces may be connected to pumps in the machinery spaces. Dry duct keels with ballast piping passing through, may be connected to pumps in the machinery spaces, provided the connections are led directly to the pumps and the discharge from the pumps lead directly overboard with no valves or manifolds in either line which could connect the line from the duct keel to lines serving gas-safe spaces. Pump vents should not be open to machinery spaces.

308. Bow or stern loading and unloading arrangements (IGC Code 3.8)

1. Subject to the requirements in **308.,** cargo piping may be arranged to permit bow or stern loading and unloading.

(1) Bow or stern loading and unloading lines which are led past accommodation spaces, service spaces or control stations should not be used for the transfer of products requiring a type 1G ship. Bow or stern loading and unloading lines should not be used for the transfer of toxic products as specified in **106. 38** unless specifically approved by the Society.

2. Portable arrangements should not be permitted.

3. In addition to the requirements of **Sec 5** the following provisions apply to cargo piping and related piping equipment:

(1) Cargo piping and related piping equipment outside the cargo area should have only welded connections. The piping outside the cargo area should run on the open deck and should be at least 760 mm inboard except for thwartships shore connection piping. Such piping should be clearly identified and fitted with a shutoff valve at its connection to the cargo piping system within the cargo area. At this location, it should also be capable of being separated by means of a removable spool piece and blank flanges when not in use.

(2) The piping is to be full penetration butt welded, and fully radiographed regardless of pipe diameter and design temperature. Flange connections in the piping are only permitted within the cargo area and at the shore connection.

(3) Arrangements should be made to allow such piping to be purged and gas-freed after use When not in use, the spool pieces should be removed and the pipe ends be blank-flanged. The vent pipes connected with the purge should be located in the cargo area.

4. Entrances, air inlets and openings to accommodation spaces, service spaces, machinery spaces and control stations should not face the cargo shore connection location of bow or stern loading and unloading arrangements. They should be located on the outboard side of the superstructure or deckhouse at a distance of at least 4% of the length of the ship but not less than 3m from the end of the superstructure or deck house facing the cargo shore connection location of the bow or stern loading and unloading arrangements. This distance, however, need not exceed 5m. Sidescuttles facing the shore connection location and on the sides of the superstructure or deckhouse within the distance mentioned above should be of the fixed (non-opening) type. In addition. during the use of the bow or stern loading and unloading arrangements, all doors, ports and other openings on the corresponding superstructure or deckhouse side should be kept closed. Where, in the case of small ships, compliance with **302. 4** and this paragraph is not possible, the Society may approve relaxations from the above requirements.

5. Deck openings and air inlets to spaces within distances of $10m$ from the cargo shore connection location should be kept closed during the use of bow or stern loading or unloading arrangements.

6. Electrical equipment within a zone of $3m$ from the cargo shore connection location should be in accordance with **Sec 10.**

7. Fire-fighting arrangements for the bow or stern loading and unloading areas should be in accordance with **1103. 1** (3) and **1104. 7.**

8. Means of communication between the cargo control station and the shore connection location should be provided and if necessary certified safe.

SECTION 4
Cargo Containment

401. General (IGC Code 4.1)

1. The Society should take appropriate steps to ensure uniformity in the implementation and application of the provisions of this Section.

2. In addition to the definitions in **106.,** the definitions given in this Section apply throughout this Chapter.

402. Definitions (IGC Code 4.2)

1. Integral tanks

(1) Integral tanks form a structural part of the ship's hull and are influenced in the same manner and by the same loads which stress the adjacent hull structure.

(2) The design vapour pressure P_0 as defined in **Par 6** should not normally exceed 0.025 MPa. If, however, the hull scantlings are increased accordingly, P_0 may be increased to a higher value but less than 0.07 MPa.

(3) Integral tanks may be used for products provided the boiling point of the cargo is not below -10°C. A lower temperature may be accepted by the Society subject to special consideration.

2. Membrane tanks

(1) Membrane tanks are non-self-supporting tanks which consist of a thin layer (membrane) supported through insulation by the adjacent hull structure. The membrane is designed in such a way that thermal and other expansion or contraction is compensated for without undue stressing of the membrane.

(2) The design vapour pressure P_0 should not normally exceed 0.025 MPa. If, however, the hull scantlings are increased accordingly and consideration is given, where appropriate, to the strength of the supporting insulation, P_0 may be increased to a higher value but less than 0.07 MPa.

(3) The definition of membrane tanks does not exclude designs such as those in which non-metallic membranes are used or in which membranes are included or incorporated in insulation. Such designs require, however, special consideration by the Society. In any case the thickness of the membranes should normally not exceed $10mm$.

3. Semi-membrane tanks

(1) Semi-membrane tanks are non-self-supporting tanks in the loaded condition and consist of a layer, parts of which are supported through insulation by the adjacent hull structure, whereas the rounded parts of this layer connecting the above-mentioned supported parts are designed also to accommodate the thermal and other expansion or contraction

(2) The design vapour pressure P_0 should not normally exceed 0.025 MPa. If, however, the hull scantlings are increased accordingly, and consideration is given, where appropriate, to the strength of the supporting insulation, P_0 may be increased to a higher value but less than 0.7 bar.

4. Independent tanks

(1) Independent tanks are self-supporting; they do not form part of the ship's hull and are not essential to the hull strength. There are three categories of independent tanks referred to in (2) to (4).

(2) Type A independent tanks are tanks which are designed primarily using recognized standards of classical ship-structural analysis procedures. Where such tank are primarily constructed of plane surfaces (gravity tanks), the design vapour pressure P_0 should be less than 0.07 MPa.

(3) Type B independent tanks are tanks which are designed using model tests, refined analytical tools and analysis methods to determine stress levels, fatigue life and crack propagation characteristics. Where such tanks are primarily constructed of plane surfaces (gravity tanks) the design vapour pressure P_0 should be less than 0.07 MPa.

(4) Type C independent tanks (also referred to as pressure vessels) are tanks meeting pressure vessel criteria and having a design vapour pressure not less than:

$$P_0 = 0.2 + A \cdot C(\rho_r)^{\frac{3}{2}} \quad (MPa)$$

where:

$$A = 0.00185\left(\frac{\sigma_m}{\Delta\sigma_A}\right)^2$$

with
σ_m = design primary membrane stress

$\Delta\sigma_A$ = allowable dynamic membrane stress (double amplitude at probability level Q = 10^{-8})
55 N/mm^2 for ferritic-perlitic, martensitic and austenitic steels
25 N/mm^2 for aluminium alloy (5083-0)

C = a characteristic tank dimension to be taken as the greatest of the following:

h, 0.75b, or 0.45l

with

h = height of tank (dimension in ship's vertical direction) (m)
b = width of tank (dimension in ship's transverse direction) (m)
l = length of tank (dimension in ship's longitudinal direction) (m)

ρ_r = the relative density of the cargo (ρ_r = 1 for fresh water) at the design temperature.

However, the Society may allocate a tank complying with the criterion of this subparagraph to type A or type B, dependent on the configuration of the tank and the arrangement of its supports and attachments.

5. Internal insulation tanks

(1) Internal insulation tanks are non-self-supporting and consist of thermal insulation materials which contribute to the cargo containment and are supported by the structure of the adjacent inner hull or of an independent tank. The inner surface of the insulation is exposed to the cargo.

(2) The two categories of internal insulation tanks are:

(a) Type 1 tanks which are tanks in which the insulation or a combination of the insulation and one or more liners functions only as the primary barrier. The inner hull or an independent tank structure should function as the secondary barrier when required.

(b) Type 2 tanks which are tanks in which the insulation or a combination of the insulation and one or more liners functions as both the primary and the secondary barrier and where these barriers are clearly distinguishable.

The terms "liner" means a thin, non-self-supporting, metallic, nonmetallic or composite material which forms part of an internal insulation tank in order to enhance its fracture resistance or other mechanical properties. A liner differs from a membrane in that it is not intended to function alone as a liquid barrier.

(3) Internal insulation tanks should be of suitable materials enabling the cargo containment system to be designed using model tests and refined analytical methods as required in **404. 7.**

(4) The design vapour pressure P_0 should not normally exceed 0.025 MPa. If, however, the cargo containment system is designed for a higher vapour pressure, P_0 may be increased to such higher value, but not exceeding 0.07 MPa if the internal insulation tanks are supported by the inner hull structure. However, a design vapour pressure of more than 0.07 MPa may be accepted by the Society provided the internal insulation tanks are supported by suitable independent tank structures.

6. Design vapour pressure

(1) The design vapour pressure P_0 is the maximum gauge pressure at the top of the tank which has been used in the design of the tank.

(2) For cargo tanks where there is no temperature control and where the pressure of the cargo is dictated only by the ambient temperature, P_0 should not be less than the gauge vapour pressure of the cargo at a temperature of 45°C. However, lesser values of this temperature may be accepted by the Society for ships operating in restricted areas or on voyages of restricted duration and account may be taken in such cases of any insulation of the tanks. Conversely, higher values of this temperature may be required for ships permanently operating in areas of high ambient temperature.

(3) In all cases, including (2), P_0 should not be less than MARVS.

(4) Subject to special consideration by the Society and to the limitations given in **Pars 1** to **5** for the various tank types, a vapour pressure higher than P_0 may be accepted in harbour conditions, where dynamic loads are reduced.

7. Design temperature

The design temperature for selection of materials is the minimum temperature at which cargo may be loaded or transported in the cargo tanks. Provision to the satisfaction of the Society should be made to ensure that the tank or cargo temperature cannot be lowered below the design temperature.

403. Design loads (IGC Code 4.3)

1. General

(1) Tanks together with their supports and other fixtures should be designed taking into account proper combinations of the following loads:

- internal pressure
- external pressure
- dynamic loads due to the motions of the ship
- thermal loads sloshing loads
- loads corresponding to ship deflection
- tank and cargo weight with the corresponding reactions in way of supports
- insulation weight
- loads in way of towers and other attachment

The extent to which these loads should be considered depends on the type of tank, and is more fully detailed in the following paragraphs.

(2) Account should be taken of the loads corresponding to the pressure test referred to in **410.**

(3) Account should be taken of an increase of vapour pressure in harbour conditions referred to in **402. 6** (4).

(4) The tanks should be designed for the most unfavourable static heel angle within the range 0° to 30° without exceeding allowable stresses given in **405. 1.**

2. Internal pressure

(1) The internal pressure P_{eq} in bars gauge resulting from the design vapour pressure P_0 and the internal liquid pressure P_{gd} defined in (2), but not including effects of liquid sloshing, should be calculated as follows:

$$P_{eq} = P_0 + (P_{gd})_{max} \quad \text{(MPa)}$$

Equivalent calculation procedures may be applied.

(2) The internal liquid pressures are those created by the resulting acceleration of the centre of gravity of the cargo due to the motions of the ship referred to in **Par 4** (1). The value of internal liquid pressure P_{gd} resulting from combined effects of gravity and dynamic accelerations should be calculated as follows:

$$P_{gd} = a_\beta \cdot Z_\beta \frac{\rho}{1.02 \times 10^5} \qquad \text{(MPa)}$$

where:

a_β = dimensionless acceleration (i.e. relative to the acceleration of gravity), resulting from gravitational and dynamic loads, in an arbitrary direction β (see **Fig. 7.5.2**).

Z_β = largest liquid height (m) above the point where the pressure is to be determined measured from the tank shell in the β direction (see **Fig. 7.5.3**). Tank domes considered to be part of the accepted total tank volume should be taken into account when determining Z_β unless the total volume of tank domes V_d does not exceed the following value:

$$V_d = V_t \left(\frac{100 - FL}{FL} \right)$$

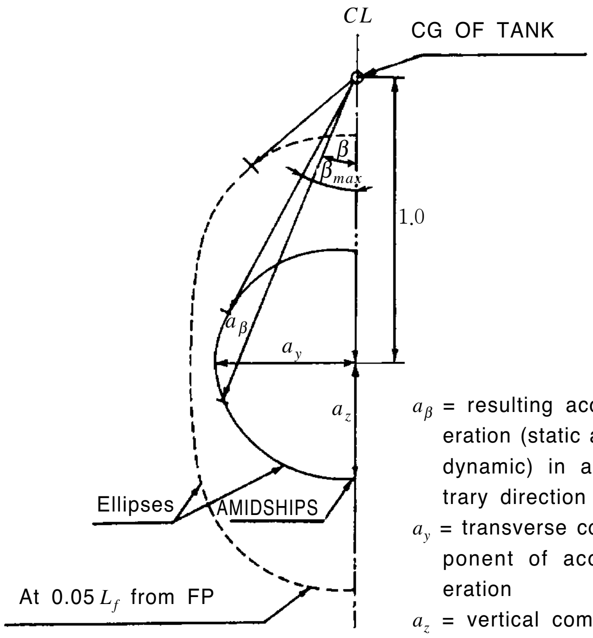
where:

V_t = tank volume without any domes.

FL = filling limit (%) according to **Sec 15**

ρ = maximum cargo density (kg/m^3) at the design temperature.

The direction which gives the maximum value $(P_{gd})_{max}$ of P_{gd} should be considered. Where



a_β = resulting acceleration (static and dynamic) in arbitrary direction β

a_y = transverse component of acceleration

a_z = vertical component of acceleration

Fig. 7.5.2 Acceleration Ellipse

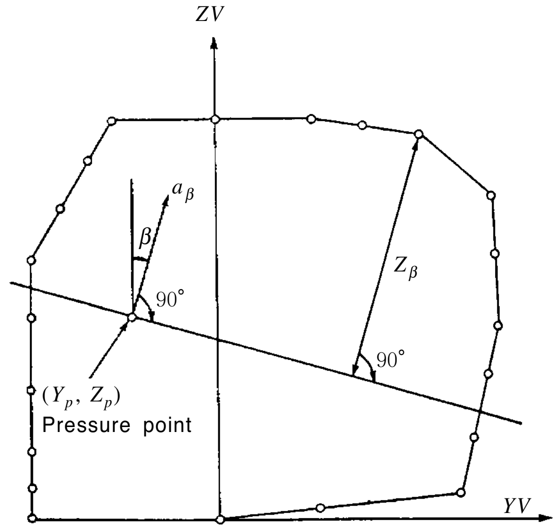


Fig. 7.5.3 Determination of Internal Pressure Heads

acceleration components in three directions need to be considered, an ellipsoid should be used instead of the ellipse in **Fig. 7.5.2.** The above formula applies only to full tanks.

3. External pressure

External design pressure loads should be based on the difference between the minimum internal pressure (maximum vacuum) and the maximum external pressure to which any portion of the tank may be subjected simultaneously.

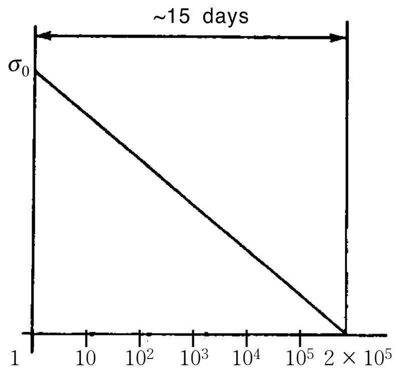
4. Dynamic loads due to ship motions

(1) The determination of dynamic loads should take account of the long-term distribution of ship motions, including the effects of surge, sway, heave, roll, pitch and yaw on irregular seas which the ship will experience during its operating life (normally taken to correspond to 10^8 wave encounters). Account may be taken of reduction in dynamic loads due to necessary speed reduction and variation of heading when this consideration has also formed part of the hull strength assessment.

(2) For design against plastic deformation and buckl ing the dynamic loads should be taken as the most probable largest loads the ship will encounte during its operating life (normally taken to correspond to a probability level of 10^{-8}). Guidance formulae for acceleration components are given in **412.**

(3) When design against fatigue is to be considered the dynamic spectrum should be determined by long-term distribution calculation based on the operating life of the ship (normally taken to correspond to 10^8 wave encounters). If simplified dynamic loading spectra are used for the estimation of the fatigue life, those should be specially considered by the Society.

(4) For practical application of crack propagation estimates, simplified load distribution over a period of 15 days may be used. Such distributions may be obtained as indicated in **Fig. 7.5.4.**



σ_0 = most probable maximum stress over the life of the ship
Response cycle scale is logarithmic; the value of 2 x 10^5 is given as an example of estimate.

Fig. 7.5.4 Simplified Load Ditribution

(5) Ships for restricted service may be given special consideration.

(6) The accelerations acting on tanks are estimated at their centre of gravity and include the following components:
vertical acceleration: motion accelerations of heave, pitch and, possibly, roll (normal to the ship base);
transverse acceleration: motion accelerations of sway, yaw and roll; and gravity component of roll;
longitudinal acceleration: motion accelerations of surge and pitch; and gravity component of pitch.

5. Sloshing loads

(1) When partial filling is contemplated, the risk of significant loads due to sloshing induced by any of the ship motions referred to in **Par 4** (6) should be considered.

(2) When risk of significant sloshing-induced loads in found to be present, special tests and calculations should be required.

6. Thermal loads

(1) Transient thermal loads during cooling down periods should be considered for tanks intended for cargo temperatures below -55°C.

(2) Stationary thermal loads should be considered for tanks where design supporting arrangement and operating temperature may given rise to significant thermal stresses.

7. Loads on supports

The loads on supports are covered by **406.**

404. Structural analyses (IGC Code 4.4)

1. Integral tanks

The structural analysis of integral tanks should be in accordance with the requirements of **Pt 3, Ch 15** of the Rules. The tank boundary scantlings should meet at least the requirements for deep tanks taking into account the internal pressure as indicated in **403. 2,** but the resulting scantlings should not be less than normally required by such standards.

2. Membrane tanks

(1) For membrane tanks, the effects of all static and dynamic loads should be considered to determine the suitability of the membrane and of the associated insulation with respect to plastic deformation and fatigue.

(2) Before approval is given, a model of both the primary and secondary barriers, including corners and joints, should normally be tested to verify that they will withstand the expected combined strains due to static, dynamic and thermal loads. Test conditions should represent the most extreme service conditions the cargo containment system will see in its life. Material tests should ensure that ageing is not liable to prevent the materials from carrying out their intended function.

(3) For the purpose of the test referred to in (2), a complete analysis of the particular motions,

accelerations and response of ships and cargo containment systems should be performed, unless these data are available from similar ships.

(4) Special attention should be paid to the possible collapse of the membrane due to an overpressure in the interbarrier space, to a possible vacuum in the cargo tank, to the sloshing effects and to hull vibration effects.

(5) A structural analysis of the hull should be to the satisfaction of the Society, taking into account the internal pressure as indicated in **403. 2.** Special attention, however, should be paid to deflections of the hull and their compatibility with the membrane and associated insulation. Inner hull plating thickness should meet at least the requirements of **Pt 3, Ch 15** of the Rules for deep tanks taking into account the internal pressure as indicated in **403. 2.** The allowable stress for the membrane, membrane-supporting material and insulation should be determined in each particular case.

3. Semi-membrane tanks

A structural analysis should be performed in accordance with the requirements for membrane tanks or independent tanks as appropriate, taking into account the internal pressure as indicated in **403. 2.**

4. Type A independent tanks

(1) A structural analysis should be performed to the satisfaction of the Society taking into account the internal pressure as indicated in **403. 2.** The cargo tank plating thickness should meet at least the requirements of **Pt 3, Ch 15** of the Rules for deep tanks taking into account the internal pressure as indicated in **403. 2** and any corrosion allowance required by **405. 2.**

(2) For parts such as structure in way of supports not otherwise covered by the requirements of **Pt 3, Ch 15** of the Rules, stresses should be determined by direct calculations, taking into account the loads referred to in **403.** as far as applicable, and the ship deflection in way of supports.

5. Type B independent tanks

For tanks of this type the following applies:

(1) The effects of all dynamic and static loads should be used to determine the suitability of the structure with respect to:
- plastic deformation
- buckling
- fatigue failure
- crack propagation

Statistical wave load analysis in accordance with **403. 4,** finite element analysis or similar methods and fracture mechanics analysis or an equivalent approach, should be carried out.

(2) A three-dimensional analysis should be carried out to evaluate the stress levels contributed by the ship's hull. The model for this analysis should include the cargo tank with its supporting and keying system as well as a reasonable part of the hull.

(3) A complete analysis of the particular ship accelerations and motions in irregular waves and of the response of the ship and its cargo tanks to these forces and motions should be performed unless these data are available from similar ships.

(4) A buckling analysis should consider the maximum construction tolerances.

(5) Where deemed necessary by the Society, model tests may be required to determine stress concentration factors and fatigue life of structural elements.

(6) The cumulative effect of the fatigue load should comply with:

$$\sum \frac{n_i}{N_i} + \frac{10^3}{N_j} \le C_w$$

where:

n_i = number of stress cycles at each stress level during the life of the ship

N_i = number of cycles to fracture for the respective stress level according to the Wöhler (S-N) curve

N_j = number of cycles to fracture for the fatigue loads due to loading and unloading

C_w should be less than or equal to 0.5, except that the Society may give special consideration to the use of a value greater than 0.5 but not greater than 1.0, dependent on the test procedure and data used to establish the Wöhler (S-N) curve.

6. Type C independent tanks

(1) Scantlings based on internal pressure should be calculated as follows:

(a) The thickness and form of pressure-containing parts of pressure vessels under internal pressure, including flanges should be determined according to the requirements of **Pt 5, Ch 5** of the Rules. These calculations in all cases should be based on generally accepted pressure vessel design theory, Openings in pressure-containing parts of pressure vessels should be reinforced in accordance with the requirements of **Pt 5, Ch 5** of the Rules.

(b) The design liquid pressure defined in **403. 2** should be taken into account in the above calculations.

(c) The welded joint efficiency factor to be used in the calculation according to (a) should be 0.95 when the inspection and the non-destructive testing referred to in

410. 9 are carried out. This figure may be increased up to 1.0 when account is taken of other considerations, such as the material used, type of joints, welding procedure and type of loading. For process pressure vessels the Society may accept partial non-destructive examinations, but not less than those of **410. 9** (2) (b) depending on such factors as the material used, the design temperature, the nil ductility transition temperature of the material as fabricated, the type of joint and welding procedure, but in this case an efficiency factor of not more than 0.85 should be adopted. For special materials, the above-metioned factors should be reduced depending on the specified mechanical properties of the welded joint.

(2) Buckling criteria should be as follows:

(a) The thickness and form of pressure vessels subject to external pressure and other loads causing compressive stresses should be to a standard acceptable to the Society. These calculations in all cases should be based on generally accepted pressure vessel buckling theory and should adequately account for the difference in theoretical and actual buckling stress as a result of plate edge misalignment, ovality and deviation from true circular form over a specified arc or chord length.

(b) The design external pressure P_e used for verifying the buckling of the pressure vessels should not be less than that given by:

$$P_e = P_1 + P_2 + P_3 + P_4 \quad \text{(MPa)}$$

where:

P_1 = setting value of vacuum relief valves. For vessels not fitted with vacuum relief valves P_1 should be specially considered, but should not in general be taken as less than 0.025 MPa.

P_2 = the set pressure of the pressure relief valves for completely closed spaces containing pressure vessels or parts of pressure vessels; elsewhere P_2 = 0.

P_3 = compressive actions in the shell due to the weight and contraction of insulation, weight of shell, including corrosion allowance, and other miscellaneous external pressure loads to which the pressure vessel may be subjected. These include, but are not limited to, weight of domes, weight of towers and piping, effect of product in the partially filled condition, accelerations and hull deflection. In addition the local effect of external or internal pressure or both should be taken into account.

P_4 = external pressure due to head of water for pressure vessels or part of pressure vessels on exposed decks; elsewhere P_4 = 0.

(3) Stress analysis in respect of static and dynamic loads should be performed as follows:

(a) Pressure vessel scantlings should be determined in accordance with (1) and (2).

(b) Calculations of the loads and stresses in way of the supports and the shell attachment of the support should be made. Loads referred to in **403.** should be used, as applicable. Stresses in way of the supports should be to a standard acceptable to the Society. In special cases a fatigue analysis may be required by the Society.

(c) If required by the Society, secondary stresses and thermal stresses should be specially considered.

(4) For pressure vessels, the thickness calculated according to (1) or the thickness required by (2) plus the corrosion allowance, if any, should be considered as a minimum without any negative tolerance.

(5) For pressure vessels, the minimum thickness of shell and heads including corrosion allowance, after forming, should not be less than 5mm for carbon-manganese steels and nickel steels, 3mm for austenitic steels or 7mm for aluminium al!oys.

7. Internal insulation tanks

(1) The effects of all static and dynamic loads should be considered to determine the suitability of the tank with respect to:

- fatigue failure
- crack propagation from both free and supported surfaces
- adhesive and cohesive strength
- compressive, tensile and shear strength.

Statistical wave load analysis in accordance with **403. 4,** finite element analysis or similar methods and fracture mechanics analysis or an equivalent approach should be carried out.

(2) (a) Special attention should be given to crack resistance and to deflections of the inner hull or independent tank structure and their compatibility with the insulation materials. A three-dimensional structural analysis should be carried out to the satisfaction of the Society. This analysis is to evaluate the stress levels and deformations contributed either by the inner hull or by the independent tank structure or both and should also take into account the internal pressure as indicated in **403. 2.** Where water ballast spaces are adjacent to the inner hull forming the supporting structure of the internal insulation tank, the analysis should take account of the dynamic loads caused by water ballast under the influence of ship motions.

(b) The allowable stresses and associated deflections for the internal insulation tank and the inner hull structure or independent tank structure should be determined in each particular case.

(c) Thicknesses of plating of the inner hull or of an independent tank should at least comply with the requirements of Recognized Standards, taking into account the internal pressure as indicated in **403. 2.** Tanks constructed of plane surfaces should at least comply with the requirements of **Pt 3, Ch 15** of the Rules for deep tanks.

(3) A complete analysis of the response of ship, cargo and any ballast to accelerations and motions in irregular waves of the particular ship should be performed to the satisfaction of the Society unless such analysis is available for a similar ship.

(4) (a) In order to confirm the design principles, prototype testing of composite models including structural elements should be carried out under combined effects of static, dynamic and thermal loads.

(b) Test conditions should represent the most extreme service conditions the cargo containment system will be exposed to during the lifetime of the ship, including thermal cycles. For this purpose, 400 thermal cycles are considered to be a minimum, based upon 19 round voyages per year; where more than 19 round voyages per year are expected, a higher number of thermal cycles will be required. These 400 thermal cycles may be divided into 20 full cycles (cargo temperature to 45°C) and 380 partial cycles (cargo temperature to that temperature expected to be reached in the ballast voyage).

(c) Models should be representative of the actual construction including corners, joints, pump mounts, piping penetrations and other critical areas, and should take into account variations in any material properties, workmanship and quality control.

(d) Combined tension and fatigue tests should be carried out to evaluate crack behaviour of the insulation material in the case where a through crack develops in the inner hull or independent tank structure. In these tests, where applicable the crack area should be subjected to the maximum hydrostatic pressure of the ballast water.

(5) The effects of fatigue loading should be determined in accordance with **Par 5** (6) or by an equivalent method.

(6) For internal insulation tanks, repair procedures should be developed during the prototype testing programme for both the insulation material and the inner hull or the independent tank structure.

405. Allowable stresses and corrosion allowances (IGC Code 4.5)

1. Allowable stresses

(1) For integral tanks, allowable stresses should normally be those given for hull structure in the requirements of **Pt 3, Ch 1, 206.** of the Rules.

(2) For membrane tanks, reference is made to the requirements of **404. 2.** (5).

(3) For type A independent tanks primarily constructed of plane surfaces, the stresses for primary and secondary members (stiffeners, webframes, stringers, girders) when calculated by classical analysis procedures should not exceed the lower of $R_m/2.66$ or $R_e/1.33$ for carbon-manganese steels and aluminium alloys, where R_m and R_e are defined in (7). However, if detailed calculations are carried out for the primary members, the equivalent stress σ_c as defined in (8) may be increased over that indicated above to a stress acceptable to the Society; calculations should take into account the effects of bending, shear, axial and torsional deformation as well as the hull/cargo tank interaction forces due to the deflection of the double bottom and cargo tank bottoms.

(4) For type B independent tanks, primarily constructed of bodies of revolution, the allowable stresses should not exceed:

$$\sigma_m \le f$$
$$\sigma_L \le 1.5f$$
$$\sigma_b \le 1.5F$$
$$\sigma_L+\sigma_b \le 1.5F$$
$$\sigma_m+\sigma_b \le 1.5F$$

where:

σ_m = equivalent primary general membrane stress
σ_L = equivalent primary local membrane stress
σ_b = equivalent primary bending stress

f = the lesser of R_m/A or R_e/B

F = the lesser of R_m/C or R_e/D

with R_m and R_e as defined in (7). With regard to the stresses σ_m, σ_L and σ_b see also the definition of stress categories in **413.** The values of A, B, C and D should be shown on the International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk and should have at least the minimum values of **Table 7.5.1.**

(5) For type B independent tanks, primarily constructed of plane surfaces, the Society may require compliance with additional or other stress criteria.

(6) For type C independent tanks the maximum allowable membrane stress to be used in cal-

culation according to **404. 6** (1) (a) should be the lower of:

R_m/A or R_e/B

where:

R_m and R_e are as defined in (7).

The values of A and B should be shown on the International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk, and should have at least the minimum values indicated in the **Table 7.5.1.**

Table 7.5.1 Values of A, B, C and D

	Nickel steels and carbon-manganese steels	Austenitic steels	Aluminium alloys
A	3	3.5	4
B	2	1.6	1.5
C	3	3	3
D	1.5	1.5	1.5

(7) For the purpose of (3), (4) and (6) the following apply:

(a) R_e = specified minimum yield stress at room temperature (N/mm^2). If the stress strain curve does not show a defined yield stress, the 0.2% proof stress applies.

R_m = specified minimum tensile strength at room temperature (N/mm^2).

For welded connections in aluminium alloys the respective values of R_e or R_m in annealed conditions should be used.

(b) The above properties should correspond to the minimum specified mechanical properties of the material, including the weld metal in the as-fabricated condition. Subject to special consideration by the Society, account may be taken of enhanced yield stress and tensile strength at low temperature. The temperature on which the material properties are based should be shown on the International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk.

(8) The equivalent stress σ_c (von Mises, Huber) should be determined by:

$$\sigma_c = \sqrt{\sigma_x^2 + \sigma_y^2 - \sigma_x\sigma_y + 3\tau_{xy}^2}$$

where:

σ_x = total normal stress in x-direction

σ_y = total normal stress in y-direction

τ_{xy} = total shear stress in x-y plane.

(9) When the static and dynamic stresses are calculated separately and unless other methods of calculation are justified, the total stresses should be calculated according to:

$$\sigma_x = \sigma_{x \cdot st} \pm \sqrt{\Sigma\,(\sigma_{x \cdot dyn})^2}$$

$$\sigma_y = \sigma_{y \cdot st} \pm \sqrt{\Sigma\,(\sigma_{y \cdot dyn})^2}$$

$$\tau_{xy \cdot} = \tau_{xy \cdot st} \pm \sqrt{\Sigma\,(\tau_{xy \cdot dyn})^2}$$

where:

$\sigma_{x \cdot st}$, $\sigma_{y \cdot st}$ and $\tau_{xy \cdot st}$ = static stresses

$\sigma_{x \cdot dyn}$, $\sigma_{y \cdot dyn}$ and $\tau_{xy \cdot dyn}$ = dynamic stresses

all determined separately from acceleration components and hull strain components due to deflection and torsion.

(10) For internal insulation tanks, reference is made to the requirements of **404. 7** (2).

(11) Allowable stresses for materials other than those covered by **Sec 6** should be subject to approval by the Society in each case.

(12) Stresses may be further limited by fatigue analysis, crack propagation analysis and buckling criteria.

2. Corrosion allowances

(1) No corrosion allowance should generally be required in addition to the thickness resulting from the structural analysis. However, where there is no environmental control around the cargo tank, such as inerting, or where the cargo is of a corrosive nature, the Society may require a suitable corrosion allowance.

(2) For pressure vessels no corrosion allowance is generally required if the contents of the pressure vessel are non-corrosive and the external surface is protected by inert atmosphere or by an appropriate insulation with an approved vapour barrier. Paint or other thin coatings should not be credited as protection. Where special alloys are used with acceptable corrosion resistance, no corrosion allowance should be required. If the above conditions are not satisfied, the scantiings calculated according to **404. 6** should be increased as appropriate.

406. Supports (IGC Code 4.6)

1. Cargo tanks should be supported by the hull in a manner which will prevent bodily movement of the tank under static and dynamic loads while allowing contraction and expansion of the tank under temperature variation sand hull deflections without undue stressing of the tank and of the hull.

2. The tanks with supports should also be designed for a static angle of heel of 30° without exceeding allowable stresses given in **405. 1.**

3. The supports should be calculated for the most probable largest resulting acceleration, taking into account rotational as well as translational effects. This acceleration in a given direction may be determined as shown in **Fig. 7.5.2.** The half axes of the **"acceleration ellipse"** should be determined according to **403. 4** (2).

4. Suitable supports should be provided to withstand a collision force acting on the tank corresponding to one half the weight of the tank and cargo in the forward direction and one quarter the weight of the tank and cargo in the aft direction without deformation likely to endanger the tank structure.
5. The loads mentioned in **Pars 2** and **4** need not be combined with each other or with wave-induced loads
6. For independent tanks and, where appropriate, for membrane and semi-membrane tanks, provision should be made to key the tanks against the rotational effects referred to in **Par 3.**
7. Antiflotation arrangements should be provided for independent tanks. The antiflotation arrangements should be suitable to withstand an upward force caused by an empty tank in a hold space flooded to the summer load draught of the ship, without plastic deformation likely to endanger the hull structure.

407. Secondary barrier (IGC Code 4.7)

1. Where the cargo temperature at atmospheric pressure is below -10°C, a secondary barrier should be provided when required by **Par 3** to act as a temporary containment for any envisaged leakage of liquid cargo through the primary barrier.
2. Where the cargo temperature at atmospheric pressure is not below -55°C, the hull structure may act as a secondary barrier. In such a case:
   (1) the hull material should be suitable for the cargo temperature at atmospheric pressure as required by **409. 2**; and
   (2) the design should be such that this temperature will not result in unacceptable hull stresses.
3. Secondary barriers in relation to tank types should normally be provided in accordance with **Table 7.5.2.** For tanks which differ from the basic tank types as defined in **402.** the secondary barrier requirements should be decided by the Society in each case.
4. The secondary barrier should be so designed that:
   (1) it is capable of containing any envisaged leakage of liquid cargo for a period of 15 days, unless different requirements apply for particular voyages, taking into account the load spectrum referred to in **403. 4** (4);
   (2) it will prevent lowering of the temperature of the ship structure to an unsafe level in the case of leakage of the primary barrier as indicated in **408. 2**; and
   (3) the mechanism of failure for the primary barrier does not also cause the failure of the secondary barrier and vice versa.
5. The secondary barrier should fulfil its functions at a static angle of heel of 30°.

Table 7.5.2 Secondary Barriers in Relation to Tank Types

Cargo temperature at atmospheric pressure	-10°C and above	Below -10°C down to -55°C	Below -55°C
Basic tank type	No secondary barrier required	Hull may act as secondary barrier	Separate secondary barrier where required
Integral		Tank type not normally allowed(1)	
Membrane		Complete secondary barrier	
Semi-membrane		Complete secondary barrier(2)	
Independent			
Type A		Complete secondary barrier	
Type B		Partial secondary barrier	
Type C		No secondary barrier required	
Internal insulation			
Type 1		Complete secondary barrier	
Type 2		Complete secondary barrier is incorporated	

Notes:
(1) A complete secondary barrier should normally be required if cargoes with a temperature at atmospheric pressure below -10° are permitted in accordance with **402.1**(3).
(2) In the case of semi-membrane tanks which comply in all respects with the requirements applicable to type independent tanks, except for the manner of support the Society may, after special consideration, accept a partial secondary barrier.

6. (1) Where a partial secondary barrier is required, its extent should be determined on the basis of cargo leakage corresponding to the extent of failure resulting from the load spectrum referred to in **403. 4** (4) after the initial detection of a primary leak. Due account may be taken of liquid evaporation, rate of leakage, pumping capacity and other relevant factors. In all cases, however, the inner bottom adjacent to cargo tanks should be protected against liquid cargo.
   (2) Clear of the partial secondary barrier, provision such as a spray shield should be made to deflect any liquid cargo down into the space between the primary and secondary barriers and to keep the temperature of the hull structure to a safe level.
7. The secondary barrier should be capable of being periodically checked for its effectiveness, by means of a pressure/vacuum test, a visual inspection or another suitable method acceptable to the Society. The method should be submitted to the Society for approval.

408. Insulation (IGC Code 4.8)

1. Where a product is carried at a temperature below -10°C suitable insulation should be provided to

ensure that the temperature of the hull structure does not fall below the minimum allowable design temperature given in **Sec 6** for the grade of steel concerned, as detailed in **409.,** when the cargo tanks are at their design temperature and the ambient temperatures are 5°C for air and 0°C for seawater. These conditions may generally be used for world-wide service. However, higher values of the ambient temperatures may be accepted by the Society for ships operated in restricted areas. Conversely, lesser values of the ambient temperatures may be fixed by the Society for ships trading occasionally or regularly to areas in latitudes where such lower temperatures are expected during the winter months. The ambient temperatures used in the design should be shown on the International Certificate of Fitness for the Carriage of Liquefied Gases on Bulk.

2. Where a complete or partial secondary barrier is required, calculations should be made with the assumptions in **Par 1** to check that the temperature of the hull structure does not fall below the minimum allowable design temperature given in **Sec 6** for the grade of steel concerned, as detailed in **409.** The complete or partial secondary barrier should be assumed to be at the cargo temperature at atmospheric pressure.

3. Calculations required by **Pars 1** and **2** should be made assuming still air and still water, and except as permitted by **Par 4,** no credit should be given for means of heating. In the case referred to in **Par 2,** the cooling effect of the rising boil-off vapour from the leaked cargo should be considered in the heat transmission studies. For structural members connecting inner and outer hulls, the mean temperature may be taken for determining the steel grade.

4. In all cases referred to in **Pars 1** and **2** and for ambient temperature conditions of 5°C for air and 0°C for seawater, approved means of heating transverse hull structural material may be used to ensure that the temperatures of this material do not fall below the minimum allowable values. If lower ambient temperatures are specified, approved means of heating may also be used for longitudinal hull structural material, provided this material remains suitable for the temperature conditions of 5°C for air and 0°C for seawater without heating. Such means of heating should comply with the following requirements:

(1) sufficient heat should be available to maintain the hull structure above the minimum allowable temperature in the conditions referred to in **Pars 1** and **2**;
(2) the heating system should be so arranged that, in the event of a failure in any part of the system, stand-by heating could be maintained equal to not less than 100% of the theoretical heat load;
(3) the heating system should be considered as an essential auxiliary; and
(4) the design and construction of the heating system should be to the satisfaction of the Society.

5. In determining the insulation thickness, due regard should be paid to the amount of acceptable boil-off in association with the reliquefaction plant on board, main propulsion machinery or other temperature control system.

409. Materials (IGC Code 4.9)

1. The shell and deck plating of the ship and all stiffeners attached thereto should be in accordance with the requirements of **Pt 3** of the Rules, unless the calculated temperature of the material in the design condition is below -5°C due to the effect of the low temperature cargo, in which case the material should be in accordance with **Table 7.5.7** assuming the ambient sea and air temperature of 0°C and 5°C respectively. In the design condition, the complete or partial secondary barrier should be assumed to be at the cargo temperature at atmospheric pressure and for tanks without secondary barriers, the primary barrier should be

Table 7.5.3

PLATES, PIPES (SEAMLESS AND WELDED)(1), SECTIONS AND FORGINGS FOR CARGO TANKS AND PROCESS PRESSURE VESSELS FOR DESIGN TEMPERATURES NOT LOWER THAN 0°C.	
CHEMICAL COMPOSITION AND HEAT TREATMENT CARBON-MANGANESE STEEL Fully killed Fine grain steel where thickness exceeds 20 mm Small additions of alloying elements by agreement with the Society Composition limits to be approved by the Society Normalized, or quenched and tempered(2)	
TENSILE AND TOUGHNESS (IMPACT) TEST REQUIREMENTS	
Plates	Each "piece" to be tested
Sections and forgings	Batch test
Tensile properties	Specified minimum yield stress not to exceed 410N/mm^2 (3)
CHARPY V-NOTCH TEST	
Plates	Transverse test pieces. Minimum average energy value (E) 27 J
Sections and forgings	Longitudinal test pieces. Minimum average energy value (E) 41 J
Test temperature	Thickness t (mm) / Test temperature (°C)
	$t \leq 20$ / 0
	$20 < t \leq 40$ / -20
Notes: (1) For seamless pipes and fittings normal practice applies. The use of longitudinally and spirally welded pipes should be specially approved by the Society. (2) A controlled rolling procedure may be used as an alternative to normalizing or quenching and tempering, subject to special approval by the Society. (3) Materials with specified minimum yield stress exceeding 410 N/mm^2 may be specially approved by the Society. For these materials, particular attention should be given to the hardness of the weld and heat affected zone.	

assumed to be at the cargo temperature.

2. Hull material forming the secondary barrier should be in accordance with **Table 7.5.4.** Metallic materials used in secondary barriers not forming part of the hull structure should be in accordance with **Table 7.5.4** or **7.5.5** as applicable. Insulation materials forming a secondary barrier should comply with the requirements of **Par 7.** Where the secondary barrier is formed by the deck or side shell plating, the material grade required by **Table 7.5.4** should be carried into the adjacent deck or side shell plating, where applicable, to a suitable extent.

3. Materials used in the construction of cargo tanks should be in accordance with **Table 7.5.3, 7.5.4** or **7.5.5.**

4. Materials other than those referred to in **Pars 1, 2** and **3** used in the construction of the ship which are subject to reduced temperature due to the cargo and which do not form part of the secondary barrier should be in accordance with **Table 7.5.7** for temperatures as determined by **408.** This includes inner bottom plating, longitudinal bulkhead plating, transverse bulkhead plating, floors, webs, stringers and all attached stiffening members.

5. The insulation materials should be suitable for loads which may be imposed on them by the adjacent structure.

6. Where applicable, due to location or environmental conditions, insulation materials should have suitable properties of resistance to fire and flame spread and should be adequately protected against penetration of water vapour and mechanical damage.

7. (1) Materials used for thermal insulation should be tested for the following properties as applicable, to ensure that they are adequate for the intended service:
(a) compatibility with the cargo
(b) solubility in the cargo

Table 7.5.4

PLATES, SECTIONS AND FORGINGS [1] FOR CARGO TANKS, SECONDARY BARRIERS AND PROCESS PRESSURE VESSELS FOR DESIGN TEMPERATURES BELOW 0°C AND DOWN TO -55°C
Maximum thickness 25 mm[2]

CHEMICAL COMPOSITION AND HEAT TREATMENT
CARBON-MANGANESE STEEL Fully killed Aluminium treated fine grain steel

Chemical composition (ladle analysis)

C	Mn	Si	S	P
0.16% max.[3]	0.70 -1.60%	0.10-0.50%	0.035% max.	0.035% max.

Optional additions: Alloys and grain refining elements may be generally in accordance with the following:

Ni	Cr	Mo	Cu	Nb	V
0.80% max.	0.25% max.	0.08% max.	0.35% max	0.05% max.	0.10% max.

Normalized or quenched and tempered[4]

TENSILE AND TOUGHNESS (IMPACT) TEST REQUIREMENTS

Plates	Each “piece” to be tested
Sections and forgings	Batch test
CHARPY V-NOTCH TEST	Test temperature 5°C below the design temperature or -20°C whichever is lower
Plates	Transverse test pieces. Minimum average energy value (E) 27 J
Sections and forgings[1]	Longitudinal test pieces. Minimum average energy value (E) 41 J

Notes:
(1) The Charpy V-notch and chemistry requirements for forgings may be specially considered by the Society.
(2) For material thickness of more than 25 mm, Charpy V-notch tests should be conducted as follows:

Material thickness (mm)	Test temperature (°C)
$25 < t \leq 30$	10° below design temperature or -20° whichever is lower
$30 < t \leq 35$	15° below design temperature or -20° whichever is lower
$35 < t \leq 40$	20° below design temperature

The impact energy value should be in accordance with the table for the applicable type of test specimen. For material thickness of more than 40 mm, the Charpy V-notch values should be specially considered.
Materials for tanks and parts of tanks which are completely thermally stress relieved after welding may be tested at a temperature 5°C below design temperature or-20°C whichever is lower.
For thermally stress relieved reinforcements and other fittings, the test temperature should be the same as that required for the adjacent tank-shell thickness.
(3) By special agreement with the Society, the carbon content may be increased to 0.18% rnaximum provided the design temperature is not lower than -40°C.
(4) A controlled rolling procedure may be used as an alternative to normalizing or quenching and tempering, subject to special approval by the Society.
Guidance: For materials exceeding 25 mm in thickness for which the test temperature is -60°C or lower, the application of specially treated steels or steels in accordance with **Table 7.5.5** may be necessary.

Table 7.5.5

PLATES, SECTIONS AND FORGINGS[1] FOR CARGO TANKS, SECONDARY BARRIERS AND PROCESS PRESSURE VESSELS FOR DESIGN TEMPERATURES BELOW -55°C AND DOWN TO -165°C[2]
Maximum thickness 25 *mm*[3]

Minimum design temp. (°C)	Chemical composition[4] and heat treatment	Impact test temp.(°C)
-60	1.5% nickel steel-normalized	-65
-65	2.25% nickel steel-normalized or normalized and tempered[5]	-70
-90	3.5% nickel steel-normalized or normalized and tempered[5]	-95
-105	5% nickel steel-normalized or normalized and tempered[5][6]	-110
-165	9% nickel steel-double normalized and tempered or quenched and tempered	-196
-165	Austenitic steels, such as types 304, 304L, 316, 316L, 321 and 347 solution treated[7]	-196
-165	Aluminium alloys; such as type 5083 annealed	Not required
-165	Austenitic Fe-Ni alloy (36% nickel).Heat treatment as agreed	Not required

TENSILE AND TOUGHNESS (IMPACT) TEST REQUIREMENTS

Plates	Each "piece" to be tested
Sections and forgings	Batch test
CHARPY V-NOTCH TEST PLATES	Transverse test pieces. Minimum average energy value (E) 27 *J*
Sections and forgings	Longitudinal test pieces. Minimum average energy value (E) 41 *J*

Notes:
(1) The impact test required for forgings used in critical applications should be subject to special consideration by the Society.
(2) The requirements for design temperatures below -165°C should be specially agreed with the Society.
(3) For materials 1.5% Ni, 2.25% Ni, 3.5% Ni and 5% Ni, with thicknesses greater than 25 *mm*, the impact tests should be conducted as follows:

Material thickness (*mm*)	Test temperature (°C)
$25 < t \leq 30$	10°C below design temperature
$30 < t \leq 35$	15°C below design temperature
$35 < t \leq 40$	20°C below design temperature

In no case should the test temperature be above that indicated in this table. The energy value should be in accordance with this table for the applicable type of test specimen. For material thickness of more than 40 *mm*, the Charpy V-notch values should be specially considered. For 9% Ni, austenitic stainless steels and aluminium alloys, thicknesses greater than 25 *mm* may be used at the discretion of the Society.
(4) The chemical composition limits should be approved by the Society.
(5) A lower minimum design temperature for quenched and tempered steels may be specially agreed with the Society.
(6) A specially heat treated 5% nickel steel, for example triple heat treated 5% nickel steel, may be used down to -165°C upon special agreement with the Society, provided that the impact tests are carried out at -196°C.
(7) The impact test may be omitted subject to agreement with the Society.

(c) absorption of the cargo
(d) shrinkage
(e) ageing
(f) closed cell content
(g) density
(h) mechanical properties
(i) thermal expansion
(j) abrasion
(k) cohesion
(l) thermal conductivity
(m) resistance to vibrations
(n) resistance to fire and flame spread

(2) In addition to meeting the above requirements, insulation materials which form part of the cargo containment as defined in **402. 5** should be tested for the following properties after simulation of ageing and thermal cycling to ensure that they are adequate for the intended service:
(a) bonding (adhesive and cohesive strength)
(b) resistance to cargo pressure
(c) fatigue and crack propagation properties
(d) compatibility with cargo constituents and any other agent expected to be in contact with the insulation in normal service.
(e) where applicable the influence of presence of water and water pressure on the insulation properties should be taken into account.
(f) gas de-absorbing.

(3) The above properties, where applicable, should be tested for the range between the expected maximum temperature in service and 5°C below the minimum design temperature, but not lower

Teble 7.5.6

PIPES (SEAMLESS AND WELDED)(1), FORGINGS(2) AND CASTINGS(2) FOR CARGO AND PROCESS PIPING FOR DESIGN TEMPERATURES BELOW 0°C AND DOWN TO -165°C(3)
Maximum thickness 25 *mm*

Minimum design temp. (°C)	Chemical composition(5) and heat treatment	Impact test	
		Test temp.(°C)	Minimum average energy (E)(J)
-55	Carbon-manganese steel. Fully killed fine grain. Normalized or as agreed(6)	(4)	27
-65	2.25% nickel steel. Normalized or normalized and tempered(6)	-70	34
-90	3.5% nickel steel. Normalized or normalized and tempered(6)	-95	34
-165	9% nickel steel(7). Double normalized and tempered or quenched and tempered	-196	41
	Austenitic steels, such as types 304, 304L, 316, 316L, 321 and 347. Solution treated(8)	-196	41
	Aluminium alloys, such as type 5083 annealed	-	Not required

TENSILE AND TOUGHNESS (IMPACT) TEST REQUIREMENTS
Each batch to be tested
IMPACT TEST Longitudinal test pieces

Notes:
(1) The use of longitudinally or spirally welded pipes should be specially approved by the Society.
(2) The requirements for forgings and castings may be subject to special consideration by the Society.
(3) The requirements for design temperatures below-165°C should be specially agreed with the Society.
(4) The test temperature should be 5°C below the design temperature or -20°C whichever is lower.
(5) The composition limits should be approved by the Society.
(6) A lower design temperature may be specially agreed with the Society for quenched and tempered materials.
(7) This chemical composition is not suitable for castings.
(8) Impact tests may be omitted subject to agreement with the Society.

Table 7.5.7

PLATES AND SECTIONS FOR HULL STRUCTURES REQUIRED BY **409. 1** AND **409. 4**

Minimum design temperature of hull structure (°C)	Maximum thickness (*mm*) for steel grades in accordance with **601. 9**						
	A	B	D	E	AH	DH	EH
0 and above(1) -5 and above(2)	Normal practice						
down to -5	15	25	30	50	25	45	50
down to -10	×	20	25	50	20	40	50
down to -20	×	×	20	50	×	30	50
down to -30	×	×	×	40	×	20	40
Below -30	In accordance with **Table 7.5.4** except that the thickness limitation given in **Table 7.5.4** and in footnote (2) of that table does not apply.						

Notes: “x'' means steel grade not to be used.
(1) For the purpose of **409. 4**
(2) For the purpose of **409. 1**

than -196°C.

8. The procedure for fabrication, storage, handling, erection, quality control and control against harmful exposure to sunlight of insulation materials should be to the satisfaction of the Society.

9. Where powder or granulated insulation is used, the arrangements should be such as to prevent compacting of the material due to vibrations. The design should incorporate means to ensure that the material remains sufficiently buoyant to maintain the required thermal conductivity and also prevent any undue increase of pressure on the cargo containment system.

410. Construction and testing (IGC Code 4.10)

1. (1) All welded joints of the shells of independent tanks should be of the butt weld, full penetration type. For dome-to-shell connections, the Society may approve tee welds of the full penetration type. Except for small penetrations on domes, nozzle welds are also generally to be designed with full penetration.

(2) Welding joint details for type C independent tanks should be as follows:

(a) All longitudinal and circumferential joints of pressure vessels should be of butt welded, full penetration, double vee or single vee type. Full penetration butt welds should be obtained by double welding or by the use of backing rings. If used, backing rings should be removed, unless specifically approved by the Society for very small process pressure vessels. Other edge preparations may be allowed by the Society depending on the results of the tests carried out at the approval of the welding procedure.

(b) The bevel preparation of the joints between the pressure vessel body and domes and between domes and relevant fittings should be designed according to a standard for pressure vessels acceptable to the Society. All welds connecting nozzles, domes or other penetrations of the vessel and all welds connecting flanges to the vessel or nozzles should be full penetration welds extending through the entire thickness of the vessel wall or nozzle wall, unless specially approved by the Society for small nozzle diameters.

2. Workmanship should be to the satisfaction of the Society. Inspection and non-destructive testing of welds for tanks other than type C independent tanks should be in accordance with the requirements of **603. 7.**

3. For membrane tanks, quality assurance measures, weld procedure qualification, design details, materials, construction, inspection and production testing of components, should be to standards developed during the prototype testing programme.

4. For semi-membrane tanks the relevant requirements in this Article for independent tanks or for membrane tanks should be applied as appropriate.

5. (1) For internal insulation tanks, in order to ensure uniform quality of the material, quality control procedures including environmental control, application procedure qualification, corners, penetrations and other design details, materials specification, installation and production testing of components should be to standards developed during the prototype test programme.

(2) A quality control specification including maximum permissible size of constructional defects, tests and inspections during the fabrication, installation and also sampling tests at each of these stages should be to the satisfaction of the Society.

6. Integral tanks should be hydrostatically or hydropneumatically tested to the satisfaction of the Society. The test in general should be so performed that the stresses approximate, as fas as practicable, to the design stresses and that the pressure at the top of the tank corresponds at least to the MARVS.

7. In ships fitted with membrane or semi-membrane tanks, cofferdams and all spaces which may normally contain liquid and are adjacent to the hull structure supporting the membrane should be hydrostatically or hydropneumatically tested in accordance with Recognized Standards. In addition, any other hold structure supporting the membrane should be tested for tightness. Pipe tunnels and other compartments which do not normally contain liquid need not be hydrostatically tested.

8. (1) In ships fitted with internal insulation tanks where the inner hull is the supporting structure, all inner hull structure should be hydrostatically or hydropheumatically tested in accordance with Recognized Standards, taking into account the MARVS.

(2) In ships fitted with internal insulation tanks where independent tanks are the supporting structure, the independent tanks should be tested in accordance with **Par 10** (1).

(3) For internal insulation tanks where the inner hull structure or an independent tank structure acts as a secondary barrier, a tightness test of those structures should be carried out using techniques to the satisfaction of the Society.

(4) These tests should be performed before the application of the materials which will form the internal insulation tank.

9. For type C independent tanks, inspection and non-destructive testing should be as follows:

(1) Manufacture and workmanship - The tolerances relating to manufacture and workmanship such as out-of-roundness, local deviations from the true form, welded joints alignment and tapering of plates having different thicknesses, should comply with standards acceptable to the Society. The tolerances should also be related to the buckling analysis referred to in **404. 6** (2).

(2) Non-destructive testing - As far as completion and extension of non-destructive testing of welded joints are concerned, the extent of non-destructive testing should be total or partial according to standards acceptable to the Society, but the controls to be carried out should not be less than the following:

(a) Total non-destructive testing referred to in **404. 6** (1) (c):
Radiography:

butt welds 100% and

Surface crack detection:

all welds 10%;

reinforcement rings around holes, nozzles, etc. 100%.

As an alternative, ultrasonic testing may be accepted as a partial substitute for the radiographic testing, if specially allowed by the Society. In addition, the Society may require total ultrasonic testing on welding of reinforcement rings around holes, nozzles, etc.

(b) Partial non-destructive testing referred to in **404. 6** (1) (c):

Radiography:

butt welds: all welded crossing joints and at least 10% of the full length at selected positions uniformly distributed and

Surface crack detection:

reinforcement rings around holes, nozzles, etc. 100%

Ultrasonic testing:

as may be required by the Society in each instance.

10. Each independent tank should be subjected to hydrostatic or hydropneumatic test as follows:

(1) For type A independent tanks, this test should be so performed that the stresses approximate, as far as practicable, to the design stresses and that the pressure at the top of the tank corresponds at least to the MARVS. When a hydropneumatic test is performed, the conditions should simulate, as far as practicable, the actual loading of the tank and of its supports.

(2) For type B independent tanks, the test should be performed as required in (1) for type A independent tanks. In addition, the maximum primary membrane stress or maximum bending stress in primary members under test conditions should not exceed 90% of the yield strength of the material (as fabricated) at the test temperature. To ensure that this condition is satisfied, when calculations indicate that this stress exceeds 75% of the yield strength, the prototype test should be monitored by the use of strain gauges or other suitable equipment.

(3) Type C independent tanks should be tested as follows:

(a) Each pressure vessel, when completely manufactured, should be subjected to a hydrostatic test at a pressure measured at the top of the tanks, of not less than 1.5 P_0, but in no case during the pressure test should the calculated primary membrane stress at any point exceed 90% of the yield stress of the material. The definition of P_0 is given in **402. 6.** To ensure that this condition is satisfied where calculations indicate that this stress will exceed 0.75 times the yield strength, the prototype test should be monitored by the use of strain gauges or other suitable equipment in pressure vessels other than simple cylindrical and spherical pressure vessels.

(b) The temperature of the water used for the test should be at least 30°C above the nil ductility transition temperature of the material as fabricated.

(c) The pressure should be held for 2h per 25 mm of thickness but in no case less than 2h.

(d) Where necessary for cargo pressure vessels, and with the specific approval of the Society, a hydropneumatic test may be carried out under the conditions prescribed in (a), (b) and (c).

(e) Special consideration may be given by the Society to the testing of tanks in which higher allowable stresses are used, depending on service temperature. However, the requirements of (a) should be fully complied with.

(f) After completion and assembly, each pressure vessel and its related fittings should be subjected to an adequate tightness test.

(g) Pneumatic testing of pressure vessels other than cargo tanks should be considered on an individual case basis by the Society. Such testing should be permitted only for those vessels which are so designed or supported that they cannot be safely filled with water, or for those vessels which cannot be dried and are to be used in a service where traces of the testing medium cannot be tolerated .

11. All tanks should be subjected to a tightness test which may be performed in combination with the pressure test referred to in **Par 10** or separately.

12. Requirements with respect to inspection of secondary barriers should be decided by the Society in each case.

13. In ships fitted with type B independent tanks, at least one tank and its support should be instrumented to confirm stress levels unless the design and arrangement for the size of ship involved are supported by full-scale experience. Similar instrumentation may be required by the Society for type C independent tanks dependent on their configuration and on the arrangement of their supports and attachments.

14. The overall performance of the cargo containment system should be verified for compliance with the design parameters during the initial cooldown, loading and discharging of the cargo. Records of the performance of the components and equipment essential to verify the design parameters should be maintained and be available to the Society.

15. Heating arrangements, if fitted in accordance with **408. 4,** should be tested for required heat output and heat distribution.

16. The hull should be inspected for cold spots following the first loaded voyage.

17. The insulation materials of internal insulation tanks should be subjected to additional inspection in order to verify their surface conditions after the third loaded voyage of the ship, but not later than the first 6 months of the ship's service after building or a major repair work is undertaken on the internal insulation tanks.

18. For type C independent tanks, the required marking of the pressure vessel should be achieved by a method which does not cause unacceptable local stress raisers.

411. Stress relieving for type C independent tanks (IGC Code 4.11)

1. For type C independent tanks of carbon and carbon-manganese steel, post-weld heat treatment should be performed after welding if the design temperature is below -10°C. Post-weld heat treatment in all other cases and for materials other than those mentioned above should be to the satisfaction of the Society. The soaking temperature and holding time should be to the satisfaction of the Society.

2. In the case of large cargo pressure vessels of carbon or carbon-manganese steel for which it is difficult to perform the heat treatment, mechanical stress relieving by pressurizing may be carried out as an alternative to the heat treatment subject to the following conditions:

(1) Complicated welded pressure vessel parts, such as sumps or domes with nozzles, with adjacent shell plates should be heat treated before they are welded to larger parts of the pressure vessel.

(2) The mechanical stress relieving process should preferably be carried out during the hydrostatic pressure test required by the requirement in **410. 10** (3), by applying a higher pressure than the test pressure required by **410. 10** (3) (a). The pressurizing medium should be water.

(3) For the water temperature, the requirement in **410.10** (3) (b) applies.

(4) Stress relieving should be performed while the tank is supported by its regular saddles or supporting structure or, when stress relieving cannot be carried out on board, in a manner which will give the same stresses and stress distribution as when supported by its regular saddles or supporting structure.

(5) The maximum stress relieving pressure should be held for two hours per 25 mm of thickness but in no case less than two hours.

(6) The upper limits placed on the calculated stress levels during stress relieving should be the following:
- equivalent general primary membrane stress: 0.9 R_e
- equivalent stress composed of primary bending stress plus membrane stress: 1.35 R_e

where R_e is the specific lower minimum yield stress or 0.2% proof stress at test temperature of the steel used for the tank.

(7) Strain measurements will normally be required to prove these limits for at least the first tank of a series of identical tanks built consecutively. The location of strain gauges should be included in the mechanical stress relieving procedure to be submitted in accordance with **411. 2** (14).

(8) The test procedure should demonstrate that a linear relationship between pressure and strain is achieved at the end of the stress relieving process when the pressure is raised again up to the design pressure.

(9) High stress areas in way of geometrical discontinuities such as nozzles and other openings should be checked for cracks by dye penetrant or magnetic particle inspection after mechanical stress relieving. Particular attention in this respect should be given to plates exceeding 30 mm in thickness.

(10) Steels which have a ratio of yield stress to ultimate tensile strength greater than 0.8 should generally not be mechanically stress relieved. If however the yield stress is raised by a method giving high ductility of the steel, slightly higher rates may be accepted upon consideration in each case.

(11) Mechanical stress relieving cannot be substituted for heat treatment of cold formed parts of tanks if the degree of cold forming exceeds the limit above which heat treatment is required.

(12) The thickness of the shell and heads of the tank should not exceed 40 mm. Higher thicknesses may be accepted for parts which are thermally stress relieved.

(13) Local buckling should be guarded against particularly when tori-spherical heads are used for tanks and domes.

(14) The procedure for mechanical stress relieving should be submitted beforehand to the Society for approval.

412. Guidance formulae for acceleration components (IGC Code 4.12)

The following formulae are given as guidance for the components of acceleration due to ship's motions corresponding to a probability level of 10^{-8} in the North Atlantic and apply to ships with a length exceeding 50 m.

Vertical acceleration as defined in **403. 4** (6).

$$a_z = \pm a_0 \sqrt{1 + \left(5.3 - \frac{45}{L_0}\right)^2 \left(\frac{x}{L_0} + 0.05\right)^2 \left(\frac{0.6}{C_b}\right)^{1.5}}$$

Transverse acceleration as defined in **403. 4** (6).

$$a_y = \pm a_0 \sqrt{0.6 + 2.5\left(\frac{x}{L_0} + 0.05\right)^2 + K\left(1 + 0.6K\frac{z}{B}\right)^2}$$

Longitudinal acceleration as defined in **403. 4** (6).

$$a_x = \pm a_0 \sqrt{0.06 + A^2 - 0.25A}$$

with:

$$A = \left(0.7 - \frac{L_0}{1200} + 5\frac{z}{L_0}\right)\left(\frac{0.6}{C_b}\right)$$

where:

L_0 = length of the ship for determination of scantlings as defined in Recognized Standards (m)
C_b = block coefficient
B = greatest moulded breadth of the ship (m)
x = longitudinal distance (m) from amidships to the centre of gravity of the tank with contents; x is positive forward of amidships, negative aft of amidships
z = vertical distance (m) from the ship's actual water-line to the centre of gravity of tank with contents; z is positive above and negative below the waterline.

$$a_0 = 0.2\frac{V}{\sqrt{L_0}} + \frac{34 - \frac{600}{L_0}}{L_0}$$

where: V = service speed (knots)
K = 1 in general. For particular loading conditions and hull forms, determination of K according to the formula below may be necessary.
$K = 13GM/B$, where K $\geq$ 1.0 and GM = metacentric height (m)
a_x, a_y and a_z = maximum dimensionless accelerations (i.e. relative to the acceleration of gravity) in the respective directions and they are considered as acting separately for calculation purposes. a_z does not include the component due to the static weight, a_y includes the component due to the static weight in the transverse direction due to rolling and a_x includes the component due to the static weight in the longitudinal direction due to pitching.

413. Stress categories (IGC Code 4.13)

For the purpose of stress evaluation referred to in **405. 1** (4), stress categories are defined in this Article.

1. Normall stress is the component of stress normal to the plane of reference.

2. Membrane stress is the component of normal stress which is uniformly distributed and equal to the average value of the stress across the thickness of the section under consideration.

3. Bending stress is the variable stress across the thickness of the section under consideration, after the subtraction of the membrane stress.

4. Shear stress is the component of the stress acting in the plane of reference.

5. Primary stress is a stress produced by the imposed loading and which is necessary to balance the external forces and moments. The basic characteristic of a primary stress is that it is not self-limiting. Primary stresses which considerably exceed the yield strength will result in failure or at least in gross deformations.

6. Primary general membrane stress is a primary membrane stress which is so distributed in the structure that no redistribution of load occurs as a result of yielding.

7. Primary local membrane stress arises where a membrane stress produced by pressure or other mechanical loading and associated with a primary or a discontinuity effect produces excessive distortion in the transfer of loads for other portions of the structure. Such a stress is classified as a primary local membrane stress although it has some characteristics of a secondary stress. A stress region may be considered as local if:

$$S_1 \leq 0.5\sqrt{Rt}$$
$$S_2 \geq 2.5\sqrt{Rt}$$

where:

S_1 = distance in the meridional direction over which the equivalent stress exceeds 1.1 f
S_2 = distance in the meridional direction to another region where the limits for primary general membrane stress are exceeded
R = mean radius of the vessel
t = wall thickness of the vessel at the location where the primary general membrane stress limit is exceeded
f = allowable primary general membrane stress.

8. Secondary stress is a normal stress or shear stress developed by constraints of adjacent parts or by self constraint of a structure. The basic characteristic of a secondary stress is that it is self-limiting. Local yielding and minor distortions can satisfy the conditions which cause the stress to occur.

SECTION 5
Process Pressure Vessels and Liquid, Vapour, and Pressure Piping Systems

501. General (IGC Code 5.1)

1. The Society should take appropriate steps to ensure uniformity in the implementaiton and application of the provisions of this Section.

2. The requirements for type C independent tanks in **Sec 4** may also apply to process pressure vessels if required by the Society. If so required the term “pressure vessels” as used in **Sec 4** covers both type C independent tanks and process pressure vessels.

502. Cargo and process piping (IGC Code 5.2)

1. General

(1) The requirements of **502.** to **505.** apply to product and process piping including vapour piping and vent lines of safety valves or similar piping. Instrument piping not containing cargo is exempt from these requirements.

(2) Provision should be made by the use of offsets, loops, bends, mechanical expansion joints such as bellows, slip joints and ball joints or similar suitable means to protect the piping, piping system components and cargo tanks from excessive stresses due to thermal movement and from movements of the tank and hull structure. Where mechanical expansion joints are used in piping they should be held to a minimum and, where located outside cargo tanks, should be of the bellows type.

(3) Low-temperature piping should be thermally isolated from the adjacent hull structure, where necessary, to prevent the temperature of the hull from falling below the design temperature of the hull material. Where liquid piping is dismantled regularly, or where liquid leakage may be anticipated, such as at shore connections and at pump seals, protection for the hull beneath should be provided.

(4) Where tanks or piping are separated from the ship’s structure by thermal isolation, provision should be made for electrically bonding both the piping and the tanks. All gasketed pipe joints and hose connections should be electrically bonded.

(5) Suitable means should be provided to relieve the pressure and remove liquid contents from cargo loading and discharging crossover headers and cargo hoses to the cargo tanks or other suitable location, prior to disconnecting the cargo hoses.

(6) All pipelines or components which may be isolated in a liquid full condition should be provided with relief valves.

(7) Relief valves discharging liquid cargo from the cargo piping system should discharge into the cargo tanks; alternatively they may discharge to the cargo vent mast if means are provided to detect and dispose of any liquid cargo which may flow into the vent system. Relief valves on cargo pumps should discharge to the pump suction.

2. Scantlings based on internal pressure

(1) Subject to the conditions stated in **Par 4,** the wall thickness of pipes should not be less than:

$$t = \frac{t_0 + b + c}{1 - \dfrac{a}{100}} \qquad (mm)$$

where:

t_0 = theoretical thickness (mm)

$$t_0 = \frac{PD}{2K \cdot e + P}$$

with:

P = design pressure (MPa) referred to in **Par 3**

D = outside diameter (mm)

K = allowable stress (N/mm^2) referred to in **Par 4**

e = efficiency factor equal to 1.0 for seamless pipes and for longitudinally or spirally welded pipes, delivered by approved manufacturers of welded pipes, which are considered equivalent to seamless pipes when non-destructive testing on welds is carried out in accordance with Recognized Standards. In other cases an efficiency factor of less than 1.0, in accordance with recognized standards, may be required depending on the manufacturing process.

b = allowance for bending (mm). The value of b should be chosen so that the calculated stress in the bend, due to internal pressure only, does not exceed the allowable stress. Where such justification is not given, b should be:

$$b = \frac{Dt_0}{2.5r}$$

with:

r = mean radius of the bend (mm)

c = corrosion allowance (mm). If corrosion or erosion is expected, the wall thickness of the piping should be increased over that required by other design requirements. This allowance should be consistent with the expected life of the piping.

a = negative manufacturing tolerance fo thickness (%).

3. Design pressure

(1) The design pressure P in the formula for to in **Par 2** (1) is the maximum gauge pressure to which the system may be subjected in service.

(2) The greater of the following design conditions should be used for piping, piping systems and components as appropriate:

(a) for vapour piping systems or components which may be separated from their relief valves and which may contain some liquid: the saturated vapour pressure at 45°C, or higher or lower if agreed upon by the Society (see **402. 6** (2));

(b) for systems or components which may be separated from their relief valves and which contain only vapour at all times: the superheated vapour pressure at 45°C or higher or lower if agreed upon by the Society (see **402. 6** (2)), assuming an initial condition of saturated vapour in the system at the system operating pressure and temperature; or

(c) the MARVS of the cargo tanks and cargo processing systems; or

(d) the pressure setting of the associated pump or compressor discharge relief valve; or

(e) the maximum total discharge or loading head of the cargo piping system; or

(f) the relief valve setting on a pipeline system.

(3) The design pressure should not be less than 1.0 MPa gauge except for open ended lines where it should be not less than 0.5 MPa gauge.

4. Permissible stresses

(1) For pipes, the permissible stress to be considered in the formula for t in **Par 2** (1) is the lower of the following values:

$$R_m/A \quad \text{or} \quad R_e/B$$

where:

R_m = specified minimum tensile strength at room temperature (N/mm^2)

R_e = specified minimum yield stress at room temperature (N/mm^2). If the stress-strain curve does not show a defined yield stress, the 0.2% proof stress applies.

The values of A and B should be shown on the International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk and have values of at least A = 2.7 and B = 1.8.

(2) The minimum wall thickness should be in accordance with Recognized Standards.

(3) Where necessary for mechanical strength to prevent damage, collapse, excessive sag or buckling of pipes due to superimposed loads from supports, ship deflection or other causes, the wall thickness should be increased over that required by **Par 2,** or, if this is impracticable or would cause excessive local stresses, these loads should be reduced, protected against or eliminated by other design methods.

(4) Flanges, valves and other fittings should comply with recognized standards, taking into account the design pressure defined in **Par 3.** For bellows expansion joints used in vapour service, a lower minimum design pressure may be accepted by the Society.

(5) For flanges not complying with a standard, the dimensions of flanges and related bolts should be to the satisfaction of the Society.

5. Stress analysis

When the design temperature is -110°C or lower, a complete stress analysis, taking into account all the stresses due to weight of pipes, including acceleration loads if significant, internal pressure, thermal contraction and loads induced by hog and sag of the ship for each branch of the piping system should be submitted to the Society. For temperatures of above -110°C, a stress analysis may be required by the Society in relation to such matters as the design or stiffness of the piping system and the choice of materials. In any case, consideration should be given to thermal stresses, even though calculations are not submitted. The analysis may be carried out according to a code of practice acceptable to the Society.

6. Materials

(1) The choice and testing of materials used in piping systems should comply with the requirements of **Sec 6** taking into account the minimum design temperature. However, some relaxation may be permitted in the quality of material of open ended vent piping, provided the temperature of the cargo at the pressure relief valve setting is -55°C or greater and provided no liquid discharge to the vent piping can occur. Similar relaxations may be permitted under the same temperature conditions to open ended piping inside cargo tanks, excluding discharge piping and all piping inside membrane and semi-membrane tanks.

(2) Materials having a melting point below 925°C should not be used for piping outside the cargo tanks except for short lengths of pipes attached to the cargo tanks, in which case fire-resisting insulation should be provided.

503. Type tests on piping components (IGC Code 5.3)

1. Each type of piping component should be subject to type tests.

(1) Each size and type of valve intended to be used at a working temperature below -55°C should be subjected to a tightness test to the minimum design temperature or lower, and to a pressure not lower than the design pressure of the valve. During the test the satisfactory

operation of the valve should be ascertained.

(2) The following type tests should be performed on each type of expansion bellows intended for use on cargo piping outside the cargo tank and, where required, on those expansion bellows installed within the cargo tanks:

(a) A type element of the bellows, not pre-compressed, should be pressure tested at not less than 5 times the design pressure without bursting. The duration of the test should not be less than 5 *min*.

(b) A pressure test should be performed on a type expansion joint complete with all the accessories such as flanges, stays and articulations, at twice the design pressure at the extreme displacement conditions recommended by the manufacturer without permanent deformation. Depending on the materials used, the Society may require the test to be at the minimum design temperature.

(c) A cyclic test (thermal movements) should be performed on a complete expansion joint, which is to successfully withstand at least as many cycles, under the conditions of pressure, temperature, axial movement, rotational movement and transverse movement, as it will encounter in actual service. Testing at ambient temperature is permitted, when this testing is at least as severe as testing at the service temperature.

(d) A cyclic fatigue test (ship deformation) should be performed on a complete expansion joint, without internal pressure, by simulating the bellows movement corresponding to a compensated pipe length, for at least 2,000,000 cycles at a frequency not higher than 5 cycles/*s*. This test is only required when, due to the piping arrangement, ship deformation loads are actually experienced.

(e) The Society may waive performance of the tests referred to in this paragraph provided that complete documentation is supplied to establish the suitability of the expansion joints to withstand the expected working conditions. When the maximum internal pressure exceeds 0.1 MPa gauge this documentation is to include sufficient test data to justify the design method used, with particular reference to correlation between calculation and test results.

504. Piping fabrication and joining details (IGC Code 5.4)

1. The requirements of this Article apply to piping inside and outside the cargo tanks. Relaxations from these requirements may be accepted, in accordance with recognized standards, for piping inside cargo tanks and open-ended piping.

2. The following direct connection of pipe lengths, without flanges, may be considered:

(1) Butt-welded joints with complete penetration at the root may be used in all applications. For design temperatures below -10°C, butt welds should be either double welded or equivalent to a double welded butt joint. This may be accomplished by use of a backing ring, consumable insert or inert gas back-up on the first pass. For design pressures in excess of 1.0 MPa and design temperatures of -10°C or lower, backing rings should be removed.

(2) Slip-on welded joints with sleeves and related welding, having dimensions in accordance with recognized standards, should only be used for open-ended lines with external diameter of 50 *mm* or less and design temperatures not lower than -55°C.

(3) Screwed couplings complying with recognized standards only be used for accessory lines and instrumentation lines with external diameters of 25 *mm* or less.

3. (1) Flanges in flange connections should be of the welded neck, slip-on or socket welded type.

(2) Flanges should comply with recognized standards as to their type, manufacture and test. In particular, for all piping except open ended, the following restrictions apply:

(a) For design temperatures lower than -55°C, only welded neck flanges should be used.

(b) For design temperatures lower than -10°C, slip-on flanges should not be used in nominal sizes above 100 *mm* and socket welded flanges should not be used in nominal sizes above 50 *mm*.

4. Piping connections, other than those mentioned in **Pars 2** and **3,** may be accepted by the Society in each case.

5. Bellows and expansion joints should be provided to allow for expansion of piping.

(1) If necessary, bellows should be protected against icing.

(2) Slip joints should not be used except within the cargo tanks.

6. Welding, post-weld heat treatment and non-destructive testing.

(1) Welding should be carried out in accordance with **603.**

(2) Post-weld heat treatment should be required for all butt welds of pipes made with carbon, carbon-manganese and low alloy steels. The Society may waive the requirement for thermal stress relieving of pipes having wall thickness less than 10 *mm* in relation to the design temperature and pressure of the piping system concerned.

(3) In addition to normal controls before and during the welding and to the visual inspection of the finished welds, as necessary for proving that the welding has been carried out correctly

and according to the requirements of this paragraph, the following tests should be required:

(a) 100% radiographic inspection of butt welded joints for piping systems with design temperatures lower than -10°C and with inside diameters of more than 75 *mm* or wall thicknesses greater than 10 *mm*. When such butt welded joints of piping sections are made by automatic welding procedures in the pipe fabrication shop, upon special approval by the Society, the extent of radiographic inspection may be progressively reduced but in no case to less than 10% of each joint, If defects are revealed, the extent of examination should be increased to 100% and should include inspection of previously accepted welds. This special approval can only be granted if well-documented quality assurance procedures and records are available to enable the Society to assess the ability of the manufacturer to produce satisfactory welds consistently.

(b) For other butt-welded joints of pipes not covered by (a), spot radiographic tests or other non-destructive tests should be carried out at the discretion of the Society depending upon service, position and materials. In general, at least 10% of butt-welded joints of pipes should be radiographed.

505. Testing of piping (IGC Code 5.5)

1. The requirements of this Article apply to piping inside and outside the cargo tanks. However, the Society may accept relaxations from these requirements for piping inside cargo tanks and open-ended piping.

2. After assembly, all cargo and process piping should be subjected to a hydrostatic test to at least 1.5 times the design pressure. When piping systems or parts of systems are completely manufactured and equipped with all fittings, the hydrostatic test may be conducted prior to installation aboard ship. Joints welded on board should be hydrostatically tested to at least 1.5 times the design pressure. Where water cannot be tolerated and the piping cannot be dried prior to putting the system into service, proposals for alternative testing fluids or testing means should be submitted to the Society for approval.

3. After assembly on board, each cargo and process piping system should be subjected to a leak test using air, halides, or other suitable medium to a pressure depending on the leak detection method applied.

4. All piping systems including valves, fittings and associated equipment for handling cargo or vapours should be tested under normal operating conditions not later than at the first loading operation.

506. Cargo system valving requirements (IGC Code 5.6)

1. Every cargo piping system and cargo tank should be provided with the following valves, as applicable:

(1) For cargo tanks with a MARVS not exceeding 0.07 MPa gauge, all liquid and vapour connections, except safety relief valves and liquid level gauging devices, should have shutoff valves located as close to the tank as practicable. These valves may be remotely controlled but should be capable of local manual operation and provide full closure. One or more remotely controlled emergency shutdown valves should be provided on the ship for shutting down liquid and vapour cargo transfer between ship and shore. Such valves may be arranged to suit the ship's design and may be the same valve as required in **Par 3** and should comply with the requirements of **Par 4.**

(2) For cargo tanks with a MARVS exceeding 0.07 MPa gauge, all liquid and vapour connections, except safety relief valves and liquid level gauging devices, should be equipped with a manually operated stop valve and a remotely controlled emergency shutdown valve. These valves should be located as close to the tank as practicable. Where the pipe size does not exceed 50 *mm* in diameter, excess flow valves may be used in lieu of the emergency shutdown valve. A single valve may be substituted for the two separate valves provided the valve complies with the requirements of **Par 4,** is capable of local manual operation and provides full closure of the line.

(3) Cargo pumps and compressors should be arranged to shutdown automatically if the emergency shutdown valves required by **Par 1** (1) and (2) are closed by the emergency shutdown system required by **Par 4.**

2. Cargo tank connections for gauging or measuring devices need not be equipped with excess flow or emergency shutdown valves provided that the devices are so constructed that the outward flow of tank contents cannot exceed that passed by a 1.5 *mm* diameter circular hole.

3. One remotely operated emergency shutdown valve should be provided at each cargo hose connection in use. Connections not used in transfer operations may be blinded with blank flanges in lieu of valves.

4. The control system for all required emergency shutdown valves should be so arranged that all such valves may be operated by single controls situated in at least two remote locations on the ship. One of these locations should be the control position required by **1301. 3** or cargo control room. The control system should also be provided with fusible elements designed to melt at temperatures between 98°C and 104°C which will cause the emergency shutdown valves to close in the event of fire. Locations for such fusible elements should include the tank domes and loading stations. Emergency shutdown valves should be of the fail-closed (closed on loss of power) type and be capable of local manual closing operation. Emergency shutdown valves in liquid piping should fully close under all serivce conditions within 30 s of actuation. Information about the closing time of the valves and their operating characteristics should be available on board and the closing time should be verifiable and reproducible. Such valves should close smoothly.

5. The closure time of 30 s for the emergency shutdown valve referred to in **506. 4** should be measured from the time of manual or automatic initiation to final closure. This is called the total shutdown time and is made up of a signal response time and a valve closure time. The valve closure time should be such as to avoid surge pressure in pipelines. Such valves should close in such a manner as to cut off the flows smoothly. This paragraph applies to ships constructed on or after 1 July 2002.

6. Excess flow valves should close automatically at the rated closing flow of vapour or liquid as specified by the manufacturer. The piping including fittings, valves, and appurtenances protected by an excess flow valve, should have a greater capacity than the rated closing flow of the excess flow valve. Excess flow valves may be designed with a bypass not exceeding an area of 1.0 mm diameter circular opening to allow equalization of pressure, after an operating shutdown.

507. Ship's cargo hoses (IGC Code 5.7)

1. Liquid and vapour hoses used for cargo transfer should be compatible with the cargo and suitable for the cargo temperature.

2. Hoses subject to tank pressure, or the discharge pressure of pumps or vapour compressors, should be designed for a bursting pressure not less than 5 times the maximum pressure the hose will be subjected to during cargo transfer.

3. For cargo hoses installed on board ships on or after 1 July 2002, each new type of cargo hose, complete with end-fittings, should be prototype-tested at a normal ambient temperature with 200 pressure cycles from zero to at least twice the specified maximum working pressure. After this cycle pressure test has been carried out, the prototype test should demonstrate a bursting pressure of at least 5 times its specified maximum working pressure at the extreme service temperature. Hoses used for prototype testing should not be used for cargo service. Thereafter, before being placed in service, each new length of cargo hose produced should be hydrostatically tested at ambient temperature to a pressure not less than 1.5 times its specified maximum working pressure but not more than two-fifths of its bursting pressure. The hose should be stencilled or otherwise marked with the date of testing, its specified maximum working pressure and, if used in services other than the ambient temperature services, its maximum and minimum service temperature, as applicable. The specified maximum working pressure should not be less than 1 MPa gauge.

508. Cargo transfer methods (IGC Code 5.8)

1. Where cargo transfer is by means of cargo pumps not accessible for repair with the tanks in service, at least two separate means should be provided to transfer cargo from each cargo tank and the design should be such that failure of one cargo pump, or means of transfer, will not prevent the cargo transfer by another pump or pumps, or other cargo transfer means.

2. The procedure for transfer of cargo by gas pressurization should preclude lifting of the relief valves during such transfer. Gas pressurization may be accepted as a means of transfer of cargo for those tanks so designed that the design factor of safety is not reduced under the conditions prevailing during the cargo transfer operation.

509. Vapour return connections (IGC Code 5.9)

Connections for vapour return lines to the shore installations should be provided.

SECTION 6
Materials of Construction

601. General (IGC Code 6.1)

1. The Society should take appropriate steps to ensure uniformity in the implementation and application of the provisions of this Section.

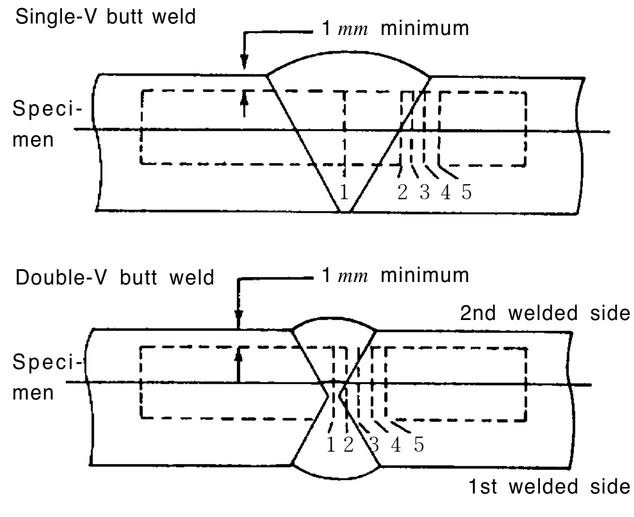
2. This Section gives the requirements for plates, sections, pipes, forgings, castings and weldments used in the construction of cargo tanks, cargo process pressure vessels, cargo and process piping, secondary barriers and contiguous hull structures associated with the transportation of the products. The requirements for rolled materials, forgings and castings are given in **602.** and **Tables 7.5.3** to **7.5.7.** The requirements for weldments are given in **603.**

3. The manufacture, testing, inspection and documentation should be in accordance with the requirements of **Pt 2** of the Rules and the specified requirements given in this Chapter.

4. (1) Acceptance tests should include Charpy V-notch toughness tests unless otherwise specified by the Society. The specified Charpy V-notch requirements are minimum average energy values for three full size (10 *mm* x 10 *mm*) specimens and minimum single energy values for individual specimens. Dimensions and tolerances of Charpy V-notch specimens should be in accordance with Recognized Standards. The testing and requirements for specimens smaller than 5.0 *mm* size should be in accordance with the requirements of **Pt 2** of the Rules. Minimum average values for subsized specimens should be:

Charpy V-notch specimen size	Minimum energy average of three specimens
10 x 10 *mm*	E
10 x 7.5 *mm*	5/6 E
10 x 5.0 *mm*	2/3 E

where: E = the energy values (J) specified in **Tables 7.5.3** to **7.5.6**



Notch location:

1. Centre of weld
2. On fusion line
3. In HAZ, 1 *mm* from fusion line
4. In HAZ, 3 *mm* from fusion line
5. In HAZ, 5 *mm* from fusion line

HAZ = heat-affected zone

The largest size Charpy specimens possible for the material thickness should be machined with the centre of the specimens located as near as practicable to a point midway between the surface and the centre of the thickness. In all cases, the distance from the surface of the material to the edge of the specimen should be approximately 1 *mm* or greater In addition for double-V butt welds, specimens should be machined closer to the surface of the second welded side.

Fig. 7.5.5 Orientation of Weld Test Specimen

Only one individual value may be below the specified average value provided it is not less than 70% of that value.

(2) In all cases, the largest size Charpy specimens possible for the material thickness should be machined with the specimens located as near as practicable to a point midway between the surface and the centre of the thickness and the length of the notch perpendicular to the suface (see **Fig. 7.5.5**). If the average value of the three initial Charpy V-notch specimens fails to meet the stated requirements, or the value for more than one specimen is below the required average value, or when the value for one specimen is below the minimum value permitted for a single specimen,
three additional specimens from the same material may be tested and the results combined with those previously obtained to form a new average. If this new average complies with the requirements and if no more than two individual results are lower than the required average and no more than one result is lower than the required value for a single specimen, the piece or batch may be accepted. At the discretion of the Society other types of toughness tests, such as a drop weight test, may be used. This may be in addition to or in lieu of the Charpy V-notch test.

5. Tensile strength, yield stress and elongation should be to the satisfaction of the Society. For carbon-manganese steel and other materials with definitive yield points, consideration should be given to the limitation of the yield to tensile ratio.

6. The bend test may be omitted as a material acceptance test, but is required for weld tests.

7. Materials with alternative chemical composition or mechanical properties may be accepted by the Society.

8. Where post-weld heat treatment is specified or required, the properties of the base material should be determined in the heat treated condition in accordance with the applicable table of this Section and the weld properties should be determined in the heat treated condition in accordance with **603.** In cases where a post-weld heat treatment is applied, the test requirements may be modified at the discretion of the Society.

9. Where reference is made in this Section to A, B, D, E, AH, DH and EH hull structural steels, these steel grades are the grades of steel according to **Pt 2** of the Rules, as follows: A: RA, B: RB, D: RD, E: RE, AH: RA32, RA36, DH: RD32, RD36, EH: RE32, RE36.

602. Material requirements (IGC Code 6.2)

The requirements for materials of construction are shown in the tables as follows:

Table 7.5.3: Plates, pipes (seamless and welded), sections and forgings for cargo tanks and process pressure vessels for design temperatures not lower than 0°C.

Table 7.5.4: Plates, sections and forgings for cargo tanks, secondary barriers and process pressure vessels for design temperatures below 0°C and down to -55°C.

Table 7.5.5: Plates, sections and forgings for cargo tanks, secondary barriers and process pressure vessels for design temperatures below -55°C and down to -165°C.

Table 7.5.6: Pipes (seamless and welded), forgings and castings for cargo and process piping for design temperatures below 0°C and down to -165°C.

Table 7.5.7: Plates and sections for hull structures required by **409. 1** and **409. 4.**

603. Welding and non-destructive testing (IGC Code 6.3)

1. General

The requirements of this Article are those generally employed for carbon, carbon-managanese, nickel alloy and stainless steels, and may form the basis for acceptance testing of other material. At the discretion of the Society, impact testing of stainless steel and aluminium alloy weldments may be omitted and other tests may be specially required for any material.

2. Welding consumables

Welding consumables intended for welding of cargo tanks should be in accordance with Recognized Standards unless otherwise agreed with the Society. Deposited weld metal tests and butt weld tests should be required for all welding consumables, unless otherwise specially agreed with the Society. The results obtained from tensile and Charpy V-notch impact tests should be in accordance with Recognized Standards. The chemical composition of the deposited weld metal should be recorded for information and approval.

3. Welding procedure tests for cargo tanks and process pressure vessels

(1) Welding procedure tests for cargo tanks and process pressure vessels are required for all butt welds and the test assemblies should be representative of:
- each base material
- each type of consumable and welding process
- each welding position.

For butt welds in plates, the test assemblies should be so prepared that the rolling direction is parallel to the direction of welding. The range of thickness qualified by each welding procedure test should be in accordance with Recognized Standards. Radiographic or ultrasonic testing may be performed at the option of the fabricator or the Society. Procedure tests for consumables intended for fillet welding should be in accordance with Recognized Standards. In such cases consumables should be selected which exhibit satisfactory impact properties.

(2) The following welding procedure tests for cargo tanks and process pressure vessels should be made from each test assembly:
(a) Cross-weld tensile tests.
(b) Transverse bend tests which may be face, root or side bends at the discretion of the Society. However, longitudinal bend test may be required in lieu of transverse bend tests in cases where the base material and weld metal have different strength levels.
(c) One set of three Charpy V-notch impacts, generally at each of the following locations, as shown in **Fig. 7.5.5**:
- Centreline of the welds
- Fusion line (F.L.)
- 1 mm from the F.L.
- 3 mm from the F.L.
- 5 mm from the F.L
(d) Macrosection, microsection and hardness survey may also be required by the Society.

4. Test requirements

(1) Tensile tests: Generally, tensile strength should not be less than the specified minimum tensile strength for the appropriate parent materials. The Society may also require that the transverse weld tensile strength should not be less than the specified minimum tensile strength for the weld metal, where the weld metal has a lower tensile strength than that of the parent metal. In every case, the position of fracture is to be reported for information.

(2) Bend tests: No fracture is acceptable after a 180° bend over a former of a diameter 4 times the thickness of the test pieces, unless otherwise specially required by or agreed with the Society.

(3) Charpy V-notch impact tests: Charpy tests should be conducted at the temperature prescribed for the base material being joined. The results of weld metal impact tests, minimum average energy (E), should be no less than 27 J. The weld metal requirements for subsize specimens and single energy values should be in accordance with **601. 4.** The results of fusion line and heat affected zone impact tests should show a minimum average energy (E) in accordance with the transverse or longitudinal requirements of the base material, whichever is applicable, and for subsize specimens, the minimum average energy (E) should be in accordance with **601. 4.** If the material thickness does not

permit machining either full-size or standard subsize specimens, the testing procedure and acceptance standards should be in accordance with Recognized Standards.

5. Welding procedure tests for piping

Welding procedure tests for piping should be carried out and should be similar to those detailed for cargo tanks in **Par 3.** Unless otherwise specially agreed with the Society, the test requirements should be in accordance with **Par 4.**

6. Production weld tests

(1) For all cargo tanks and process pressure vessels except integral and membrane tanks, production weld tests should generally be performed for approximately each 50 m of butt weld joints and should be representative of each welding position. For secondary barriers, the same type production tests as required for primary tanks should be performed except that the number of tests may be reduced subject to agreement with the Society. Tests, other than those specified in (2), (3) and (4), may be required for cargo tanks or secondary barriers at the discretion of the Society.

(2) The production tests for types A and B independent tanks and semi-membrane tanks should include the following tests:

(a) Bend tests, and where required for procedure tests one set of three Charpy V-notch tests should be made for each 50 m of weld. The Charpy V-notch tests should be made with specimens having the notch alternately located in the centre of the weld and in the heat affected zone (most critical location based on procedure qualification results). For austenitic stainless steel, all notches should be in the centre of the weld.

(b) The test requirements are the same as the applicable test requirements listed in **Par 4,** except that impact tests that do not meet the prescribed energy requirements may still be accepted, upon special consideration by the Society, by passing a drop weight test. In such cases, two drop weight specimens should be tested for each set of Charpy specimens that failed and both must show "no break" performance at the temperature at which the Charpy tests were conducted.

(3) In addition to those tests listed in (2) (a) for type C independent tanks and process pressure vessels transverse weld tensile tests are required. The test requirements are listed in **Par 4** except that impact tests that do not meet the prescribed energy requirements may still be accepted upon special consideration by the Society, by passing a drop weight test. In such cases, two drop weight specimens should be tested for each set of Charpy specimens that failed, and both must show "no break" performance at the temperature at which the Charpy tests were conducted.

(4) Production tests for integral and membrane tanks should be in accordance with Recognized Standards.

7. Non-destructive testing

(1) For type A independent tanks and semi-membrane tanks where the design temperature is -20°C or less, and for type B independent tanks regardless of temperature, all full penetration butt welds of the shell plating of cargo tanks should be subjected to 100% radiographic inspection.

(a) Where the design temperature is higher than -20°C, all full penetration butt welds in way of intersections and at least 10% of the remaining full penetration welds of tank structures should be subjected to radiographic inspection.

(b) In each case the remaining tank structure including the welding of stiffeners and other fittings and attachments should be examined by magnetic particle or dye penetrant methods as considered necessary by the Society.

(c) All test procedures and acceptance standards should be in accordance with Recognized Standards. The Society may accept an approved ultrasonic test procedure in lieu of radiographic inspection, but may in addition require supplementary inspection by radiography at selected locations. Further, the Society may require ultrasonic testing in addition to normal radiographic inspection.

(2) Inspection of type C independent tanks and process pressure vessels should be carried out in accordance with **410. 9.**

(3) For integral and membrane tanks, special weld inspection procedures and acceptance criteria should be in accordance with Recognized Standards.

(4) The inspection and non-destructive testing of the inner hull or the independent tank structures supporting internal insulation tanks should take into account the design criteria given in **404. 7.** The schedule for inspection and non-destructive testing should be to the satisfaction of the Society.

(5) Inspection of piping should be carried out in accordance with the requirements of **Sec 5.**

(6) The secondary barrier should be radiographed as considered necessary by the Society. Where the outer shell of the hull is part of the secondary barrier, all sheer strake butts and the intersections of all butts and seams in the side shell should be tested by radiography.

SECTION 7
Cargo Pressure/Temperature Control

701. General (IGC Code 7.1)

1. Unless the entire cargo system is designed to withstand the full gauge vapour pressure of the cargo under conditions of the upper ambient design temperatures, maintenance of the cargo tank pressure below the MARVS should be provided by one or more of the following means, except as otherwise provided in this Article:

(1) a system which regulates the pressure in the cargo tanks by the use of mechanical refrigeration;
(2) a system whereby the boil-off vapours are utilized as fuel for shipboard use or waste heat system subject to the provisions of **Sec 16.** This system may be used at all times, including while in port and while manoeuvring, provided that a means of disposing of excess energy is provided, such as a steam dump system, that is satisfactory to the Society;
(3) a system allowing the product to warm up and increase in pressure. The insulation or cargo tank design pressure or both should be adequate to provide for a suitable margin for the operating time and temperatures involved. The system should be acceptable to the Society in each case;
(4) other systems acceptable to the Society;
(5) in addition to the above means, the Society may permit certain cargoes to be controlled by venting cargo vapours to the atmosphere at sea. This may also be permitted in port with the permission of the port Administration;

2. The systems required by **Par 1** should be constructed, fitted and tested to the satisfaction of the Society. Materials used in their construction should be suitable for use with the cargoes to be carried. For normal service, the upper ambient design temperature should be:

- sea : 32°C
- air : 45°C

For service in especially hot or cold zones these design temperatures should be increased or reduced, as appropriate, by the Society.

3. For certain highly dangerous cargoes specified in **Sec 17,** the cargo containment system should be capable of withstanding the full vapour pressure of the cargo under condition of the upper ambient design temperature irrespective of any system provided for dealing with boil-off gas.

702. Refrigeration systems(IGC Code 7.2)

1. A refrigeration system should consist of one or more units capable of maintaining the required cargo pressure/temperature under conditions of the upper ambient design temperatures. Unless an alternative means of controlling the cargo pressure/temperature is provided to the satisfaction of the Society, a stand-by unit (or units) affording spare capacity at least equal to the largest required single unit should be provided. A stand-by unit should consist of a compressor with its driving motor, control system and any necessary fittings to permit operation independently of the normal service units. A stand-by heat exchanger should be provided unless the normal heat exchanger for the unit has an excess capacity of at least 25% of the largest required capacity. Separate piping systems are not required.

2. (1) Where two or more refrigerated cargoes which may react chemically in a dangerous manner are carried simultaneously, special consideration should be given to the refrigeration systems to avoid the possibility of mixing cargoes. For the carriage of such cargoes, separate refrigeration systems, each complete with a stand-by unit as specified in **Par 1,** should be provided for each cargo. However, where cooling is provided by an indirect or combined system and leakage in the heat exchangers cannot cause mixing of the cargoes under any envisaged condition, separate refrigeration units need not be fitted.
(2) Where two or more refrigerated cargoes are not mutually soluble under the conditions of carriage, so that their vapour pressures would be additive on mixing, special consideration should be given to the refrigeration systems to avoid the possibility of mixing cargoes.

3. Where cooling water is required in refrigeration systems, an adequate supply should be provided by a pump or pumps used exclusively for this purpose. This pump or these pumps should have at least two sea suction lines, where practicable leading from sea-chests, one port and one starboard. A spare pump of adequate capacity should be provided, which may be a pump used for other services so long as its use for cooling would not interfere with any other essential service.

4. The refrigeration system may be arranged in one of the following ways:

(1) a direct system where evaporated cargo is compressed, condensed and returned to cargo tanks. For certain cargoes specified in **Sec 17** this system should not be used;
(2) an indirect system where cargo or evaporated cargo is cooled or condensed by refrigerant without being compressed;
(3) a combined system where evaporated cargo is compressed and condensed in a cargo/refrigerant heat exchanger and returned to the cargo tanks. For certain cargoes specified in **Sec 17** this system should not be used.

5. All primary and secondary refrigerants must be compatible with each other and with the cargo with which they come into contact. The heat exchange may take place either remotely from the cargo tank or by cooling coils fitted inside or outside the cargo tank.

SECTION 8
Cargo Tank Vent Systems

801. General (IGC Code 8.1)

All cargo tanks should be provided with a pressure relief system appropriate to the design of the cargo containment system and the cargo being carried. Hold spaces, interbarrier spaces and cargo piping which may be subject to pressures beyond their design capabilities should also be provided with a suitable pressure relief system. The pressure relief system should be connected to a vent piping system so designed as to minimize the possibility of cargo vapour accumulating on the decks, or entering accommodation spaces, service spaces, control stations and machinery spaces, or other spaces where it may create a dangerous condition. Pressure control systems specified by **Sec 7** should be independent of the pressure relief valves.

802. Pressure relief systems (IGC Code 8.2)

1. Each cargo tank with a volume exceeding 20 m^3 should be fitted with at least two pressure relief valves of approximately equal capacity, suitably designed and constructed for the prescribed service. For cargo tanks with a volume not exceeding 20 m^3, a single relief valve may be fitted.

2. Interbarrier spaces should be provided with pressure relief devices complying with recognized standards.

3. In general, the setting of the pressure relief valves should not be higher than the vapour pressure which has been used in the design of the tank. However, where two or more pressure relief valves are fitted, valves comprising not more than 50% of the total relieving capacity may be set at a pressure up to 5% above MARVS.

4. Pressure relief valves should be connected to the highest part of the cargo tank above deck level. Pressure relief valves on cargo tanks with a design temperature below 0°C should be arranged to prevent their becoming inoperative due to ice formation when they are closed. Due consideration should be given to the construction and arrangement of pressure relief valves on cargo tanks subject to low ambient temperatures. Valves should be constructed of materials with a melting point above 925°C. Consideration should be given to lower melting point materials for internal parts and seals if their use will yield a significant improvement in the general operation of the valve.

5. Pressure relief valves should be prototype tested to ensure that the valves have the capacity required. Each valve should be tested to ensure that it opens at the prescribed pressure setting with an allowance not exceeding ±10% for 0 to 0.15 MPa, ±6% for 0.15 to 0.3 MPa, ±3% for 0.3 MPa and above. Pressure relief valves should be set and sealed by a competent authority acceptable to the Society and a record of this action, including the values of set pressure, should be retained aboard the ship.

6. In the case of cargo tanks permitted to have more than one relief valve setting this may be accomplished by:

(1) installing two or more properly set and sealed valves and providing means as necessary for isolating the valves not in use from the cargo tank; or
(2) installing relief valves whose settings may be changed by the insertion of previously approved spacer pieces or alternative springs or by other similar means not requiring pressure testing to verify the new set pressure. All other valve adjustment should be sealed.

7. The changing of the set pressure under the provisions of **802. 6,** and the corresponding resetting of the alarms referred to in **1304. 1,** should be carried out under the supervision of the master in accordance with procedures approved by the Society and specified in the ship's operating manual. Changes in set pressures should be recorded in the ship's log and a sign posted in the cargo control room, if provided, and at each relief valve, stating the set pressure.

8. Stop valves or other means of blanking off pipes between tanks and pressure relief valves to facilitate maintenance should not be fitted unless all the following arrangements are provided:

(1) suitable arrangements to prevent more than one pressure relief valve being out of service at the same time;
(2) a device which automatically and in a clearly visible way indicates which one of the pressure relief valves is out of service; and
(3) pressure relief valve capacities such that if one valve is out of service the remaining valves have the combined relieving capacity required by **805.** However, this capacity may be provided by the combined capacity of all valves, if a suitably maintained spare valve is carried on board.

9. Each pressure relief valve installed on a cargo tank should be connected to a venting system, which should be so constructed that the discharge of gas will be unimpeded and directed vertically upwards at the exit and so arranged as to minimize the possibility of water or snow entering the vent system. The height of vent exits should not be less than $B/3$ or 6 m, whichever is the greater, above the weather deck and 6 m above the working area, the fore and aft gangway, deck storage tanks and cargo liquid lines.

10. Cargo tank pressure relief valve vent exits should be arranged at a distance at least equal to B or 25 m, whichever is less, from the nearest air intake or opening to accommodation spaces, service spaces and control stations, or other gas-safe spaces. For ships less than 90 m in length, smaller distances may be permitted by the Society. All other vent exits connected to the cargo containment system should be arranged at a distance of at least 10 m from the nearest air intake or opening to accommodation spaces, service spaces and control stations, or other gas-safe spaces.

11. All other cargo vent exits not dealt with in other sections should be arranged in accordance with **Pars 9** and **10.**

12. If cargoes which react in a hazardous manner with each other are carried simultaneously, a separate pressure relief system should be fitted for each cargo carried.

13. In the vent piping system, means for draining liquid from places where it may accumulate should be provided. The pressure relief valves and piping should be so arranged that liquid can under no circumstances accumulate in or near the pressure relief valves.

14. Suitable protection screens should be fitted on vent outlets to prevent the ingress of foreign objects.

15. All vent piping should be so designed and arranged that it will not be damaged by temperature variations to which it may be exposed, or by the ship's motions.

16. The back pressure in the vent lines from the pressure relief valves should be taken into account in determining the flow capacity required by **805.** The pressure drop in the vent line from the tank to the pressure relief valve inlet should not exceed 3% of the valve set pressure. For unbalanced pressure relief valves the back pressure in the discharge line should not exceed 10% of the gauge pressure at the relief valve inlet with the vent lines under fire exposure as referred to in **805. 2.**

17. Pressure relief valves should be positioned on the cargo tank so that they will remain in the vapour phase under conditions of 15° list and 0.015 L trim, where L is as defined in **106. 23** at the maximum allowable filling limit(FL).

18. The adequacy of the vent system fitted on tanks loaded in accordance with **1501. 4** is to be demonstrated using the special guidelines. A relevant certificate should be permanently kept on board the ship. For the purposes of this paragraph, vent system means :

(1) the tank outlet and the piping to the pressure relief valve;
(2) the pressure relief valve;
(3) the piping from the pressure relief valve to the location of discharge to the atmosphere and including any interconnections and piping which joins other tanks.

This paragraph may apply to all ships regardless of the date of construction.

803. Additional pressure relieving system for liquid level control (IGC Code 8.3)

1. Where required by **1501. 4** (2), an additional pressure relieving system to prevent the tank from becoming liquid full at any time during relief under the fire exposure conditions referred to in **805.** should be fitted to each tank. This pressure relieving system should consist of:

(1) one or more relief valves set at a pressure corresponding to the gauge vapour pressure of the cargo at the reference temperature defined in **1501. 4** (2); and
(2) an override arrangement, whenever necessary, to prevent its normal operation. This arrangement should include fusible elements designed to melt at temperatures between 98°C and 104°C and to cause relief valves specified in to become operable. The fusible elements should be located, in particular, in the vicinity of relief valves. The system should become operable upon loss of system power if provided. The override arrangement should not be dependent on any source of ship's power.

2. The total relieving capacity of the additional pressure relieving system at the pressure mentioned in **Par 1** (1) should not be less than:

$$Q' = FG'A^{0.82} \ (m^3/s)$$

where:

Q' = minimum required rate of discharge of air at standard conditions of 273 K and 0.1013 MPa.

$$G' = \frac{12.4}{(L+\rho_r m)D}\sqrt{\frac{Z \cdot T'}{M}}$$

with:

ρ_r : relative density of liquid phase of product at relieving conditions (ρ_r = 1.0 for fresh water)

m = $-di/d\rho_r$: gradient of decrease of liquid phase enthalpy against increase of liquid phase density (kJ/kg) at relieving conditions. For set pressures not higher than 0.2 MPa the value in **Table 7.5.8** may be used.

Table 7.5.8 Factor m

Poduct	$m = -di/d\rho_r\ (KJ/kg)$
Ammonia, anhydrous	3,400
Butadiene	1,800
Butane	2,000
Butylenes	1,900
Ethane	2,100
Ethylene	1,500
Methane	2,300
Methyl chloride	816
Nitrogen	400
Propane	2,000
Propylene	1,600
Propylene oxide	1,550
Vinyl chloride	900
The values in this table may be used for set pressures not hlgher than 0.2 MPa.	

For products not listed in the table and for higher set pressures, the value of m should be calculated on the basis of the thermodynamic data of the product itself

i : enthalpy of liquid (kJ/kg)

T' : temperature in kelvins (K) at relieving conditions, i.e. at the pressure at which the additional pressure relieving system is set

F, A, L, D, Z and M are defined in **805. 2.**

3. Compliance with **Par 1** (1) requires changing of the setting of the relief valves provided for in this Article. This should be accomplished in accordance with the provisions of **802. 6** and **7.**

4. Relief valves mentioned under **Par 1** (1) above may be the same as the pressure relief valves mentioned in **802.,** provided the setting pressure and the relieving capacity are in compliance with the requirements of this Article.

5. The exhaust of such pressure relief valves may be led to the venting system referred to in **802. 9.** If separate venting arrangements are fitted these should be in accordance with the requirements of **802. 9** to **15.**

804. Vacuum protection systems (IGC Code 8.4)

1. Cargo tanks designed to withstand a maximum external pressure differential exceeding 0.025 MPa and capable of withstanding the maximum external pressure differential which can be attained at maximum discharge rates with no vapour return into the cargo tanks, or by operation of a cargo refrigeration system, need no vacuum protection systems.

2. Cargo tanks designed to withstand a maximum external pressure differential not exceeding 0.025 MPa, or tanks which cannot withstand the maximum external pressure differential that can be attained at maximum discharge rates with no vapour return into the cargo tanks, or by operation of a cargo refrigeration system, or by sending boil-off vapour to the machinery spaces, should be fitted with:

(1) two independent pressure switches to sequentially alarm and subsequently stop all suction of cargo liquid or vapour from the cargo tank, and refrigeration equipment if fitted, by suitable means at a pressure sufficiently below the maximum external designed pressure differential of the cargo tank; or
(2) vacuum relief valves with a gas flow capacity at least equal to the maximum cargo discharge rate per cargo tank, set to open at a pressure sufficiently below the external design differential pressure of the cargo tank; or
(3) other vacuum relief systems acceptable to the Society.

3. Subject to the requirements of **Sec 17,** the vacuum relief valves should admit an inert gas, cargo vapour or air to the cargo tank and should be arranged to minimize the possibility of the entrance of water or snow. If cargo vapour is admitted, it should be from a source other than the cargo vapour lines.

4. The vacuum protection system should be capable of being tested to ensure that it operates at the prescribed pressure.

805. Size of valves (IGC Code 8.5)

Pressure relief valves should have a combined relieving capacity for each cargo tank to discharge the greater of the following with not more than a 20% rise in cargo tank pressure above the MARVS:

(1) the maximum capacity of the cargo tank inerting system if the maximum attainable working pressure of the cargo tank inerting system exceeds the MARVS of the cargo tanks; or
(2) vapours generated under fire exposure computed using the following formula:

$$Q = FGA^{0.82} \quad (m^3/s)$$

where:

Q = minimum required rate of discharge of air at standard conditions of 273 K and 0.1013 MPa.

F = fire exposure factor for different cargo tank types:

F = 1.0 for tanks without insulation located on deck;

F = 0.5 for tanks above the deck when insulation is approved by the Society (Approval will be based on the use of an approved fireproofing material, the thermal conductance of insulation, and its stability under fire exposure);

F = 0.5 for uninsulated independent tanks installed in holds;

F = 0.2 for insulated independent tanks in holds (or uninsulated independent tanks in insulated holds);

F = 0.1 for insulated independent tanks in inerted holds (or uninsulated independent tanks in inerted, insulated holds);

F = 0.1 for membrane and semi-membrane tanks.

For independent tanks partly protruding through the open deck, the fire exposure factor should be determined on the basis of the surface areas above and below deck.

G = gas factor

$$G = \frac{12.4}{LD}\sqrt{\frac{ZT}{M}}$$

with:

T = temperature in kelvins (K) at relieving conditions, i.e. 120% of the pressure at which the pressure relief valve is set.

L = latent heat of the material being vaporized at relieving conditions, in kJ/kg.

D = constant based on relation of specific heats k, shown in **Table 7.5.9**; if k is not known, D = 0.606 should be used. The constant D may also be calculated by the following formula:

$$D = \sqrt{k\left(\frac{2}{k+1}\right)^{\frac{k+1}{k-1}}}$$

Z = compressibility factor of the gas at relieving conditions; if not known, Z = 1.0 should be used.

M = molecular mass of the product

A = external surface area of the tank (m^2) for different tank types:

for body-of-revolution type tanks:

A = external surface area;

for other than body-of-revolution type tanks:

A = external surface area less the projected bottom surface area;

for tanks consisting of an array of pressure vessel tanks:

insulation on the ship's structure:

A = external surface area of the hold less its projected bottom area;

insulation on the tank structure:

A = external surface area of the array of pressure vessels excluding insulation, less the projected bottom area as shown in **Fig. 7.5.6.**

Table 7.5.9 Constant D

k	D	k	D
1.00	0.606	1.52	0.704
1.02	0.611	1.54	0.707
1.04	0.615	1.56	0.710
1.06	0.620	1.58	0.713
1.08	0.624	1.60	0.716
1.10	0.628	1.62	0.719
1.12	0.633	1.64	0.722
1.14	0.637	1.66	0.725
1.16	0.641	1.68	0.728
1.18	0.645	1.70	0.731
1.20	0.649	1.72	0.734
1.22	0.652	1.74	0.736
1.24	0.656	1.76	0.739
1.26	0.660	1.78	0.742
1.28	0.664	1.80	0.745
1.30	0.667	1.82	0.747
1.32	0.671	1.84	0.750
1.34	0.674	1.86	0.752
1.36	0.677	1.88	0.755
1.38	0.681	1.90	0.758
1.40	0.685	1.92	0.760
1.42	0.688	1.94	0.763
1.44	0.691	1.96	0.765
1.46	0.695	1.98	0.767
1.48	0.698	2.00	0.770
1.50	0.701	2.02	0.772
		2.20	0.792

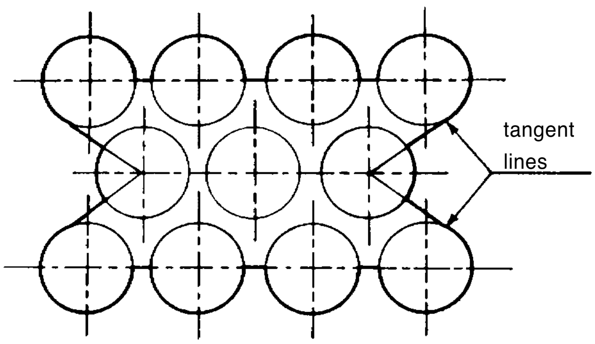


Fig. 7.5.6 Determination of the Projected Bottom Area for Tanks Consisting of an Array

SECTION 9
Environmental Control

901. Environmental control within cargo tanks and cargo piping systems (IGC Code 9.1)

1. A piping system should be provided to enable each cargo tank to be safely gas-freed, and to be safely purged with cargo gas from a gas-free condition. The system should be arranged to minimize the possibility of pockets of gas or air remaining after gas-freeing or purging.

2. A sufficient number of gas sampling points should be provided for each cargo tank in order to adequately monitor the progress of purging and gas-freeing. Gas sampling connections should be valved and capped above the main deck.

3. For flammable gases, the system should be arranged to minimize the possibility of a flammable mixture existing in the cargo tank during any part of the gas-freeing operation by utilizing an inerting medium as an intermediate step. In addition, the system should enable the cargo tank to be purged with an inerting medium prior to filling with cargo vapour or liquid, without permitting a flammable mixture to exist at any time within the cargo tank.

4. Piping systems which may contain cargo should be capable of being gas-freed and purged as provided in **Pars 1** and **3.**

5. Inert gas utilized in these procedures may be provided from the shore or from the ship.

902. Environmental control within the hold spaces (cargo containment systems other than type C independent tanks) (IGC Code 9.2)

1. Interbarrier and hold spaces associated with cargo containment systems for flammable gases requiring full secondary barriers should be inerted with a suitable dry inert gas and kept inerted with make-up gas provided by a shipboard inert gas generation system, or by shipboard storage which should be sufficient for normal consumption for at least 30 days.

2. (1) Interbarrier and hold spaces associated with cargo containment systems for flammable gases requiring partial secondary barriers should be inerted with suitable dry inert gas and kept inerted with makeup gas provided by a shipboard inert gas generation system or by shipboard storage which should be sufficient for normal consumption for at least 30 days.

(2) Alternatively, subject to the restrictions specified in **Sec 17**, the Society may allow the spaces referred to in (1) to be filled with dry air provided that the ship maintains a stored charge of inert gas or is fitted with an inert gas generation system sufficient to inert the largest of these spaces; and provided that the configuration of the spaces and the relevant vapour detection systems, together with the capability of the inerting arrangements, ensure that any leakage from the cargo tanks will be rapidly detected and inerting effected before a dangerous condition can develop. Equipment for the provision of sufficient dry air of suitable quality to satisfy the expected demand should be provided.

3. For non-flammable gases, the spaces referred to in **Par 1** and **Par 2** (1) may be maintained with a suitable dry air or inert atmosphere.

4. In case of internal insulation tanks, environmental control arrangements are not required for interbarrier spaces and spaces between the secondary barrier and the inner hull or independent tank structures completely filled with insulation materials complying with **409. 7** (2).

903. Environmental control of spaces surrounding type C independent tanks (IGC Code 9.3)

Spaces surrounding refrigerated cargo tanks not having secondary barriers should be filled with suitable dry inert gas or dry air and be maintained in this condition with make-up inert gas provided by a ship-board inert gas generation system, shipboard storage of inert gas, or dry air provided by suitable air drying equipment.

904. Inerting (IGC Code 9.4)

1. Inerting refers to the process of providing a non-combustible environment by the addition of compatible gases, which may be carried in storage vessels or produced on board the ship or supplied from the shore. The inert gases should be compatible chemically and operationally, at all temperatures likely to occur within the spaces to be inerted, with the materials of construction of the spaces and the cargo. The dew points of the gases should be taken into consideration.

2. Where inert gas is also stored for fire-fighting purposes, it should be carried in separate containers and should not be used for cargo services.

3. Where inert gas is stored at temperature below 0°C, either as a liquid or as a vapour, the storage and supply system should be so designed that the temperature of the ship’s structure is not reduced below the limiting values imposed on it.

4. Arrangements suitable for the cargo carried should be provided to prevent the backflow of cargo vapour into the inert gas system.

5. The arrangements should be such that each space being inerted can be isolated and the necessary controls and relief valves etc. should be provided for controlling pressure in these spaces.

905. Inert gas production on board (IGC Code 9.5)

1. The equipment should be capable of producing inert gas with an oxygen content at no time greater than 5% by volume subject to the special requirements of **Sec 17.** A continuous-reading oxygen content meter should be fitted to the inert gas supply from the equipment and should be fitted with an alarm set at a maximum of 5% oxygen content by volume subject to the requirements of **Sec 17.** Additionally, where inert gas is made by an on-board process of fractional distillation of air which involves the storage of the cryogenic liquefied nitrogen for subsequent release, the liquefied gas entering the storage vessel should be monitored for traces of oxygen to avoid possible initial high oxygen enrichment of the gas when released for inerting purposes.

2. An inert gas system should have pressure controls and monitoring arrangements appropriate to the cargo containment system. A means acceptable to the Society, located in the cargo area, of preventing the backflow of cargo gas should be provided.

3. Spaces containing inert gas generating plants should have no direct access to accommodation spaces, service spaces or control stations, but may be located in machinery spaces. If such plants are located in machinery spaces or other spaces outside the cargo area, two non-return valves, or equivalent devices should be fitted in the inert gas main in the cargo area as required in **Par 2.** Inert gas piping should not pass through accommodation spaces, service spaces or control stations. When not in use, the inert gas system should be made separate from the cargo system in the cargo area except for connections to the hold spaces or interbarrier spaces.

4. Flame burning equipment for generating inert gas should not be located within the cargo area. Special consideration may be given to the location of inert gas generating equipment using the catalytic combustion process.

SECTION 10
Electrical Installations

1001. General (IGC Code 10.1)

1. The provisions of the Seciton are applicable to ships carrying flammable products and should be applied in conjunction with part D of chapter II-1of the 1983 SOLAS amendments.

2. Electrical installations should be such as to minimize the risk of fire and explosion from flammable products. Electrical installations complying with this Section need not be considered as a source of ignition for the purposes of **Sec 3.**

3. The Society should take appropriate steps to ensure uniformity in the implementation and application of the provisions of this Section in respect of electrical installations.

4. Electrical equipment or wiring should not be installed in gas-dangerous spaces or zones unless essential for operational purposes, when the exceptions listed in **1002.** are permitted.

5. Where electrical equipment is installed in gas-dangerous spaces or zones as provided in **Par 4,** it should be to the satisfaction of the Society and approved by the relevant authorities recognized by the Society for operation in the flammable atmosphere concerned.

1002. Types of equipment (IGC Code 10.2)

Certified safe type equipment may be fitted in gas-dangerous spaces and zones in accordance with the following provisions:

1. Gas-dangerous spaces and zones, general

Intrinsically safe electrical equipment and wiring may be fitted in all gas-dangerous spaces and zones as defined in **106. 17.**

2. Cargo containment systems

Submerged cargo pump motors and their supply cables may be fitted in cargo containment systems. Arrangements should be made to automatically shut down the motors in the event of low liquid level. This may be accomplished by sensing low pump discharge pressure, low motor current, or low liquid level. This shutdown should be alarmed at the cargo control station. Cargo pump motors should be capable of being isolated from their electrical supply during gas-freeing operations.

3. Hold spaces and certain other spaces

(1) In hold spaces where cargo is carried in a cargo containment system requiring a secondary barrier, supply cables for submerged cargo pump motors may be installed.

(2) In hold spaces where cargo is carried in a cargo containment system not requiring a secondary barrier and in spaces described in **106. 17** (5), the following may be installed:

(a) through runs of cables;

(b) lighting fittings with pressurized enclosures or of the flameproof type. The lighting system should be divided between at least two branch circuits. All switches and protective devices should interrupt all poles or phases and be located in a gas-safe space; and

(c) electrical depth sounding or log devices and impressed current cathodic protection system anodes or electrodes. These devices should be housed in gastight enclosures;

and only in spaces described in **106. 17** (5):
(d) flameproof motors for valve operation for cargo or ballast systems; and
(e) flameproof general alarm audible indicators.

4. Cargo pump and cargo compressor rooms

(1) Lighting fittings should have pressurized enclosures or should be of the flameproof type. The lighting system should be divided between at least two branch circuits. All switches and protective devices should interrupt all poles or phases and be located in a gas-safe space.
(2) Electric motors for driving cargo pumps or cargo compressors should be separated from these spaces by a gastight bulkhead or deck. Flexible couplings or other means of maintaining alignment should be fitted to the shafts between the driven equipment and its motors and, in addition, suitable glands should be provided where the shafts pass through the gastight bulkhead or deck. Such electric motors and associated equipment should be located in a compartment complying with **Sec 12.**
(3) Where operational or structural requirements are such as to make it impossible to comply with the method described in (2), motors of the following certified safe types may be installed:
(a) increased safety type with flameproof enclosure; and
(b) pressurized type.
(4) General alarm audible indicators should have flameproof enclosures.

5. Zones on open decks, spaces other than hold spaces

(1) In zones on open decks or non-enclosed spaces on the open deck, within 3 m of any cargo tank outlet, gas or vapour outlet, cargo pipe flange, cargo valves or entrances and ventilation openings to cargo pump rooms and cargo compressor rooms; in zones on the open deck over the cargo area and 3 m forward and aft of the cargo area on the open deck and up to a height of 2.4 m above the deck, in zones within 2.4 m of the outer surface of a cargo containment system where such surface is exposed to the weather the following may be installed:
(a) certified safe type equipment; and
(b) through runs of cables.
(2) In enclosed or semi-enclosed spaces in which pipes containing cargoes are located and in compartments for cargo hoses the following may be installed:
(a) lighting fittings with pressurized enclosures, or of the flameproof type. The lighting system should be divided between at least two branch circuits. All switches and protective devices should interrupt all poles or phases and be located in a gas-safe space; and
(b) through runs of cables.
(3) In enclosed or semi-enclosed spaces having a direct opening into any gas-dangerous space or zone there should be installed electrical installations complying with the requirements for the space or zone to which the opening leads.
(4) Electrical equipment within spaces protected by air locks should be of the certified safe type unless arranged to be de-energized by measures required by **306. 4.**

SECTION 11
Fire Protection and Fire Extinction

1101. Fire safety requirements (IGC Code 11.1)

1. The requirements for tankers in chapter II-2 of the 1983 SOLAS adendments should apply to ships covered by this Chapter, irrespective of tonnage including ships of less than 500 tons gross tonnage, except that:

(1) regulation 56.6 does not apply;
(2) regulation 4 as applicable to cargo ships and regulation 7 should apply as they would apply to tankers of 2,000 tons gross tonnage and over;
(3) the following regulations of chapter II-2 of the 1983 SOLAS amendments related to tankers do not apply and are replaced by Sections and articles of this Chapter as detailed below:

Regulation	Replaced by
17	1106.
56.1 and 56.2	Sec 3
60, 61, 62	1103. and 1104.
63	1105.

2. All sources of ignition should be excluded from spaces where flammable vapour may be present except as otherwise provided in **Secs 10** and **16.**

3. The provisions of this article apply in conjunction with **Sec 3.**

4. For the purposes of fire fighting, any open deck areas above cofferdams, ballast or void spaces at the after end of the aftermost hold space or at the forward end of the forwardmost hold space shoulc be included in the cargo area.

1102. Fire water main equipment (IGC Code 11.2)

1. All ships, irrespective of size, carrying products which are subject to this Chapter should comply with the requirements of regulations 11-2/4 and II-2/7 of the 1983 SOLAS amendments, except that the required fire pump capacity and fire main and water service pipe diameter should not be limited by the provisions of regulations 4.2.1 and 4.4.1 when the fire pump and fire main are used as part of the water spray system as permitted by **1103. 3.** In addition, the requirements of regulation 4.4.2 should be met at a pressure of at least 0.5 MPa gauge.

2. The arrangements should be such that at least two jets of water can reach any part of the deck in the cargo area and those portions of the cargo containment system and tank covers above the deck. The necessary number of fire hydrants should be located to satisfy the above arrangements and to comply with the requirements of regulations II-2/4.5.1 and II-2/4.8 of the 1983 SOLAS amendments, with hose lengths not exceeding 33 m.

3. Stop valves should be fitted in any crossover provided and in the fire main or mains at the poop front and at intervals of not more than 40 m between hydrants on the deck in the cargo area for the purpose of isolating damaged sections of the main.

4. All water nozzles provided for fire-fighting use should be of an approved dual-purpose type capable of producing either a spray or a jet. All pipes, valves, nozzles and other fittings in the fire-fighting systems should be resistant to the effects of fire and to corrosion by water.

5. Where the ship's engine-room is unattended, arrangements should be made to start and connect to the fire main at least one fire pump by remote control from the navigating bridge or other control station outside the cargo area.

1103. Water spray system (IGC Code 11.3)

1. On ships carrying flammable or toxic products or both, a water spray system for cooling, fire prevention and crew protection should be installed to cover:

(1) exposed cargo tank domes and any exposed parts of cargo tanks;
(2) exposed on-deck storage vessels for flammable or toxic products;
(3) cargo liquid and vapour discharge and loading manifolds and the area of their control valves and any other areas where essential control valves are situated and which should be at least equal to the area of the drip trays provided; and
(4) boundaries of superstructures and deckhouses normally manned, cargo compressors rooms, cargo pump rooms, store-rooms containing high fire risk items and cargo control rooms, all facing the cargo area. Boundaries of unmanned forecastle structures not containing high fire risk items or equipment do not require water spray protection.

2. The system should be capable of covering all areas mentioned in **Par 1** with a uniformly distributed water spray of at least 10 l/m^2 per minute for horizontal projected surfaces and 4 l/m^2 per minute for vertical surfaces. For structures having no clearly defined horizontal or vertical surfaces, the capacity of the water spray system should be the greater of the following:

(1) projected horizontal surface multiplied by 10 l/m^2 per minute; or
(2) actual surface multiplied by 4 l/m^2 per minute.

On vertical surfaces, spacing of nozzles protecting lower areas may take account of anticipated rundown from higher areas. Stop valves should be fitted at intervals in the spray main for the purpose of isolating damaged sections. Alternatively, the system may be divided into two or more sections which may be operated independently provided the necessary controls are located together, aft of the cargo area. A section protecting any area included in **Par 1** (1) and (2) should cover the whole of the athwartship tank grouping which includes that area.

3. The capacity of the water spray pumps should be sufficient to deliver the required amount of water to all areas simultaneously or where the system is divided into sections, the arrangements and capacity should be such as to supply water simultaneously to anyone section and to the surfaces specified in **Par 1** (3) and (4). Alternatively, the main fire pumps may be used for this service provided that their total capacity is increased by the amount needed for the spray system. In either case, a connection, through a stop valve, should be made between the fire main and water spray main outside the cargo area.

4. Subject to the approval of the Society, water pumps normally used for other services may be arranged to supply the water spray main.

5. All pipes, valves, nozzles and other fittings in the water spray systems should be resistant to corrosion by seawater, for which purpose galvanized pipe, for example, may be used, and to the effect of fire.

6. Remote starting of pumps supplying the water spray system and remote operation of any normally closed valves in the system should be arranged in suitable locations outside the cargo area, adjacent to the accommodation spaces and readily accessible and operable in the event of fire in the areas protected.

1104. Dry chemical powder fire-extinguishing systems (IGC Code 11.4)

1. Ships in which the carriage of flammable products is intended should be fitted with fixed dry chemical powder type extinguishing systems for the purpose of fighting fire on the deck in the cargo area and bow or stern cargo handling areas if applicable. The system and the dry chemical powder should be adequate fo this purpose and satisfactory to the Society.

2. The system should be capable of delivering powder from at least two hand hose lines or combination monitor/hand hose lines to any part of the above-deck exposed cargo area including above-deck product piping. The system should be activated by an inert gas such as nitrogen, used exclusively for this purpose and stored in pressure vessels adjacent to the powder containers.

3. The system for use in the cargo area should consist of at least two independent self-contained dry chemical powder units with associated controls, pressurizing medium fixed piping, monitors or hand hose lines. For ships with a cargo capacity of less than 1,000 m^3 only one such unit need be fitted, subject to approval by the Society. A monitor should be provided and so arranged as to protect the cargo loading and discharge manifold areas and be capable of actuation and discharge locally and remotely. The monitor is not required to be remotely aimed if it can deliver the necessary powder to all required areas of coverage from a single position. All hand hose lines and monitors should be capable of actuation at the hose storage reel or monitor. At least one hand hose line or monitor should be situated at the after end of the cargo area.

4. A fire-extinguishing unit having two or more monitors, hand hose lines, or combinations thereof, should have independent pipes with a manifold at the powder container, unless a suitable alternative means is provided to ensure proper performance as approved by the Society. Where two or more pipes are attached to a unit the arrangement should be such that any or all of the monitors and hand hose lines should be capable of simultaneous or sequential operation at their rated capacities.

5. The capacity of a monitor should be not less than 10 kg/s. Hand hose lines should be non-kinkable and be fitted with a nozzle capable of on/off operation and discharge at a rate not less than 3.5 kg/s. The maximum discharge rate should be such as to allow operation by one man. The length of a hand hose line should not exceed 33 m. Where fixed piping is provided between the powder container and a hand hose line or monitor, the length of piping should not exceed that length which is capable of maintaining the powder in a fluidized state during sustained or intermittent use, and which can be purged of powder when the system is shut down. Hand hose lines and nozzles should be of weather-resistant construction or stored in weater-resistant housing or covers and be readily accessible.

6. A sufficient quantity of dry chemical powder should be stored in each container to provide a minimum 45 seconds discharge time for all monitors and hand hose lines attached to each powder unit. Coverage from fixed monitors should be in accordance with **Table 7.5.10.**

Table 7.5.10 Coverage from Fixed Monitors

Capacity of fixed monitors(kg/sec) each	10	25	45
Maximum distance of coverage(m)	10	30	40

Hand hose lines should be considered to have a maximum effective distance of coverage equal to the length of hose. Special consideration should be given where areas to be protected are substantially higher than the monitor or hand hose reel locations.

7. Ships fitted with bow or stern loading and discharge arrangements should be provided with an additional dry chemical powder unit complete with at least one monitor and one hand hose line complying with the requirements of **Pars 1** to **6**. This additional unit should be located to protect the bow or stern loading and discharge arrangements. The area of the cargo line forward or aft of the cargo area should be protected by hand hose lines.

1105. Cargo compressor and pump rooms (IGC Code 11.5)

1. The cargo compressor and pump rooms of any ship should be provided with a carbon dioxide system as specified in regulation II-2/5.1 and 2 of the 1974 SOLAS Convention, as amended. A notice should be exhibited at the controls stating that the system is only to be used for fire-extinguishing and not for inerting purposes, due to the electrostatic ignition hazard. The alarms referred to in regulation II-2/ 5.1.6 of the 1983 SOLAS amendments should be safe for use in a flammable cargo vapour-air mixture. For the purpose of this requirement, an extinguishing system should be provided which would be suitable for machinery spaces. However, the amount of carbon dioxide gas carried should be sufficient to provide a quantity of free gas equal to 45% of the gross volume of the cargo compressor and pump rooms in all cases.

2. Cargo compressor and pump rooms of ships which are dedicated to the carriage of a restricted number of cargoes should be protected by an appropriate fire-extinguishing system approved by the Society.

1106. Firemen’s outfits (IGC Code 11.6)

1. Every ship carrying flammable products should

carry firemen's outfits complying with the requirements of regulation II-2/17 of the 1983 SOLAS amendments as follows:

Total cargo capacity	Number of outfits
5,000 m^3 and below	4
above 5,000 m^3	5

2. Additional requirements for safety equipment are given in **Sec 14.**

3. Any breathing apparatus required as part of a fireman's outfit should be a self-contained air-breathing apparatus having a capacity of at least 1,200 l of free air.

SECTION 12
Mechanical Ventilation in the Cargo Area

The requirements of this Section should be substituted for regulation II-2/59.3 of the 1983 SOLAS amendments.

1201. Spaces required to be entered during normal cargo handling operations (IGC Code 12.1)

1. Electric motor rooms, cargo compressor and pump rooms, other enclosed spaces which contain cargo handling equipment and similar spaces in which cargo handling operations are performed should be fitted with mechanical ventilation systems capable of being controlled from outside such spaces. Provision should be made to ventilate such spaces prior to entering the compartment and operating the equipment and a warning notice requiring the use of such ventilation should be placed outside the compartment.

2. Mechanical ventilation inlets and outlets should be arranged to ensure sufficient air movement through the space to avoid the accumulation of flammable or toxic vapours and to ensure a safe working environment, but in no case should the ventilation system have a capacity of less than 30 changes of air per hour based upon the total volume of the space. As an exception, gas-safe cargo control rooms may have eight changes of air per hour.

3. Ventilation systems should be fixed and, if of the negative pressure type, permit extraction from either the upper or the lower parts of the spaces, or from both the upper and the lower parts, depending on the density of the vapours of the products carried.

4. In rooms housing electric motors driving cargo compressors or pumps, spaces except machinery spaces containing inert gas generators, cargo control rooms if considered as gas-safe spaces and other gas-safe spaces within the cargo area, the ventilation should be of the positive pressure type.

5. In cargo compressor and pump rooms and in cargo control rooms if considered gas-dangerous, the ventilation should be of the negative pressure type.

6. Ventilation exhaust ducts from gas-dangerous spaces should discharge upwards in locations at least 10 m in the horizontal direction from ventilation intakes and openings to accommodation spaces, service spaces and control stations and other gas-safe spaces.

7. Ventilation intakes should be so arranged as to minimize the possibility of re-cycling hazardous vapours from any ventilation discharge opening.

8. Ventilation ducts from gas-dangerous spaces should not be led through accommodation, service and machinery spaces or control stations, except as allowed in **Sec 16.**

9. Electric motors driving fans should be placed outside the ventilation ducts if the carriage of flammable products is intended. Ventilation fans should not produce a source of vapour ignition in either the ventilated space or the ventilation system associated with the space. Ventilation fans and fan ducts, in way of fans only, for gas-dangerous spaces should be of nonsparking construction defined as:

(1) impellers or housing of nonmetallic construction, due regard being paid to the elimination of static electricity;
(2) impellers and housing of nonferrous materials;
(3) impellers and housing of austenitic stainless steel; and
(4) ferrous impellers and housing with not less than 13 mm design tip clearance.

Any combination or an aluminium or magnesium alloy fixed or rotating component and a ferrous fixed or rotating component, regardless of tip clearance, is considered a sparking hazard and should not be used in these places.

10. Spare parts should be carried for each type of fan on board referred to in this Section.

11. Protection screens of not more than 13 mm square mesh should be fitted in outside openings of ventilation ducts.

1202. Spaces not normally entered (IGC Code 12.2)

Hold spaces, interbarrier spaces, void spaces, cofferdams, spaces containing cargo piping and other spaces where cargo vapour may accumulate, should be capable of being ventilated to ensure a safe environment when entry into the spaces is necessary. Where a permanent ventilation system is not provided for such spaces, approved means of portable mechanical ventilation should be provided. Where necessary owing to the arrangement of spaces, such as hold spaces and interbarrier spaces, essential ducting for such ventilation should be permanently installed. Fans or blowers should be clear of personnel access openings, and should comply with **1201. 9.**

SECTION 13
Instrumentation (Gauging, Gas Detection)

1301. General (IGC Code 13.1)

1. Each cargo tank should be provided with means for indicating level, pressure and temperature of the cargo. Pressure gauges and temperature indicating devices should be installed in the liquid and vapour piping systems, in cargo refrigerating installations and in the inert gas systems as detailed in this Section.

2. Where a secondary barrier is required, permanently installed instrumentation should be provided to detect when the primary barrier fails to be liquid tight at any location or when liquid cargo is in contact with the secondary barrier at any location. This instrumentation should consist of appropriate gas detecting devices according to **1306.** However, the instrumentation need not be capable of locating the area where liquid cargo leaks through the primary barrier or where liquid cargo is in contact with the secondary barrier.

3. If the loading and unloading of the ship is performed by means of remotely controlled valves and pumps, all controls and indicators associated with a given cargo tank should be concentrated in one control position.

4. Instruments should be tested to ensure reliability in the working conditions and recalibrated at regular intervals. Test procedures for instruments and the intervals between recalibration should be approved by the Society.

1302. Level indicators for cargo tanks (IGC Code 13.2)

1. Each cargo tank should be fitted with at least one liquid level gauging device, designed to operate at pressures not less than the MARVS of the cargo tank and at temperatures within the cargo operating temperature range. Where only one liquid level gauge is fitted it should be so arranged that any necessary maintenance can be carried out while the cargo tank is in service.

2. Cargo tank liquid level gauges may be of the following types subject to any special requirement for particular cargoes shown in column ''g'' in the table of **Sec 19**:

(1) indirect devices, which determine the amount of cargo by means such as weighing or pipe flow meters;
(2) closed devices, which do not penetrate the cargo tank, such as devices using radioisotopes or ultrasonic devices;
(3) closed devices, which penetrate the cargo tank, but which form part of a closed system and keep the cargo from being released, such as float type systems, electronic probes, magnetic probes and bubble tube indicators. If a closed gauging device is not mounted directly on the tank it should be provided with a shutoff valve located as close as possible to the tank; and
(4) restricted devices, which penetrate the tank and when in use permit a small quantity of cargo vapour or liquid to escape to the atmosphere, such as fixed tube and slip tube gauges. When not in use, the devices should be kept completely closed. The design and installation should ensure that no dangerous escape of cargo can take place when opening the device. Such gauging devices should be so designed that the maximum opening does not exceed 1.5 mm diameter or equivalent area unless the device is provided with an excess flow valve.

3. Sighting ports with a suitable protective cover and situated above the liquid level with an internal scale may be allowed by the Society as a secondary means of gauging for cargo tanks having a design vapour pressure not higher than 0.07 MPa.

4. Tubular gauge glasses should not be fitted. Gauge glasses of the robust type as fitted on high-pressure boilers and fitted with excess flow valves may be allowed by the Society for deck tanks, subject to any provisions of **Sec 17.**

1303. Overflow control (IGC Code 13.3)

1. Except as provided in **Par 2,** each cargo tank should be fitted with a high liquid level alarm operating independently of other liquid level indicators and giving an audible and visual warning when activated. Another sensor operating independently of the high liquid level alarm should automatically actuate a shutoff valve in a manner which will both avoid excessive liquid pressure in the loading line and prevent the tank from becoming liquid full. The emergency shutdown valve referred to in **506. 1** and **506. 3** may be used for this purpose. If another valve is used for this purpose, the same information as referred to in **506. 4** should be available on board.

2. A high liquid level alarm and automatic shutoff of cargo tank filling need not be required when the cargo tank:

(1) is a pressure tank with a volume not more than 200 m^3; or
(2) is designed to withstand the maximum possible pressure during the loading operation and such pressure is below that of the start-to-discharge pressure of the cargo tank relief valve.

3. Electrical circuits, if any, of level alarms should be capable of being tested prior to loading.

1304. Pressure gauges (IGC Code 13.4)

1. The vapour space of each cargo tank should be provided with a pressure gauge which should incorporate an indicator in the control position required by **1301. 3.** In addition, a high-pressure alarm and, if vacuum protection is required, a low-pressure alarm should be provided on the navigating bridge. Maximum and minimum allowable pressures should be marked on the indicators. The alarms should be activated before the set pressures are reached. For cargo tanks fitted with pressure relief valves, which can be set at more than one set pressure in accordance with **802. 6,** high-pressure alarms should be provided for each set pressure.

2. Each cargo pump discharge line and each liquid and vapour cargo manifold should be provided with at least one pressure gauge.

3. Local-reading manifold pressure gauges should be provided to indicate the pressure between stop valves and hose connections to the shore.

4. Hold spaces and interbarrier spaces without open connection to the atmosphere should be provided with pressure gauges.

1305. Temperature indicating devices (IGC Code 13.5)

1. Each cargo tank should be provided with at least two devices for indicating cargo temperatures, one placed at the bottom of the cargo tank and the second near the top of the tank, below the highest allowable liquid level. The temperature indicating devices should be marked to show the lowest temperature for which the cargo tank has been approved by the Society .

2. When a cargo is carried in a cargo containment system with a secondary barrier at a temperature lower than -55°C, temperature indicating devices should be provided within the insulation or on the hull structure adjacent to cargo containment systems. The devices should give readings at regular intervals and, where applicable, audible warning of temperatures approaching the lowest for which the hull steel is suitable.

3. If cargo is to be carried at temperatures lower than -55°C, the cargo tank boundaries, if appropriate for the design of the cargo containment system, should be fitted with temperature indicating devices as follows:

(1) A sufficient number of devices to establish that an unsatisfactory temperature gradient does not occur.
(2) On one tank a number of devices in excess of those required in (1) in order to verify that the initial cool down procedure is satisfactory. These devices may be either temporary or permanent. When a series of similar ships is built, the second and successive ships need not comply with the requirements of this sub-paragraph.

4. The number and position of temperature indicating devices should be to the satisfaction of the Society.

1306. Gas detection requirements (IGC Code 13.6)

1. Gas detection equipment acceptable to the Society and suitable for the gases to be carried should be provided in accordance with column “f” in the table of **Sec 19.**

2. In every installation, the positions of fixed sampling heads should be determined with due regard to the density of the vapours of the products intended to be carried and the dilution from compartment purging or ventilation.

3. Pipe runs from sampling heads should not be led through gas-safe spaces except as permitted by **Par 5.**

4. Audible and visual alarms from the gas detection equipment, if required by this Article, should be located on the navigating bridge, in the control position required by **1301. 3,** and at the gas detector readout location.

5. Gas detection equipment may be located in the control position required by **1301. 3,** on the navigating bridge or at other suitable locations. When such equipment is located in a gas-safe space the following conditions should be met:

(1) gas-sampling lines should have shutoff valves or an equivalent arrangement to prevent cross-communication with gas-dangerous spaces; and
(2) exhaust gas from the detector should be discharged to the atmosphere in a safe location.

6. Gas detection equipment should be so designed that it may readily be tested. Testing and calibration should be carried out at regular intervals. Suitable equipment and span gas for this purpose should be carried on board. Where practicable, permanent connections for such equipment should be fitted.

7. A permanently installed system of gas detection and audible and visual alarms should be provided for:

(1) cargo pump rooms;
(2) cargo compressor rooms;
(3) motor rooms for cargo handling machinery;
(4) cargo control rooms unless designated as gas-safe;
(5) other enclosed spaces in the cargo area where vapour may accumulate including hold spaces and interbarrier spaces for independent tanks other than type C;
(6) ventilation hoods and gas ducts where required by **Sec 16**; and
(7) air locks.

8. The gas detection equipment should be capable of sampling and analysing from each sampling head location sequentially at intervals not exceeding 30 min, except that in the case of gas detection for the ventilation hoods and gas ducts referred to in **1306. 7** (6) sampling should be continuous. Common sampling lines to the detection equipment should not be fitted.

9. In the case of products which are toxic or both toxic and flammable, the Society except when column "i" in the table of **Sec 19** refers to **1709.,** may authorize the use of portable equipment for detection of toxic products as an alternative to a permanently installed system, if such equipment is used before personnel enter the spaces listed in **Par 7** and at 30 min intervals while they remain therein.

10. For the spaces listed in **Par 7,** alarms should be activated for flammable products when the vapour concentration reaches 30% of the lower flammable limit.

11. In the case of flammable products, where cargo containment systems other than independent tanks are used, hold spaces and interbarrier spaces should be provided with a permanently installed gas detection system capable of measuring gas concentrations of 0% to 100% by volume. The detection equipment, equipped with audible and visual alarms, should be capable of monitoring from each sampling head location sequentially at intervals not exceeding 30 min. Alarms should be activated when the vapour concentration reaches the equivalent of 30% of the lower flammable limit in air or such other limit as may be approved by the Society in the light of particular cargo containment arrangements. Common sampling lines to the detection equipment should not be fitted.

12. In the case of toxic gases, hold spaces and interbarrier spaces should be provided with a permanently installed piping system for obtaining gas samples from the spaces. Gas from these spaces should be sampled and analysed from each sampling head location by means of fixed or portable equipment at intervals not exceeding 4 h and in any event before personnel enter the space and at 30 min intervals while they remain therein.

13. Every ship should be provided with at least two sets of portable gas detection equipment acceptable to the Society and suitable for the products to be carried.

14. A suitable instrument for the measurement of oxygen levels in inert atmospheres should be provided.

SECTION 14
Personnel Protection

1401. Protective equipment (IGC Code 14.1)

Suitable protective equipment including eye protection should be provided for protection of crew members engaged in loading and discharging operations, taking into account the character of the products.

1402. Safety equipment (IGC Code 14.2)

1. Sufficient, but not less than two complete sets of safety equipment in addition to the firmen's outfits required by **1106. 1** each permitting personnel to enter and work in a gas-filled space, should be provided.

2. One complete set of safety equipment should consist of:

(1) one self-contained air-breathing apparatus not using stored oxygen, having a capacity of at least 1,200 l of free air;
(2) protective clothing, boots, gloves and tight fitting goggles;
(3) steel-cored rescue line with belt; and
(4) explosion-proof lamp.

3. An adequate supply of compressed air should be provided and should consist either of:

(1) one set of fully charged spare air bottles for each breathing apparatus required by **Par 1**; a special air compressor suitable for the supply of high-pressure air of the required purity; and a charging manifold capable of dealing with sufficient spare breathing apparatus air bottles for the breathing apparatus required by **Par 1**; or
(2) fully charged spare air bottles with a total free air capacity of at least 6,000 l for each breathing apparatus required by **Par 1.**

4. Alternatively, the Society may accept a low-pressure air line system with hose connection suitable for use with the breathing apparatus required by **Par 1.** This system should provide sufficient high-pressure air capacity to supply, through pressure reduction devices, enough low-pressure air to enable two men to work in a gas-dangerous space for at least 1 h without using the air bottles of the breathing apparatus. Means should be provided for recharging the fixed air bottles and the breathing apparatus air bottles from a special air compressor suitable for the supply of high-pressure air of the required purity.

5. Protective equipment required in **1401.** and safety equipment required in **Par 1** should be kept in suitable, clearly marked lockers located in readily accessible places.

6. The compressed air equipment should be inspected at least once a month by a responsible officer and the inspection recorded in the ship's logbook, and inspected and tested by an expert at least once a year.

1403. First-aid equipment (IGC Code 14.3)

1. A stretcher which is suitable for hoisting an injured person from spaces below deck should be kept in a readily accessible location.

2. The ship should have on board medical first-aid equipment, including oxygen resuscitation equipment and antidotes for cargoes to be carried. Medical First Aid Guide for Use in Accidents Involving Dangerous Goods(MFAG) numbers related to products covered by the code are given in the table of minimum requirements(Sec 19)

1404. Personnel protection requirements for individual products (IGC Code 14.4)

1. Provisions of **1404.** are applicable to ships carrying products for which those paragraphs are listed in column "i" in the table of **Sec 19.**

2. Respiratory and eye protection suitable for emergency escape purposes should be provided for every person on board subject to the following:

(1) (a) filter type respiratory protection is unacceptable;
(b) self-contained breathing apparatus should normally have a duration of service of at least 15 min;

(2) emergency escape respiratory protection should not be used for fire-fighting or cargo handling purposes and should be marked to that effect;

(3) two additional sets of the above respiratory and eye protection should be permanently located in the navigating bridge.

3. Suitably marked decontamination showers and an eyewash should be available on deck in convenient locations. The showers and eyewash should be operable in all ambient conditions.

4. In ships of a cargo capacity of 2,000 m^3 and over, two complete sets of safety equipment should be provided in addition to the equipment required by **1106. 1** and **1402. 1.** At least three spare charged air bottles should be provided for each self-contained air breathing apparatus required in this paragraph.

5. Personnel should be protected against the effects of a major cargo release by the provision of a space within the accommodation area designed and equipped to the satisfaction of the Society.

6. For certain highly dangerous products, cargo control rooms should be of the gas-safe type only.

SECTION 15
Filling Limits for Cargo Tanks

1501. General (IGC Code 15.1)

1. No cargo tanks should have a higher filling limit(FL) than 98% at the reference temperature, except as permitted by **Par 3.**

2. The maximum loading limit(LL) to which a cargo tank may be loaded should be determined by the following formula:

$$LL = FL\frac{\rho_R}{\rho_L}$$

where:
LL = loading limit expressed as a percentage, being the maximum allowable liquid volume relative to the tank volume to which the tank may be loaded(%)
FL = filling limit as specified in **Par 1** or **3**
ρ_R = relative density of cargo at the reference temperature
ρ_L = relative density of cargo at the loading temperature and pressure.

3. The Society may allow a higher filling limit(FL) than the limit of 98% specified in **Par 1** at the reference temperature, taking into account the shape of the tank, arrangements of pressure relief valves, accuracy of level and temperature gauging and the difference between the loading temperature and the temperature corresponding to the vapour pressure of the cargo at the set pressure of the pressure relief valves, provided the conditions in **802. 17** are maintained.

4. The Society may allow type C tanks to be loaded according to the following formula, provided that the tank vent system has been approved in accordance with **802. 18**:

$$LL = FL\frac{\rho_R}{\rho_L}$$

where:
LL = loading limit as specified in **Par 2**;
FL = filling limiit as specified in **Par 1** or **3**;
ρ_R = relative density of cargo at the highest temperature which the cargo may reach

upon termination or loading, during transport, or at unloading, under the ambient design temperature conditions described in **701. 2**; and

ρ_L = as specified in **Par 2**.

This paragraph does not apply to products requiring a type 1G ship.

5. For the purposes of this Section only, "reference temperature" means:

(1) the temperature corresponding to the vapour pressure of the cargo at the set pressure of the pressure relief valves when no cargo vapour pressure/temperature control as referred to in **Sec 7** is provided.

(2) the temperature of the cargo upon termination of loading, during transport, or at unloading, whichever is the greatest, when a cargo vapour pressure/temperature control as referred to in **Sec 7** is provided. If this reference temperature would result in the cargo tank becoming liquid full before the cargo reaches a temperature corresponding to the vapour pressure of the cargo at the set pressure of the relief valves required in **802.**, an additional pressure relieving system complying with **803.** should be fitted.

6. This Section applies to all ships regardless of the date of construction.

1502. Information to be provided to the master (IGC Code 15.2)

The maximum allowable loading limits for each cargo tank should be indicated for each product which may be carried, for each loading temperature which may be applied and for the applicable maximum reference temperature, on a list to be approved by the Society. Pressures at which the pressure relief valves, including those valves required by **803.**, have been set should also be stated on the list. A copy of the list should be permanently kept on board by the master.

SECTION 16
Use of Cargo as Fuel

1601. General (IGC Code 16.1)

1. Methane (LNG) is the only cargo whose vapour or boil-off gas may be utilized in machinery spaces of category A and in such spaces may be utilized only in boilers, inert gas generators, combustion engines and gas turbines.

2. These provisions do not preclude the use of gas fuel for auxiliary services in other locations, provided that such other services and locations should be subject to special consideration by the Society.

1602. Arrangement of machinery spaces of category A (IGC Code 16.2)

1. Spaces in which gas fuel is utilized should be fitted with a mechanical ventilation system and should be arranged in such a way as to prevent the formation of dead spaces. Such ventilation should be particularly effective in the vicinity of electrical equipment and machinery or of other equipment and machinery which may generate sparks. Such a ventilation system should be separated from those intended for other spaces.

2. Gas detectors should be fitted in these spaces, particularly in the zones where air circulation is reduced. The gas detection system should comply with the requirements of **Sec 13.**

3. Electrical equipment located in the double wall pipe or duct specified in **1603. 1** should be of the intrinsically safe type.

1603. Gas fuel supply (IGC Code 16.3)

1. Gas fuel piping should not pass through accommodation spaces, service spaces or control stations. Gas fuel piping may pass through or extend into other spaces provided they fulfil one of the following:

(1) the gas fuel piping should be a double wall piping system with the gas fuel contained in the inner pipe. The space between the concentric pipes should be pressurized with inert gas at a pressure greater than the gas fuel pressure. Suitable alarms should be provided to indicate a loss of inert gas pressure between the pipes; or

(2) the gas fuel piping should be installed within a ventilated pipe or duct. The air space between the gas fuel piping and the inner wall of this pipe or duct should be equipped with mechanical exhaust ventilation having a capacity of at least 30 air changes per hour. The ventilation system should be arranged to maintain a pressure less than the atmospheric pressure. The fan motors should be placed outside the ventilated pipe or duct. The ventilation outlet should be placed in a position where no flammable gas-air mixture may be ignited. The ventilation should always be in operation when there is gas fuel in the piping. Continuous gas detection should be provided to indicate leaks and to shut down the gas fuel supply to the machinery space in accordance with **Par 10.** The master gas fuel valve required by **Par 7** should close automatically, if the required air flow is not established and maintained by the exhaust ventilation system.

2. If a gas leak occurs, the gas fuel supply should not be restored until the leak has been found and repaired. Instructions to this effect should be placed in a prominent position in the machinery spaces.

3. The double wall piping system or the ventilated pipe or duct provided for the gas fuel piping should terminate at the ventilation hood or casing required by **Par 4.**

4. A ventilation hood or casing should be provided fo the areas occupied by flanges, valves, etc., and for the gas fuel piping, at gas fuel utilization units, such as boilers, diesel engines and gas turbines. If this ventilation hood or casing is not served by the exhaust ventilation fan serving the ventilated pipe or duct as specified in **Par 1** (2), then it should be equipped with an exhaust ventilation system and continuous gas detection should be provided to indicate leaks and to shut down the gas fuel supply to the machinery space in accordance with **Par 10.** The master gas fuel valve required by **Par 7** should close automatically if the required air flow is not established and maintained by the exhaust ventilation system. The ventilation hood or casing should be installed or mounted to permit the ventilating air to sweep across the gas utilization unit and be exhausted at the top of the ventilation hood or casing.

5. The ventilation inlet and discharge for the required ventilation systems should be respectively from and to a safe location.

6. Each gas utilization unit should be provided with a set of three automatic valves. Two of these valves should be in series in the gas fuel pipe to the consuming equipment. The third valve should be in a pipe that vents, to a safe location in the open air, that portion of the gas fuel piping that is between the two valves in series. These valves should be so arranged that failure of the necessary forced draft, loss of flame on boiler burners, abnormal pressure in the gas fuel supply line, or failure of the valve control actuating medium will cause the two gas fuel valves which are in series to close automatically and cause the vent valve to open automatically. Alternatively, the function of one of the valves in series and of the valve in the vent line can be incorporated into one valve body so arranged that, when one of the above conditions occurs, flow to the gas utilization unit will be blocked and the vent opened. The three shut-off valves should be arranged for manual reset.

7. A master gas fuel valve that can be closed from within the machinery space should be provided within the cargo area. The valve should be arranged so as to close automatically if leakage of gas is detected, or loss of ventilation for the duct or casing or loss of pressurization of the double wall gas fuel piping occurs.

8. Gas fuel piping in machinery spaces should comply with **502.** to **505.** as far as found applicable. The piping should, as far as practicable, have welded joints. Those parts of the gas fuel piping, which are not enclosed in a ventilated pipe or duct according to **Par 1** and are on the open deck outside the cargo area should have full penetration butt-welded joints and should be fully radiographed.

9. Provision should be made for inerting and gas-freeing that portion of the gas fuel piping system located in the machinery space.

10. Gas detection systems provided in accordance with the requirements of **Pars 1** and **4** should comply with **1306. 2** and **1306. 4** through **1306. 8** as applicable; they should activate the alarm at 30% of the lower flammable limit and shut down the master gas fuel valve referred to in **Par 7** before the gas concentration reaches 60% of the lower flammable limit.

1604. Gas make-up plant and related storage tanks (IGC Code 16.4)

1. All equipment (heaters, compressors, filters, etc.) for making up the gas for its use as fuel, and the related storage tanks should be located in the cargo area in accordance with the requirement of **301. 5** (4). If the equipment is in an enclosed space, the space should be ventilated according to **1201.** and be equipped with a fixed fire-extinguishing system according to **1105.** and with a gas detection system according to **1306.,** as applicable.

2. The compressors should be capable of being remotely stopped from a position which is always and easily accessible, and also from the engine-room. In addition, the compressors should be capable of automatically stopping when the suction pressure reaches a certain value depending on the set pressure of the vacuum relief valves of the cargo tanks. The automatic shut-down device of the compressors should have a manual resetting. Volumetric compressors should be fitted with pressure relief valves discharging into the suction line of the compressor. The size of the pressure relief valves should be determined in such a way that, with the delivery valve kept closed, the maximum pressure does not exceed by more than 10% the maximum working pressure, The requirements of **506. 1** (3) apply to these compressors.

3. If the heating medium for the gas fuel evaporator or heater is returned to spaces outside the cargo area it should first go through a degassing tank. The degassing tank should be located in the cargo area. Provisions should be made to detect and alarm the presence of gas in the tank. The vent outlet should be in a safe position and fitted with a flame screen.

4. Piping and pressure vessels in the gas fuel conditioning system should comply with **Sec 5.**

1605. Special requirements for main boilers (IGC Code 16.5)

1. Each boiler should have a separate uptake.

2. A system suitable to ensure the forced draught in the boilers should be provided. The particulars of such a system should be to the satisfaction of the Society.

3. Combustion chambers of boilers should be of suitable form such as not to present pockets where gas may accumulate.

4. The burner systems should be of dual type, suitable to burn either oil fuel or gas fuel alone or oil and gas fuel simultaneously. Only oil fuel should be used during manoeuvring and port operations unless automatic transfer from gas to oil burning is provided in which case the burning of a combination of oil and gas or gas alone may be permitted provided the system is demonstrated to the satisfaction of the Society. It should be possible to change over easily and quickly from gas fuel operation to oil fuel operation. Gas nozzles should be fitted in such a way that gas fuel is ignited by the flame of the oil fuel burner. A flame scanner should be installed and arranged to assure that gas flow to the burner is cut off unless satisfactory ignition has been established and maintained. On the pipe of each gas burner a manually operated shut-off valve should be fitted. An installation should be provided for purging the gas supply piping to the burners by means of inert gas or steam, after the extinguishing of these burners.

5. Alarm devices should be fitted in order to monitor a possible decrease in liquid fuel oil pressure or a possible failure of the related pumps.

6. Arrangements should be made that, in case of flame failure of all operating burners for gas or oil or for a combination thereof, the combustion chambers of the boilers are automatically purged before relighting. Arrangements should also be made to enable the boilers to be manually purged.

1606. Special requirements for gas-fired internal combustion engines and gas-fired turbines (IGC Code 16.6)

Special provisions for gas-fuelled internal combustion engines and for gas turbines will be considered by the Society in each case.

SECTION 17
Special Requirements

1701. General (IGC Code 17.1)

The provisions of this Section are applicable where reference is made in column ''i'' in the table of **Sec 19.** These are requirements additional to the general requirements of this Chapter.

1702. Materials of construction (IGC Code 17.2)

Materials which may be exposed to cargo during normal operations should be resistant to the corrosive action of the gases. In addition, the following materials of construction for cargo tanks, and associated pipelines, valves, fittings and other items of equipment should not be used for certain products as specified in column “i” in the table of **Sec 19**:

(1) mercury, copper and copper-bearing alloys, and zinc;
(2) copper, silver, mercury, magnesium and other acetylide-forming metals;
(3) aluminium and aluminium-bearing alloys;
(4) copper, copper alloys, zinc and galvanized steel;
(5) aluminium, copper and alloys of either;
(6) copper and copper-bearing alloys with greater than 1 % copper.

1703. Independent tanks (IGC Code 17.3)

1. Products should be carried in independent tanks only.

2. Products should be carried in type C independent tanks and the provisions of **701. 3** apply. The design pressure of the cargo tank should take into account any padding pressure or vapour discharge unloading pressure.

1704. Refrigeration systems (IGC Code 17.4)

1. Only the indirect system described in **702. 4** (2) should be used.

2. For a ship engaged in the carriage of products which readily form dangerous peroxides, recondensed cargo should not be allowed to form stagnant pockets of uninhibited liquid. This may be achieved either by:

(1) using the indirect system described in **702. 4** (2) with the condenser inside the cargo tank; or
(2) using the direct system or combined system described in **702. 4** (1) and (3) respectively, or the indirect system described in **702. 4** (2) with the condenser outside the cargo tank, and designing the condensate system to avoid any places in which liquid could collect and be retained. Where this is impossible inhibited liquid should be added upstream of such a place.

3. If the ship is to carry consecutively products as specified in **Par 2** with a ballast passage between, all uninhibited liquid should be removed prior to the ballast voyage. If a second cargo is to be carried between such consecutive cargoes, the reliquefaction system should be thoroughly drained and purged before loading the second cargo. Purging should be carried out using either inert gas or vapour from the second cargo, if compatible. Practical steps should be taken to ensure that polymers or peroxides do not accumulate in the cargo system.

1705. Deck cargo piping (IGC Code 17.5)

One hundred per cent radiography of all butt-welded joints in cargo piping exceeding 75 mm in diameter is required.

1706. Exclusion of air from vapour spaces (IGC Code 17.6)

Air should be removed from the cargo tanks and associated piping before loading and then subsequently excluded by:

(1) introducing inert gas to maintain a positive pressure. Storage or production capacity of the inert gas should be sufficient to meet normal operating requirements and relief valve leakage. The oxygen content of inert gas should at no time be greater than 0.2% by volume; or
(2) control of cargo temperatures such that a positive pressure is maintained at all times.

1707. Moisture control (IGC Code 17.7)

For gases which are non-flammable and may become corrosive or react dangerously with water, moisture control should be provided to ensure that cargo tanks are dry before loading and that during discharge, dry air or cargo vapour is introduced to prevent negative pressures. For the purposes of this paragraph, dry air is air which has a dew point of -45°C or below at atmospheric pressure.

1708. Inhibition (IGC Code 17.8)

Care should be taken to ensure that the cargo is sufficiently inhibited to prevent polymerization at all times during the voyage. Ships should be provided with a certificate from the manufacturer stating:

(1) Name and amount of inhibitor added;
(2) date inhibitor was added and the normally expected duration of its effectiveness;
(3) any temperature limitations affecting the inhibitor;
(4) the action to be taken should be length of the voyage exceed the effective lifetime of the inhibitors.

1709. Permanently installed toxic gas detectors (IGC Code 17.9)

1. Gas sampling lines should not be led into or through gas-safe spaces. Alarms referred to in **1306. 7** should be activated when the vapour concentration reaches the threshold limiting value.

2. The alternative of using portable equipment in accordance with **1306. 9** should not be permitted.

1710. Flame screens on vent outlets (IGC Code 17.10)

Cargo tank vent outlets should be provided with readily renewable and effective flame screens or safety heads of an approved type when carrying a cargo referenced to this Article. Due attention should be paid in the design of flame screens and vent heads to the possibility of the blockage of these devices by the freezing of cargo vapour or by icing up in adverse weather conditions. Ordinary protection screens should be fitted after removal of the flame screens.

1711. Maximum allowable quantity of cargo per tank (IGC Code 17.11)

When carrying a cargo referenced to this Article the quantity of the cargo should not exceed 3,000 m^3 in any one tank.

1712. Submerged electric cargo pumps (IGC Code 17.12)

The vapour space of cargo tanks equipped with submerged electric motor pumps should be inerted to a positive pressure prior to loading, during carriage and during unloading of flammable liquids.

1713. Ammonia (IGC Code 17.13)

1. Anhydrous ammonia may cause stress corrosion cracking in containment and process systems made of carbon-manganese steel or nickel steel. To minimize the risk of this occurring, measures detailed in **Pars 2** to **8** should be taken as appropriate.

2. Where carbon-manganese steel is used, cargo tanks, process pressure vessels and cargo piping should be made of fine-grained steel with a specified minimum yield strength not exceeding 355 N/mm^2 and with an actual yield strength not exceeding 440 N/mm^2. One of the following constructional or operational measures should also be taken:

(1) lower strength material with a specified minimum tensile strength not exceeding 410 N/mm^2 should be used; or
(2) cargo tanks, etc., should be post-weld stress relief heat treated; or
(3) carriage temperature should be maintained preferably at a temperature close to the product's boiling point of -33°C but in no case at a temperature above -20°C; or
(4) the ammonia should contain not less than 0.1% w/w water

3. If carbon-manganese steels with higher yield properties are used other than those specified in **Par 2,** the completed cargo tanks, piping, etc., should be given a post-weld stress relief heat treatment.

4. Process pressure vessels and piping of the condensate part of the refrigeration system should be given a post-weld stress relief heat treatment when made of materials mentioned in **Par 1.**

5. The tensile and yield properties of the welding consumables should exceed those of the tank or piping material by the smallest practical amount.

6. Nickel steel containing more than 5% nickel and carbon-manganese steel not complying with the requirements of **Pars 2** and **3** are particularly susceptible to ammonia stress corrosion cracking and should not be used for containment and piping systems for the carriage of this product.

7. Nickel steel containing not more than 5% nickel may be used provided the carriage temperature complies with the requirements specified in **2** (3).

8. In order to minimize the risk of ammonia stress corrosion cracking, it is advisable to keep the dissolved oxygen content below 2.5 *ppm w/w*. This can best be achieved by reducing the average oxygen content in the tanks prior to the introduction of liquid ammonia to less than the values given as a function of the carriage temperature T in the table below:

T (°C)	O_2 (%, v/v)
-30 and below	0.90
-20	0.50
-10	0.28
0	0.16
10	0.10
20	0.05
30	0.03

Oxygen percentages for intermediate temperatures may be obtained by direct interpolation.

1714. Chlorine (IGC Code 17.14)

1. Cargo containment system

(1) The capacity of each tank should not exceed 600 m^3 and the total capacity of all cargo tanks should not exceed 1,200 m^3.

(2) The tank design vapour pressure should not be less than 1.35 MPa (see also **701. 3** and **1703. 2**).

(3) Parts of tanks protruding above the upper deck should be provided with protection against thermal radiation taking into account total engulfment by fire.

(4) Each tank should be provided with two pressure relief valves. A bursting disc of appropriate material should be installed between the tank and the pressure relief valves. The rupture pressure of the bursting disc should be 0.1MPa lower than the opening pressure of the pressure relief valve, which should be set at the design vapour pressure of the tank but not less than 1.35 MPa gauge. The space between the bursting disc and the relief valve should be connected through an excess flow valve to a pressure gauge and a gas detection system. Provision should be made to keep this space at or near the atmospheric pressure during normal operation.

(5) Outlets from pressure relief valves should be arranged in such a way as to minimize the hazards on board the ship as well as to the environment. Leakage from the relief valves should be led through the absorption plant to reduce the gas concentration as far as possible. The relief valve exhaust line should be arranged at the forward end of the ship to discharge outboard at deck level with an arrangement to select either port or starboard side, with a mechanical interlock to ensure that one line is always open.

(6) The Society and the port Administration may require that chlorine is carried in refrigerated state at a specified maximum pressure.

2. Cargo piping systems

(1) Cargo discharge should be performed by means of compressed chlorine vapour from shore, dry air or another acceptable gas or fully submerged pumps. The pressure in the vapour space of the tank during discharging should not exceed 1.05 MPa gauge. Cargo discharge compressors on board ships should not be accepted by the Society.

(2) The design pressure of the cargo piping system should be not less than 2.1 MPa gauge. The internal diameter of the cargo pipes should not exceed 100 *mm*. Only pipe bends should be accepted for compensation of pipeline thermal movement. The use of flanged joints should be restricted to a minimum, and when used the flanges should be of the welding neck type with tongue and groove.

(3) Relief valves of the cargo piping system should discharge to the absorption plant (see also **802. 16**).

3. Materials

(1) The cargo tanks and cargo piping systems should be made of steel suitable for the cargo and for a temperature of -40°C, even if a higher transport temperature is intended to be used.

(2) The tanks should be thermally stress-relieved. Mechanical stress relief should not be accept-

ed as an equivalent.

4. Instrumentation-safety devices

(1) The ship should be provided with a chlorine absorbing plant with connections to the cargo piping system and the cargo tanks. The absorbing plant should be capable of neutralizing at least 2% of the total cargo capacity at a reasonable absorption rate.

(2) During the gas-freeing of cargo tanks, vapours should not be discharged to the atmosphere.

(3) A gas detecting system should be provided capable of monitoring chlorine concentrations of at least 1 ppm by volume. Suction points should be located:

(a) near the bottom of the hold spaces;

(b) in the pipes from the safety relief valves;

(c) at the outlet from the gas absorbing plant;

(d) at the inlet to the ventilation systems for the accommodation, service and machinery spaces and control stations;

(e) on deck at the forward end, in the middle and at the after end of the cargo area. (Only required to be used during cargo handling and gas-freeing operations).

The gas detection system should be provided with an audible and visual alarm with a set point of 5 ppm.

(4) Each cargo tank should be fitted with a high pressure alarm giving an audible alarm at a pressure equal to 1.05 MPa gauge.

5. Personnel protection

In addition to the requirements given in **Sec 14** the following requirements should be met:

(1) The enclosed space required by **1404. 5** should be easily and quickly accessible from the open deck and from accommodation spaces and should be capable of being rapidly closed gastight. Access to this space from the deck and from the accommodation spaces should be by means of an air lock. The space should be so designed as to accommodate the entire crew of the ship and be provided with a source of uncontaminated air for a period of not less than 4 h. One of the decontamination showers required by **1404. 3** should be located near the air lock to the space.

(2) A compressor and the necessary equipment for filling the air bottles should be provided.

(3) One set of oxygen therapy equipment should be carried in the space referred to in (1).

6. Filling limits for cargo tanks

(1) The requirements of **1501. 4** (2) do not apply when it is intended to carry chlorine.

(2) The chlorine content of the gas in the vapour space of the cargo tank after loading should be greater than 80% by volume.

1715. Diethyl ether and vinyl ethyl ether (IGC Code 17.15)

1. The cargo should be discharge only by deepwell pumps or by hydraulically operated submerged pumps. These pumps should be of a type designed to avoid liquid pressure against the shaft gland.

2. Inert gas displacement may be used for discharging cargo from type C independent tanks provided the cargo system is designed for the expected pressure.

1716. Ethylene oxide (IGC Code 17.16)

1. For the carriage of ethylene oxide the requirements of **1720.** apply, with the additions and modifications as given in this Article.

2. Deck tanks should not be used for the carriage of ethylene oxide.

3. Stainless steels types 416 and 442 as well as cast iron should not be used in ethylene oxide cargo containment and piping systems.

4. Before loading, tanks should be thoroughly and effectively cleaned to remove all traces of previous cargoes from tanks and associated pipework, except where the immediate prior cargo has been ethylene oxide, propylene oxide or mixtures of these products. Particular care should be taken in the case of ammonia in tanks made of steel other than stainless steel.

5. Ethylene oxide should be discharged only by deepwell pumps or inert gas displacement. The arrangement of pumps should comply with **1720. 5** (3).

6. Ethylene oxide should be carried refrigerated only and maintained at temperatures of less than 30°C.

7. Pressure relief valves should be set at a pressure of not less than 0.55 MPa gauge. The maximum set pressure should be specially approved by the Society.

8. The protective padding of nitrogen gas as required by **1720. 15** should be such that the nitrogen concentration in the vapour space of the cargo tank will at no time be less than 45% by volume.

9. Before loading and at all times when the cargo tank contains ethylene oxide liquid or vapour, the cargo tank should be inerted with nitrogen.

10. The water spray system required by **1720. 17** and that required by **1103.** should operate automatically in a fire involving the cargo containment system.

11. A jettisoning arrangement should be provided to allow the emergency discharge of ethylene oxide in the event of uncontrollable self-reaction.

1717. Isopropylamine and monoethylamine (IGC Code 17.17)

Separate piping systems should be provided as defined in **106. 32.**

1718. Methyl acetylene-propadiene mixtures (IGC Code 17.18)

1. Methyl acetylene-propadiene mixtures should be suitable stabilized for transport. Additionally, upper limits of temperature and pressure during the refrigeration should be specified for the mixtures.

2. Examples of acceptable, stabilized compositions are:

(1) Composition 1
 (a) maximum methyl acetylene to propadiene molar ratio of 3 to 1;
 (b) maximum combined concentration of methyl acetylene and propadiene of 65 mol per cent,
 (c) minimum combined concentration of propane, butane, and isobutane of 24 mol per cent, of which at least one third (on a molar basis) must be butanes and one third propane; and
 (d) maximum combined concentration of propylene and butadiene of 10 mol per cent.

(2) Composition 2
 (a) maximum methyl acetylene and propadiene combined concentration of 30 mol per cent;
 (b) maximum methyl acetylene concentration of 20 mol per cent;
 (c) maximum propadiene concentration of 20 mol per cent;
 (d) maximum propylene concentration of 45 mol per cent;
 (e) maximum butadiene and butylenes combined concentration of 2 mol per cent;
 (f) minimum saturated C_4 hydrocarbon concentration of 4 mol per cent; and
 (g) minimum propane concentration of 25 mol per cent.

3. Other compositions may be accepted provided the stability of the mixture is demonstrated to the satisfaction of the Society.

4. A ship carrying methyl acetylene-propadiene mixtures should preferably have an indirect refrigeration system as specified in **702. 4** (2). Alternatively, a ship not provided with indirect refrigeration may utilize direct vapour compression refrigeration subject to pressure and temperature limitations depending on the composition. For the example compositions given in **Par 2,** the following features should be provided:

(1) A vapour compressor that does not raise the temperature and pressure of the vapour above 60°C and 1.75 MPa gauge during its operation, and that does not allow vapour to stagnate in the compressor while it continues to run.

(2) Discharge piping from each compressor stage or each cylinder in the same stage of a reciprocating compressor should have:
 (a) two temperature-actuated shutdown switches set to operate at 60°C or less;
 (b) a pressure-actuated shutdown switch set to operate at 1.75 MPa gauge or less; and
 (c) a safety relief valve set to relieve at 1.80 MPa gauge or less.

(3) The relief valve required by **Par 4** (2) (c) should vent to a mast meeting the requirements of **802. 9, 10, 13** and **14** and should not relieve into the compressor suction line.

(4) An alarm that sounds in the cargo control position and in the navigating bridge when a high pressure switch, or a high-temperature switch operates.

5. The piping system, including the cargo refrigeration system, for tanks to be loaded with methyl acetylene-propadiene mixtures should be either independent (as defined in **106. 20**) or separate (as defined in **106. 32**) from piping and refrigeration systems for other tanks. This segregation applies to all liquid and vapour vent lines and any other possible connections, such as common inert gas supply lines.

1719. Nitrogen (IGC Code 17.19)

Materials of construction and ancillary equipment such as insulation should be resistant to the effects of high oxygen concentrations caused by condensation and enrichment at the low temperatures attained in parts of the cargo system. Due consideration should be given to ventilation in such areas where condensation might occur to avoid the stratification of oxygen-enriched atmosphere.

1720. Propylene oxide and mixtures of ethylene oxide-propylene oxide with ethylene oxide content of not more than 30% by weight (IGC Code 17.20)

1. Products transported under the provisions of this Article should be acetylene-free.

2. (1) Unless cargo tanks are properly cleaned, these products should not be carried in tanks which have contained as one of the three previous cargoes any product known to catalyse polymerization, such as:
 (a) anhydrous ammonia and ammonia solutions;
 (b) amines and amine solutions;
 (c) oxidizing substances (e.g. chlorine).

(2) Before loading, tanks should be thoroughly and effectively cleaned to remove all traces of previous cargoes from tanks and associated pipework, except where the immediate prior cargo has been propylene oxide or eth-

ylene oxide-propylene oxide mixtures. Particular care should be taken in the case of ammonia in tanks made of steel other than stainless steel.

(3) In all cases, the effectiveness of cleaning procedures for tanks and associated pipework should be checked by suitable testing or inspection to ascertain that no traces of acidic or alkaline materials remain that might create a hazardous situation in the presence of these products.

(4) Tanks should be entered and inspected prior to each initial loading of these products to ensure freedom from contamination, heavy rust deposits and any visible structural defects. When cargo tanks are in continuous service for these products, such inspections should be performed at intervals of not more than 2 years.

(5) Tanks for the carriage of these products should be of steel or strainless steel construction.

(6) Tanks which have contained these products may be used for other cargoes after thorough cleaning of tanks and associated pipework systems by washing or purging.

3. (1) All valves, flanges, fittings and accessory equipment should be of a type suitable for use with these products and should be constructed of steel or stainless steel in accordance with recognized standards. Discs or disc faces, seats and other wearing parts of valves should be made of stainless steel containing not less than 11% chromium.

(2) Gaskets should be constructed of materials which do not react with, dissolve in, or lower the autoignition temperature of these products and which are fire-resistant and possess adequate mechanical behaviour. The surface presented to the cargo should be polytetrafluorethylene (PTFE) or materials giving a similar degree of safety by their inertness. Spirally-wound stainless steel with a filler of PTFE or similar fluorinated polymer may be accepted by the Society.

(3) Insulation and packing if used should be of a material which does not react with, dissolve in, or lower the autoignition temperature of these products.

(4) The following materials are generally found unsatisfactory for gaskets, packing and similar uses in containment systems for these products and would require testing before being approved by the Society.

(a) Neoprene or natural rubber if it comes into contact with the products;

(b) Asbestos or binders used with asbestos;

(c) Materials containing oxides of magnesium, such as mineral wools.

4. Filling and discharge piping should extend to within 100 mm of the bottom of the tank or any sump.

5. (1) The products should be loaded and discharge in such a manner that venting of the tanks to atmosphere does not occur. If vapour return to shore is used during tank loading, the vapour return system connected to a containment system for the product should be independent of all other containment systems.

(2) During discharging operations, the pressure in the cargo tank should be maintained above 0.007 MPa gauge.

(3) The cargo should be discharged only by deepwell pumps, hydraulically operated submerged pumps, or inert gas displacement. Each cargo pump should be arranged to ensure that the product does not heat significantly if the discharge line from the pump is shut off or otherwise blocked.

6. Tanks carrying these products should be vented independently of tanks carrying other products. Facilities should be provided for sampling the tank contents without opening the tank to atmosphere.

7. Cargo hoses used for transfer of these products should be marked “FOR ALKYLENE OXIDE TRANSFER ONLY”.

8. Hold spaces should be monitored for these products. Hold spaces surrounding type A and B independent tanks should also be inerted and monitored for oxygen. The oxygen content of these spaces should be maintained below 2%. Portable sampling equipment is satisfactory.

9. Prior to disconnecting shore-lines, the pressure in liquid and vapour lines should be relieved through suitable valves installed at the loading header. Liquid and vapour from these lines should not be discharged to atmosphere.

10. Tanks should be designed for the maximum pressure expected to be encountered during loading, carriage or unloading of cargo.

11. Tanks for the carriage of propylene oxide with a design vapour pressure of less than 0.06 MPa and tanks for the carriage of ethylene oxide-propylene oxide mixtures with a design vapour pressure of less than 0.12 MPa should have a cooling system to maintain the cargo below the reference temperature. For reference temperaturesee **1501. 4** (1).

12. Pressure relief valve settings should not be less than 0.02 MPa gauge and for type C independent cargo tanks not greater than 0.70 MPa gauge for the carriage of propylene oxide and not greater than 0.53 MPa gauge for the carriage of ethylene oxide-propylene oxide mixtures.

13. (1) The piping system for tanks to be loaded with these products should be completely separate from piping systems for all other tanks, including empty tanks, and from all cargo compressors. If the piping system for the tanks to be loaded with these products is not independent as defined in **106. 20** the required piping separation should be accomplished by the removal of spool pieces, valves, or other pipe sections and the installation of blank flanges at these locations. The required separation applies to all liquid and vapour piping, liquid and vapour vent lines and any other possible connections such as common inert gas supply lines.

(2) The products should be transported only in accordance with cargo handling plans that have been approved by the Society. Each intended loading arrangement should be shown on a separate cargo handling plan. Cargo handling plans should show the entire cargo piping system and the locations for installation of blank flanges needed to meet the above piping separation requirements. A copy of each approved cargo handling plan should be kept on board the ship. The International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk should be endorsed to include reference to the approved cargo handling plans.

(3) Before each initial loading of these products and before every subsequent return to such services, certification verifying that the required piping separation has been achieved should be obtained from a responsible person acceptable to the port Administration and carried on board the ship. Each connection between a blank flange and pipeline flange should be fitted with a wire and seal by the responsible person to ensure that inadvertent removal of the blank flange is impossible.

14. The maximum allowable tank loading limits for each cargo tank should be indicated for each loading temperature which may be applied and for the applicable maximum reference temperature, on a list to be approved by the Society. A copy of the list should be permanently kept on board by the master.

15. The cargo should be carried under a suitable protective padding of nitrogen gas. An automatic nitrogen make-up system should be installed to prevent the tank pressure falling below 0.007MPa gauge in the event of product temperature fall due to ambient conditions or malfunctioning of refrigeration system. Sufficient nitrogen should be available on board to satisfy the demand of the automatic pressure control. Nitrogen of commercially pure quality (99.9% by valume) should be used for padding. A battery of nitrogen bottles connected to the cargo tanks through a pressure reduction valve satisfies the intention of the expression “automatic” in this context.

16. The cargo tank vapour space should be tested prior to and after loading to ensure that the oxygen content is 2% by volume or less.

17. A water spray system of sufficient capacity should be provided to blanket effectively the area surrounding the loading manifold, the exposed deck piping associated with product handling and the tank domes. The arrangement of piping and nozzles should be such as to give a uniform distribution rate of 10 l/m^2 per minute. The water spray system should be capable of both local and remote manual operation and the arrangement should ensure that any spilled cargo is washed away. Remote manual operation should be arranged such that remote starting of pumps supplying water spray system and remote operation of any normally closed valves in the system can be carried out from a suitable location outside the cargo area, adjacent to the accommodation spaces and readily accessible and operable in the event of fire in the areas protected. Additionally, a water hose with pressure to the nozzle, when ambient temperatures permit, should be connected ready for immediate use during loading and unloading operation.

1721. Vinyl chloride (IGC Code 17.21)

In cases where polymerization of vinyl chloride is prevented by addition of an inhibitor, **1708.** is applicable. In cases where no or insufficient inhibitor has been added, any inert gas used for the purposes of **1706.** should contain not more oxygen than 0.1%. Before loading is started, inert gas samples from the tanks and piping should be analysed. When vinyl chloride is carried, a positive pressure should always be maintained in the tanks, also during ballast voyages between successive carriages.

SECTION 18
Operating Requirements

1801. Cargo information (IGC Code 18.1)

1. Information should be on board and available to all concerned, giving the necessary data for the safe carriage of cargo. Such information should include for each product carried:

(1) a full description of the physical and chemical properties necessary for the safe containment of the cargo;
(2) action to be taken in the event of spills or leaks;
(3) counter-measures against accidental personal contact;
(4) fire-fighting procedures and fire-fighting media;
(5) procedures for cargo transfer, gas-freeing, ballasting, tank cleaning and changing cargoes;
(6) special equipment needed for the safe handling of the particular cargo;
(7) minimum allowable inner hull steel temperatures; and

(8) emergency procedures.

2. Products required to be inhibited should be refused if the certificate required by **1708.** is not supplied.

3. A copy of this Chapter or national regulations incorporating the provisions of this Chapter should be on board every ship covered by this Chapter.

1802. Compatibility (IGC Code 18.2)

1. The master should ascertain that the quantity and characteristics of each product to be loaded are within the limits indicated in the International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk and in the Loading and Stability Information booklet provided for in **202. 5** and that products are listed in the International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk as required under **Sec 3** of the Certificate.

2. Care should be taken to avoid dangerous chemical reactions if cargoes are mixed. This is of particular significance in respect of:

(1) tank cleaning procedures required between successive cargoes in the same tank; and
(2) simultaneous carriage of cargoes which react when mixed. This should be permitted only if the complete cargo systems including, but not limited to, cargo pipework, tanks, vent systems and refrigeration systems are separated as defined in **106. 32.**

1803. Personnel training (IGC Code 18.3)

1. Personnel involved in cargo operations should be adequately trained in handling procedures.

2. All personnel should be adequately trained in the use of protective equipment provided on board and have basic training in the procedures, appropriate to their duties, necessary under emergency conditions.

3. Officers should be trained in emergency procedures to deal with conditions of leakage, spillage or fire involving the cargo, and a sufficient number of them should be instructed and trained in essential first aid for cargoes carried.

1804. Entry into spaces (IGC Code 18.4)

1. Personnel should not enter cargo tanks, hold spaces, void spaces, cargo handling spaces or other enclosed spaces where gas may accumulate, unless:

(1) the gas content of the atmosphere in such space is determined by means of fixed or portable equipment to ensure oxygen sufficiency and the absence of toxic atmosphere; or
(2) personnel wear breathing apparatus and other necessary protective equipment and the entire operation is under the close supervision of a responsible officer.

2. Personnel entering any space designated as gas-dangerous on a ship carrying flammable products should not introduce any potential source of ignition into the space unless it has been certified gas-free and is maintained in that condition.

3. (1) For internal insulation tanks, special fire precautions should be taken in the event of hot work carried out in the vicinity of the tanks. For this purpose, gas absorbing and deabsorbing characteristics of the insulation material should be taken into account.
(2) For internal insulation tanks, repairs should be carried out in accordance with the procedures provided for in **404. 7** (6).

1805. Carriage of cargo at low temperature (IGC Code 18.5)

1. When carrying cargoes at low temperatures:

(1) if provided, the heating arrangements associated with cargo containment systems should be operated in such a manner as to ensure that the temperature does not fall below that for which the materials of the hull structure is designed;
(2) loading should be carried out in such a manner as to ensure that unsatisfactory temperature gradients do not occur in any cargo tank, piping, or other ancillary equipment; and
(3) when cooling down tanks from temperatures at or near ambient, the cool-down procedure laid down for that particular tank, piping and ancillary equipment should be followed closely.

1806. Protective equipment (IGC Code 18.6)

Personnel should be made aware of the hazards associated with the cargo being handled and should be instructed to act with care and use the appropriate protective equipment as mentioned in **1401.** during cargo handling.

1807. Systems and controls (IGC Code 18.7)

Cargo emergency shutdown and alarm systems involved in cargo transfer should be tested and checked before cargo handling operations begin. Essential cargo handling controls should also be tested and checked prior to transfer operations.

1808. Cargo transfer operations (IGC Code 18.8)

1. Transfer operations including emergency procedures should be discussed between ship personnel and the persons responsible at the shore facility prior to commencement and communications maintained throughout the transfer operations.

2. The closing time of the valve referred to in **1303.1** (i.e. time from shutdown signal initiation to complete valve closure) should not be greater than:

$$\frac{3{,}600U}{LR} \quad \text{(sec)}$$

where:

U = ullage volume at operating signal level (m^3)

LR = maximum loading rate agreed between ship and shore facility (m^3/h).

The loading rate should be adjusted to limit surge pressure on valve closure to an acceptable level taking into account the loading hose or arm, the ship and the shore piping systems where relevent.

1809. Additional operating requirements (IGC Code 18.9)

Additional operating requirements will be found in the following paragraphs of this Chapter: **308. 4, 308.5, 701.1** (5), **802. 5, 802. 7, 904. 2, 1201.1, 1201.10, 1301.4, 1402. 5, 1402.6, 1403.1, 1501., 1502., 1602. 2, 1704. 2, 1706., 1707., 1712., 1713., 1714., 1715., 1716., 1717., 1718., 1720.**

SECTION 19
Summary of Minimum Requirements

EXPLANATORY NOTES

UN Number (column b)

The UN numbers as listed in the table of **Sec 19** are intended for information only.

Vapour detection required (column f)

F - Flammable vapour detection
T - Toxic vapour detection
O - Oxygen analyser
F+T- Flammable and toxic vapour detection

Gauging-types permitted (column g)

I - Indirect, or closed, as described in **1302. 2** (1) and (2)
C - Indirect, or closed, as described in **1302. 2** (1), (2) and (3)
R - Indirect, closed or restricted, as described in **1302. 2** (1), (2), (3) and (4).

MFAG table No. (column h)

MFAG numbers are provided for information on the emergency procedures to be applied in the event of an incident with the products covered by the IGC Code. Where any of the products listed are carried at low temperature from which frostbite may occur MFAG No. 620 is also applicable.

Refrigerant gases

Non-toxic and non-flammable gases such as:
dichlorodifluoromethane (1028)
dichloromonofluoromethane (1029)
dichlorotetrafluoroethane (1958)
monochlorodifluoromethane (1018)
monochlorotetrafluoroethane (1021)
monochlorotrifluoromethane (1022)

Unless otherwise specified, gas mixtures containing less than 5% total acetylenes may be transported with no further requirements than those provided for the major components.

a	b	c	d	e	f	g	h	i
Product name	UN number	Ship type	Independent tank type C required	Control of vapour space within cargo tanks	Vapour detection	Gau-ging	MFAG table No.	Special requirements
Acetaldehyde	1089	2G/2PG	-	Inert	F+T	C	300	**1404.3, 1404.4, 1704.1, 1706.1**
Ammonia, anhydrous	1005	2G/2PG	-	-	T	C	725	**1404.2, 1404.3, 1404.4, 1702.1, 1713.**
Butadiene	1010	2G/2PG	-	-	F+T	R	310	**1702.2, 1704.2, 1704.3, 1706., 1708.**
Butane	1011	2G/2PG	-	-	F	R	310	
Butane-propane mixtures	1011/1978	2G/2PG	-	-	F	R	310	
Butylenes	1012	2G/2PG	-	-	F	R	310	
Chlorine	1017	1G	Yes	Dry	T	I	740	**1404., 1703.2, 1704.1, 1705., 1707., 1709., 1714.**
Diethyl ether*	1155	2G/2PG	-	Inert	F+T	C	330	**1404.2, 1404.3, 1702.6, 1703.1, 1706.1, 1710., 1711., 1715.**
Dimethylamine	1032	2G/2PG	-	-	F+T	C	320	**1404.2, 1404.3, 1404.4, 1702.1**
Ethane	1961	2G	-	-	F	R	310	
Ethyl chloride	1037	2G/2PG	-	-	F+T	R	340	
Ethylene	1038	2G	-	-	F	R	310	
Ethylene oxide	1040	1G	Yes	Inert	F+T	C	365	**1404.2, 1404.3, 1404.4, 1404.6, 1702.2, 1703.2, 1704.1, 1705., 1706.1, 1716.**
Ethyene oxide-propylene oxide mixtures with ethyl-ene oxide content of not more than 30% by weight*	2983	2G/2PG	-	Inert	F+T	C	365	**1404.3, 1703.1, 1704.1, 1706.1, 1710., 1711., 1720.**
Isoprene*	1218	2G/2PG	-	-	F	R	310	**1404.3, 1708., 1710., 1712.**
Isopropylamine*	1221	2G/2PG	-	-	F+T	C	320	**1404.2, 1404.3, 1702.4, 1710., 1711., 1712., 1717.**
Methane (LNG)	1972	2G	-	-	F	C	620	
Methyl acetylene-propa-diene mixtures	1060	2G/2PG	-	-	F	R	310	**1718.**
Methyl bromide	1062	1G	Yes	-	F+T	C	345	**1404., 1702.3, 1703.2, 1704.1, 1705., 1709.**
Methyl chloride	1063	2G/2PG	-	-	F+T	C	340	**1702.3**
Monoethylamine*	1036	2G/2PG	-	-	F+T	C	320	**1404.2, 1404.3, 1404.4, 1702.1, 1703.1, 1710., 1711., 1712., 1717.**
Nitrogen	2040	3G	-	-	O	C	620	**1719.**
Pentanes (all isomers)*	1265	2G/2PG	-	-	F	R	310	**1404.4, 1710., 1712.**
Pentene (all isomers)*	1265	2G/2PG	-	-	F	R	310	**1404.4, 1710., 1712.**
Propane	1978	2G/2PG	-	-	F	R	310	
Propylene	1077	2G/2PG	-	-	F	R	310	
Propylene oxide*	1280	2G/2PG	-	Inert	F+T	C	365	**1404.3, 1703.1, 1704.1, 1706.1, 1710., 1711., 1720.**
Refrigerant gases (see notes)	-	3G	-	-	-	R	350	
Sulphur dioxide	1079	1G	Yes	Dry	T	C	635	**1404., 1703.2, 1704.1, 1705., 1707., 1709.**

a	b	c	d	e	f	g	h	i
Product name	UN number	Ship type	Independent tank type C required	Control of vapour space within cargo tanks	Vapour detection	Gau-ging	MFAG table No.	Special requirements
Vinyl chloride	1086	2G/2PG	-	-	F+T	C	340	**1404.2, 1404.3, 1702.2, 1702.3, 1703.1, 1706., 1721.**
Vinyl ethyl ether*	1302	2G/2PG	-	Inert	F+T	C	330	**1404.2, 1404.3, 1702.2, 1703.1, 1706.1, 1708., 1710., 1711., 1715.**
Vinylidene chloride*	1303	2G/2PG	-	Inert	F+T	R	340	**1404.2, 1404.3, 1702.5, 1706.1, 1708., 1710., 1711.**

* This cargo is covered also by the IBC Code.

CHAPTER 6
SHIPS CARRYING DANGEROUS CHEMICALS IN BULK

Section

SECTION 1
General

101. Application (IBC Code 1.1)

1. The requirements in this Chapter apply to ships contructed on or after 1 July 1986. The requirements in **Sec 8** apply to ships constructed on or after 1 January 1994. Ships constructed before 1 January 1994, in relation to **Sec 8,** are to comply with the requirements of IMO Res. MSC. 4 (48) and its additional amendments. Ships constructed before 1 July 1986 are to comply with the requirements of IMO Res. A.212 (VII) and its additional amendments.

2. The requirements in this Chapter apply to ships carrying dangerous chemicals in bulk (hereinafter referred to as a “ship” in this Chapter) intended to be registered and classed with the Society. The term “dangerous chemicals” includes products shown below (1) and (2), having an absolute vapour pressure not exceeding 0.28 MPa at a temperature of 37.8°C, except oil petroleum products or other similar flammable products.

(1) Products having significant fire hazards in excess of those of petroleum products and similar flammable products.

(2) Products having significant hazards in addition to or other than flammability.

The provisions of this Chapter are limited to the liquids shown in the Summary of Minimum Requirements in **Sec 17.** Products that have been reviewed and determined not to come with in the scope of the provision are found in **Sec 18.**

3. Where it is intended to carry dangerous liquid chemicals in bulk which may be considered to come within the scope of the International Code for the Construction and Equipment of Ships carrying Dangerous Chemicals in Bulk (hereinafter referred to as the “IBC Code” in this Chapter) but are not designated in the Summary of Minimum Requirements in **Secs 17** or **18,** suitable construction and equipment of ships for carriage of such chemicals should be to the satisfaction of the Society. For the evaluation of the pollution hazard of such a product and assignment of its pollution category, the procedure specified in regulation 3 (4) of Annex II of MARPOL 73/78 is to be followed.

4. For ships to be classed for restricted service and ships not provided with propulsive machinery, the requirements may be modified as appropriate.

5. The ships carrying flammable dangerous chemicals in bulk are also to be in compliance with the requirements in **Pt 7, Ch 1** unless otherwise required in this Chapter.

6. The ship’s hull, machinery and equipment not specified in this Chapter are generally to comply with the requirements in the relevant Chapters of these Rules.

7. When it is intended to carry products covered by this Chapter and products covered by **Ch 5,** the ship should comply with the requirements of both Chapters appropriate to the products carried, except the following (1) and (2).

(1) The requirements of this Chapter should take precedence when a ship is designed and constructed for the carriage of the following prod-

ucts.
(a) those listed exclusively in **Sec 17** and
(b) one or more of the products which are listed both in this Chapter and in **Ch 5** (these products are marked with an asterisk (*) in column "a" in the table of **Sec 17**)
(2) When a ship is intended exclusively to carry one or more of the products noted in (1) (b) above, requirements of this Chapter only should apply.

8. The Society may be subject to IMO decisions which would be different from the requirements of this Chapter.

102. Approval for plans

For classification survey during construction, the following plans and informations as may be necessary depending upon the products intended to be loaded, condition of cargo storage, construction of cargo containment system and other design conditions are to be submitted in triplicate before the work is commenced.

1. Plans and data for approval

(1) Manufacturing specifications for independent cargo tanks (including materials to be used, welding procedures and inspection and testing procedures for weld and cargo tanks).
(2) Details of cargo tank construction.
(3) Arrangements of cargo tank accessories (including details of fittings inside the tanks).
(4) Details of independent cargo tank supports, deck portions through which cargo tanks penetrate and their sealing devices when provided.
(5) Coating or lining procedure of inside of the cargo tanks, and corrosion test results of such coating or lining, if required.
(6) Plans showing arrangement and the methods of attachment of the insulation together with the working procedure concerned.
(7) When the cargoes are required to be cooled, the plans and informations in accordance with **Ch 5, 102. 1** (1), (6), (7), (8) and (16) are to be submitted depending upon the cargo storage plan and the type of cargo tank construction.
(8) Cargo pump construction plan including list of materials to be used and their specifications.
(9) Piping arrangement in cargo tank area.
(10) Cargo tank ventilation arrangement.
(11) Ventilation plan of cargo pump rooms, cofferdams, double bottoms and others.
(12) Diagram of monitoring and measurement system for cargo level, cargo temperature and others and the detail construction of their equipment.
(13) Control system for cargo temperature.
(14) Details of environmental control system such as inerting, padding, drying or ventilation including the piping diagram and the construction of their equipment.
(15) Instruments for cargo vapour detection.
(16) Electrical wiring plans and a table of electrical equipment used in dangerous spaces.
(17) Arrangement of earth connections for cargo tanks, pipe lines, machinery and equipment, only when flammable cargoes are intended to be loaded.
(18) Plans showing dangerous spaces.
(19) Fire extinguishing system stipulated in **Sec 11.**

2. Plans and data for reference

(1) Lists showing chemical and physical properties and other special properties of the all cargoes intended to be loaded. Loading plans of the dangerous chemicals coming within the scope of this Chapter and other chemicals to be loaded simultaneously with these dangerous chemicals.
(2) Guide of reactivity hazard defined by reactivity with other chemicals, water or the chemical itself including polymerization and, where deemed necessary, with the heating or cooling media. The chemicals not intended to be loaded simultaneously with the dangerous chemicals coming within the scope of this Chapter may be excluded from these guides.
(3) Data of reactivity hazard between intended cargoes and coating or lining in cargo tanks and of piping and equipment that may come into contact with cargo liquid or vapour.
(4) Data of suitability of corrosion-resistance materials for the cargoes having corrosive properties.
(5) Strength calculation of each cargo tanks and, where deemed necessary, thermal stress calculation.
(6) Capacity calculation of heating system as required cargoes to be heated.
(7) Plans and documents in accordance with **Ch 5, 102. 2** (1), (6), (8) and (10) depending upon the cargo storage plan and the type of cargo tank construction when the cargoes require to be cooled.
(8) Arrangements of access manholes stipulated in **304.** in cargo tank area and the guide for access through these manholes.
(9) Operation manual stipulated in **Sec 16.**
(10) Caculation for ship survival capability stipulated in **Sec 2.**
(11) Equipment for personnel protection stipulated in **Sec 14.**

103. Equivalents

The construction, equipment, etc., which do not fall under the provisions of this Chapter but is considered to be equivalent to those required in this Chapter will be accepted by the Society.

104. National regulations

For the construction and equipment of the ship, attention is to be paid to the requirements of national regulations of the country in which the ship is registered and/or of the port which the ship intends to visit.

105. Hazards (IBC Code 1.2)

Hazards of products covered by this Chapter include those as given in the following.

1. Fire hazard, defined by flashpoint, boiling point, flammability limits and autoignition temperature of the chemical.

2. Health hazard, defined by the following.

(1) irritant or toxic effect given on the skin or on the mucous membranes of the eyes, nose, throat and lungs in the gas or vapour state combined with vapour pressure; or
(2) irritational effects given on the skin in the liquid state; or
(3) toxic effect, taking into account values of
LD 50 (oral): a dose which is lethal to 50% of the test subjects when administered orally;
LD 50 (skin): a dose which is lethal to 50% of the test subjects when administered to the skin;
LC 50: the concentration which is lethal by inhalation to 50% of the test subjects.

3. Water pollution hazard, defined by human toxicity, water solubility, volatility, odour or taste, and relative density.

4. Air pollution hazard defined by the following.

(1) emergency exposure limit (E.E.L.) or LC 50;
(2) vapour pressure;
(3) solubility in water;
(4) relative density of liquid;
(5) vapour density.

5. Reactivity hazard, defined by reactivity with the following.

(1) other products; or
(2) water; or
(3) the product itself (including polymerization).

6. Marine pollution hazard, as defined by the following.

(1) bioaccumulation with attendant risk to aquatic life or human health or cause tainting to seafood;
(2) damage to living resources;
(3) hazard to human health; and
(4) reduction of amenities.

106. Definitions (IBC Code 1.3)

The definitions of terms are to be as specified in the following and **Sec 4,** unless otherwise specified elsewhere.

1. "Accommodation spaces" are those spaces used for public spaces, corridors, lavatories, cabins, offices, hospitals, cinemas, games and hobbies rooms, barber shops, pantries containing no cooking appliances and similar spaces. **"Public spaces"** are those portions of the accommodation spaces which are used for halls, dining rooms, lounges and similar permanently enclosed spaces.

2. (1) **"Administration"** means the Government of the State whose flag the ship is entitled to fly.
(2) **"Port Administration"** means the appropriate authority of the country in the port of which the ship is loading or unloading.

3. "Boiling point" is the temperature at which a product exhibits a vapour pressure equal to the atmospheric pressure.

4. "Breadth (B)" means the maximum breadth of the ship, measured amidships to the moulded line of the frame in a ship with a metal shell and to the outer surface of the hull in a ship with a shell of any other material. The breadth (B) should be measured in metres.

5. "Cargo area" is that part of the ship that contains cargo tanks, slop tanks, cargo pump rooms including pump rooms, cofferdams, ballast or void spaces adjacent to cargo tanks or slop tanks and also deck areas throughout the entire length and breadth of the part of the ship over the above-mentioned spaces. Where independent tanks are installed in hold spaces, cofferdams, ballast or void spaces at the after end of the aftermost hold space or at the forward end of the forward hold space are excluded from the cargo area.

6. "Cargo pump room" is a space containing pumps and their accessories for the handling of products covered by this Chapter.

7. "Cargo service spaces" are spaces within the cargo area used for workshops, lockers and storerooms of more than 2 m^2 in area, used for cargo handling equipment.

8. "Cargo tank" is the envelope designed to contain the cargo.

9. "Chemical tanker" is a cargo ship constructed or adapted and used for the carriage in bulk of any liquid product listed in **Sec 17.**

10. "Cofferdam" is the isolating space between two adjacent steel bulkheads or decks. This space may be a void space or a ballast space.

11. "Control stations" are those spaces in which ship's radio or main navigating equipment or the emergency source of power is located or where the fire-recording or fire-control equipment is centralized. This does not include special fire control equipment which can be most practically located in the cargo area.

12. "Flammabiiity limits" are the conditions defining the state of fuel-oxidant mixture at which application of an adequately strong external ignition source is only just capable of producing flammability in a given test apparatus.

13. **"Flash point"** is the temperature in degrees Celsius at which a product will give off enough flammable vapour to be ignited. Values given in this Chapter are "closed cup test" determined by an approved flash point apparatus.

14. **"Hold space"** is the space enclosed by the ship's structure in which an independent cargo tank is situated.

15. **"Independent"** means that a piping or venting system, for example, is in no way connected to another system and that there are no provisions available for the potential connection to other systems.

16. **"Length (L)"** means 96% of the total length on a waterline at 85% of the least moulded depth measured from the top of the keel, or the length from the forside of the stem to the axis of the rudder stock on that waterline, if that be greater. In ships designed with a rake of keel, the waterline on which this length is measured should be parallel to the designed waterline. The length (L) should be measured in metres.

17. **"Machinery spaces of category A"** are those spaces and trunks to such spaces which contain:
   (1) internal combustion machinery used for main propulsion; or
   (2) internal combustion machinery used for purposes other than main propulsion where such machinery has in the aggregate a total power output of not less than 375 kW; or
   (3) any oil-fired boiler or oil fuel unit.

18. **"Machinery spaces"** are all machinery spaces of category A and all other spaces containing propelling machinery, boilers, oil fuel units, steam and internal combustion engines, generators and major electrical machinery, oil filling stations, refrigerating, stabilizing, ventilation and air-conditioning machinery, and similar spaces, and trunks to such spaces.

19. **"Oil fuel unit"** is the equipment used for the preparation of oil fuel for delivery to an oil-fired boiler, or equipment used for the preparation for delivery of heated oil to an internal combustion engine, and includes any oil pressure pumps, filters and heaters dealing with oil al a pressure of more than 0.18 MPa gauge.

20. **"Organization"** is the International Maritime Organization (IMO).

21. **"Permeability"** of a space means the ratio of the volume within the space which is assumed to be occupied by water to the total volume of that space.

22. **"Pump room"** is a space, located in the cargo area, containing pumps and their accessories for the handling of ballast and oil fuel.

23. **"Relative density"** of liquid is the ratio of the mass of a volume of a product to the mass of an equal volume of fresh water. For a product of limited solubility, the relative density indicates whether it floats on water or sinks.

24. **"Separate"** means that a cargo piping system or cargo vent system, for example, is not connected to another cargo piping or cargo vent system. This separation may be achieved by the use of design or operational methods. Operational methods should not be used within a cargo tank and should consist of one of the following types:
   (1) Removing spool pieces or valves and blanking the pipe ends;
   (2) arrangement of two spectacle flanges in series with provisions for detecting leakage into the pipe between the two spectacle flanges.

25. **"Service spaces"** are those spaces used for galleys, pantries containing cooking appliances, lockers, mail and specie rooms, store-rooms, workshops other than those forming part of the machinery spaces and similar spaces and trunks to such spaces.

26. **"1974 SOLAS Convention"** means the International Convention for the Safety of Life at Sea, 1974.

27. **"1983 SOLAS amendments"** means the amendments to the 1974 SOLAS Convention adopted by the Maritime Safety Committee of the Organization at its forty-eighth session on 17 June 1983 by resolution MSC.6(48).

28. **"Vapour density or the relative density of vapour"** is the ratio of the mass of a volume of vapour or gas (with no air present) to the mass of an equal volume of air at the same pressure and temperature. Vapour density below or above 1 indicates whether the vapour or gas is lighter or heavier than air.

29. **"Vapour pressure"** is the equilibrium pressure of the saturate vapour above the liquid expressed in bars absolute at a specified temperature.

30. **"Void space"** is an enclosed space in the cargo area external to a cargo tank, other than a hold space, ballast space, oil fuel tank, cargo pump room, pump room, or any space in normal use by personnel.

31. **"MARPOL 73/78"** means the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto.

32. **"Noxious liquid substance"** means any substance designated in appendix II to Annex II of MARPOL 73/78 or provisionally assessed under the provisions of regulation 3(4) of that Annex as falling into category A, B, C or D.

33. **"Standards for Procedures and Arrangements"** means the Standards for Procedures and Arrangements for the Discharge of Noxious Liquid Substances called for by Annex II of MARPOL 73/78

adopted by the Marine Environment Protection Committee at its twenty-second session by resolution MEPC.18(22) as may be amended by the Organization.

34. **"Recognized standards"** are applicable international or national standards acceptable to the Society or standards laid down and maintained by the Society which complies with the standards adopted by the organization.

SECTION 2
Ship Survival Capability and Location of Cargo Tanks

201. General (IBC Code 2.1)

1. Ships subject to this Chapter should survive the normal effects of flooding following assumed hull damage caused by some external force. In addition, to safeguard the ship and the environment, the cargo tanks of certain types of ships should be protected from penetration in the case of minor damage to the ship resulting, for example, from contact with a jetty or tug, and given a measure of protection from damage in the case of collision or stranding, by locating them at specified minimum distances inboard from the ship's shell plating. Both the damage to be assumed and the proximity of the cargo tanks to the ship's shell should be dependent upon the degree of hazard presented by the products to be carried.

2. Ships subject to this Chapter should be designed to one of the following standards:

(1) A **"type 1 ship"** is a chemical tanker intended to transport **Sec 17** products with very severe environmental and safety hazards which require maximum preventive measures to preclude an escape of such cargo.

(2) A **"type 2 ship"** is a chemical tanker intended to transport **Sec 17** products with appreciably severe environmental and safety hazards which require significant preventive measures to preclude an escape of such cargo.

(3) A **"type 3 ship"** is a chemical tanker intended to transport **Sec 17** products with sufficiently severe environmental and safety hazards which require a moderate degree of containment to increase survival capability in a damaged condition.

Thus a type 1 ship is a chemical tanker intended for the transportation of products considered to present the greatest overall hazard and type 2 and type 3 ships for products of progressively lesser hazards. Accordingly, a type 1 ship should survive the most severe standard of damage and its cargo tanks should be located at the maximum prescribed distance inboard from the shell plating.

3. The ship type required for individual products is indicated in column ''e'' in the table of **Sec 17.**

4. If a ship is intended to carry more than one product listed in **Sec 17,** the standard of damage should correspond to that product having the most stringent ship type requirement. The requirements for the location of individual cargo tanks, however, are those for ship types related to the respective products intended to be carried.

202. Freeboard and intact stability (IBC Code 2.2)

1. Ships subject to this Chapter may be assigned the minimum freeboard permitted by the International Convention on Load Lines in force. However, the draught associated with the assignment should not be greater than the maximum draught otherwise permitted by this Chapter.

2. The stability of the ship in all seagoing conditions should be to a standard which is acceptable to the Society.

3. When calculating the effect of free surfaces of consumable liquids for loading conditions it should be assumed that, for each type of liquid, at least one transverse pair or a single centre tank has a free surface and the tank or combination of tanks to be taken into account should be those where the effect of free surfaces is the greatest. The free surface effect in undamaged compartments should be calculated by a method acceptable to the Society.

4. Solid ballast should not normally be used in double bottom spaces in the cargo area. Where, however, because of stability considerations, the fitting of solid ballast in such spaces becomes unavoidable, then its disposition should be governed by the need to ensure that the impact loads resulting from bottom damage are not directly transmitted to the cargo tank structure.

5. The master of the ship should be supplied with a Loading and Stability Information booklet. This booklet should contain details of typical service and ballast conditions, provisions for evaluating other conditions of loading and a summary of the ship's survival capabilities. In addition, the booklet should contain sufficient information to enable the master to load and operate the ship in a safe and seaworthy manner.

203. Shipside discharges below the freeboard deck (IBC Code 2.3)

1. The provision and control of valves fitted to discharges led through the shell from spaces below the freeboard deck or from with in the superstructures and deckhouses on the freeboard deck fitted with weathertight doors should comply with the requirements of the relevant regulation of the International Convention on Load Lines in force, except that the choice of valves should be limited to:

(1) one automatic non-return valve with a positive means of closing from above the freeboard deck; or
(2) where the vertical distance from the summer load waterline to the inboard end of the discharge pipe exceeds 0.01 L, two automatic non-return valves without positive means of closing, provided that the inboard valve is always accessible for examination under service conditions.

2. For the purpose of this Section **"summer load waterline"** and **"freeboard deck",** have the meanings as defined in the International Convention on Load Lines in force.

3. The automatic non-return valves referred to in **Par 1** (1) and (2) should be of a type acceptable to the Society and should be fully effective in preventing admission of water into the ship, taking into account the sinkage, trim and heel in survival requirements in **209.** and should comply with recognized standards.

204. Conditions of loading (IBC Code 2.4)

Damage survival capability should be investigated on the basis of loading information submitted to the Society for all anticipated conditions of loading and variations in draught and trim. Ballast conditions where the chemical tanker is not carrying products covered by this Chapter, or is carrying only residues for such products, need not be considered.

205. Damage assumptions (IBC Code 2.5)

1. The assumed maximum extent of damage should be:

(1) Side damage:
  (a) Longitudinal extent: 1/3 $L^{2/3}$ or 14.5 m, whichever is less
  (b) Transverse extent: B/5 or 11.5 m, whichever is less, measured inboard from the ship's side at right angles to the centreline at the level of the summer load line
  (c) Vertical extent: upwards without limit, from the moulded line of the bottom shell plating at centreline.

(2) Bottom damage:

	For 0.3 L from the forward perpendicular of the ship	Any other part of the ship
(a) Longitudinal extent:	1/3$L^{2/3}$ or 14.5m, whichever is less	1/3$L^{2/3}$ or 5m, whichever is less
(b) Transverse extent:	B/6 or 10m, whichever is less	B/6 or 5m, whichever is less
(c) Vertical extent:	B/15 or 6m, whichever is less, measured from the moulded line of the bottom shell plating at centreline. (see **206. 2**)	B/15 or 6m, whichever is less, measured from the moulded line of the bottom shell plating at centreline. (see **206. 2**)

2. Other damage:

If any damage of a lesser extent than the maximum damage specified in **Par 1** would result in a more severe condition, such damage should be considered.

206. Location of cargo tanks (IBC Code 2.6)

1. Cargo tanks should be located at the following distances inboard.

(1) Type 1 ships: from the side shell plating not less than the transverse extent of damage specified in **205. 1** (1) (b) and from the moulded line of the bottom shell plating at centreline not less than the vertical extent of damage specified in **205. 1** (2) (c) and nowhere less than 760 mm from the shell plating. This requirement does not apply to the tanks for diluted slops arising from tank washing.
(2) Type 2 ships: from the moulded line of the bottom shell plating at centreline not less than the vertical extent of damage specified in **205. 1** (2) (c) and nowhere less than 760mm from the shell plating. This requirement does not apply to the tanks for diluted slops arising from tank washing.
(3) Type 3 ships: no requirement.

2. Except for type 1 ships, suction wells installed in cargo tanks may protrude into the vertical extent of bottom damage specified in **205. 1** (2) (c) provided that such wells are as small as practicable and the protrusion below the inner bottom plating does not exceed 25% of the depth of the double bottom or 350mm, whichever is less. Where there is no double bottom, the protrusion of the suction well of independent tanks below the upper limit of bottom damage should not exceed 350mm. Suction wells installed in accordance with this paragraph may be ignored in determining the compartments affected by damage.

207. Flooding assumptions (IBC Code 2.7)

1. The requirements of **209.** should be confirmed by calculations which take into consideration the design characteristics of the ship; the arrangements, configuration and contents of the damaged compartments; the distribution, relative densities and the free surface effects of liquids; and the draught and trim for all conditions of loading.

2. The permeabilities of spaces assumed to be damaged should be as follows:

Spaces	Permeabilities
Appropriated to stores	0.60
Occupied by accommodation	0.95
Occupied by machinery	0.85
Voids	0.95
Intended for consumable liquids	0 to 0.95
Intended for other liquids	0 to 0.95

3. Wherever damage penetrates a tank containing liquids it should be assumed that the contents are completely lost from that compartment and replaced by salt water up to the level of the final plane of equilibrium.

4. Every watertight division within the maximum extent of damage defined in **205. 1** and considered to have sustained damage in positions given in **208. 1** should be assumed to be penetrated. Where damage less than the maximum is being considered in accordance with **205. 2,** only watertight divisions or combinations of watertight divisions within the envelope of such lesser damage should be assumed to be penetrated.

5. The ship should be so designed as to keep unsymmetrical flooding to the minimum consistent with efficient arrangements.

6. Equalization arrangements requiring mechanical aids such as valves or cross-levelling pipes, if fitted, should not be considered for the purpose of reducing an angle of heel or attaining the minimum range of residual stability to meet the requirements of **209.** and sufficient residual stability should be maintained during all stages where equalization is used. Spaces which are linked by ducts of large cross-sectional area may be considered to be common.

7. If pipes, ducts, trunks or tunnels are situated within the assumed extent of damage penetration, as defined in **205.,** arrangements should be such that progressive flooding cannot thereby extend to compartments other than those assumed to be flooded for each case of damage.

8. The buoyancy of any superstructure directly above the side damage should be disregarded. The unflooded parts of superstructures beyond the extent of damage, however, may be taken into consideration provided that:

(1) they are separated from the damaged space by watertight divisions and the requirements of **209. 3** in respect of these intact spaces are complied with; and

(2) openings in such divisions are capable of being closed by remotely operated sliding watertight doors and unprotected openings are not immersed within the minimum range of residual stability required in **209.**; however the immersion of any other openings capable of being closed weathertight may be permitted.

208. Standard of damage (IBC Code 2.8)

1. Ships should be capable of surviving the damage indicated in **205.** with the flooding assumptions in **207**. to the extent determined by the ship's type according to the following standards:

(1) A type 1 ship should be assumed to sustain damage anywhere in its length;

(2) A type 2 ship of more than 150m in length should be assumed to sustain damage anywhere in its length;

(3) A type 2 ship of 150m in length or less should be assumed to sustain damage anywhere in its length except involving either of the bulkheads bounding a machinery space located aft;

(4) A type 3 ship of more than 225m in length should be assumed to sustain damage anywhere in its length;

(5) A type 3 ship of 125m in length or more but not exceeding 225m in length should be assumed to sustain damage anywhere in its length except involving either of the bulkheads bounding a machinery space located aft;

(6) A type 3 ship below 125m in length should be assumed to sustain damage anywhere in its length except involving damage to the machinery space when located aft. However, the ability to survive the flooding of the machinery space should be considered by the Society.

2. In the case of small type 2 and type 3 ships which do not comply in all respects with the appropriate requirements of **Par 1** (3) and (6), special dispensation may only be considered by the Society provided that alternative measures can be taken which maintain the same degree of safety.

209. Survival requirements (IBC Code 2.9)

1. Ships subject to this Chapter should be capable of surviving the assumed damage specified in **205.** to the standard provided in **208.** in acondition of stable equilibrium and should satisfy the following criteria.

2. In any stage of flooding:

(1) the waterline, taking into account sinkage, heel and trim, should be below the lower edge of

any opening through which progressive flooding or downflooding may take place. Such openings should include air pipes and openings which are closed by means of weathertight doors or hatch covers and may exclude those openings closed by means of watertight manhole covers and watertight flush scuttles, small watertight cargo tank hatch covers which maintain the high integrity of the deck, remotely operated watertight sliding doors, and sidescuttles of the non-opening type;

(2) the maximum angle of heel due to unsymmetrical flooding should not exceed 25° except that this angle may be increased up to 30° if no deck immersion occurs;

(3) the residual stability during intermediate stages of flooding should be to the satisfaction of the Society. However, it should never be significantly less than that required by **Par 3.**

3. At final equilibrium after flooding:

(1) the righting lever curve should have a minimum range of 20° beyond the position of equilibrium in association with a maximum residual righting lever of at least 0.1 m within the 20° range; the area under the curve within this range should not be less than 0.0175 $m{\cdot}rad$. Unprotected openings should not be immersed within this range unless the space concerned is assumed to be flooded. Within this range, the immersion of any of the openings listed in **Par 2** (1) and other openings capable of being closed weathertight may be permitted; and

(2) the emergency source of power should be capable of operating.

SECTION 3
Ship Arrangements

301. Cargo segregation (IBC Code 3.1)

1. Unless expressly provided otherwise, tanks containing cargo or residues of cargo subject to this Chapter should be segregated from accommodation, service and machinery spaces and from drinking water and stores for human consumption by means of a cofferdam, void space, cargo pump room, pump room, empty tank, oil fuel tank or other similar space.

2. Cargoes, residues of cargoes or mixtures containing cargoes which react in a hazardous manner with other cargoes, residues or mixtures, should:

(1) be segregated from such other cargoes by means of a cofferdam, void space, cargo pump room, pump room, empty tank, or tank containing a mutually compatible cargo;

(2) have separate pumping and piping systems which should not pass through other cargo tanks containing such cargoes, unless encased in a tunnel; and

(3) have separate tank venting systems.

3. Cargo piping should not pass through any accommodation, service or machinery space other than cargo pump rooms or pump rooms.

4. Cargoes subject to this Chapter should not be carried in either the fore or aft peak tank.

302. Accommodation, service and machinery spaces and control stations (IBC Code 3.2)

1. No accommodation or service spaces or control stations should be located within the cargo area except over a cargo pump room recess or pump room recess that complies with regulation II-2/56 of the 1983 SOLAS amendments and no cargo or slop tank should be aft of the forward end of any accommodation.

2. In order to guard against the danger of hazardous vapours, due consideration should be given to the location of air intakes and openings into accommodation, service and machinery spaces and control stations in relation to cargo piping and cargo vent systems.

3. Entrances, air inlets and openings to accommodation, service and machinery spaces and control stations should not face the cargo area. They should be located on the end bulkhead not facing the cargo area and/or on the outboard side of the superstructure or deck house at a distance of at least 4% of the length (L) of the ship but not less than 3m from the end of the superstructure or deckhouse facing the cargo area. This distance, however, need not exceed 5m. No doors should be permitted within the limits mentioned above, except that doors to those spaces not having access to accommodation and service spaces and control stations, such as cargo control stations and store-rooms may be fitted. Where such doors are fitted, the boundaries of the space should be insulated to “A-60” standard. Bolted plates for removal of machinery may be fitted within the limits specified above. Wheelhouse doors and wheel house windows may be located within the limits specified above so long as they are so designed that a rapid and efficient gas- and vapour-tightening of the wheelhouse can be ensured. Windows and sidescuttles facing the cargo area and on the sides of the super structures and deckhouses within the limits specified above should be of the fixed (non-opening) type. Such sidescuttles in the first tier on the main deck should be fitted with inside covers of steel or equivalent material.

303. Cargo pump rooms (IBC Code 3.3)

1. Cargo pump rooms should be so arranged as to ensure:

(1) unrestricted passage at all times from any lad-

der platform and from the floor; and

(2) unrestricted access to all valves necessary for cargo handling for a person wearing the required personnel protective equipment.

2. Permanent arrangements should be made for hoisting an injured person with a rescue line while avoiding any projecting obstacles.

3. Guard railings should be installed on all ladders and platforms.

4. Normal access ladders should not be fitted vertical and should incorporate platforms at suitable intervals.

5. Means should be provided to deal with drainage and any possible leakage from cargo pumps and valves in cargo pump rooms. The bilge system serving the cargo pump room should be operable from outside the cargo pump room. One or more slop tanks for storage of contaminated bilge water or tank washings should be provided. A shore connection with a standard coupling or other facilities should be provided for transferring contaminated liquids to onshore reception facilities.

6. Pump discharge pressure gauges should be provided outside the cargo pump room.

7. Where machinery is driven by shafting passing through a bulkhead or deck, gastight seals with efficient lubrication or other means of ensuring the permanence of the gas seal should be fitted in way of the bulkhead or deck.

304. Access to spaces in the cargo area (IBC Code 3.4)

1. Access to cofferdams, ballast tanks, cargo tanks and other spaces in the cargo area should be direct from the open deck and such as to ensure their complete inspection. Access to double bottom spaces may be through a cargo pump room, pump room, deep cofferdam, pipe tunnel or similar compartments, subject to consideration of ventilation aspects.

2. For access through horizontal openings, hatches or manholes, the dimensions should be sufficient to allow a person wearing a self-contained air breathing apparatus and protective equipment to ascend or descend any ladder without obstruction and also to provide a clear opening to facilitate the hoisting of an injured person from the bottom of the space. The minimum clear opening should be not less than 600 mm by 600 mm.

3. For access through vertical openings, or manholes providing passage through the length and breadth of the space, the minimum clear opening should be not less than 600 mm by 800 mm at a height of not more than 600 mm from the bottom shell plating unless gratings or other footholds are provided.

4. Smaller dimensions may be approved by the Society in special circumstances, if the ability to traverse such openings or to remove an injured person can be proved to the satisfaction of the Society.

305. Bilge and ballast arrangements (IBC Code 3.5)

1. Pumps, ballast lines, vent lines and other similar equipment serving permanent ballast tanks should be independent of similar equipment serving cargo tanks and of cargo tanks themselves. Discharge arrangements for permanent ballast tanks sited immediately adjacent to cargo tanks should be outside machinery spaces and accommodation spaces. Filling arrangements may be in the machinery spaces provided that such arrangements ensure filling from tank deck level and nonreturn valves are fitted.

2. Filling of ballast in cargo tanks may be arranged from deck level by pumps serving permanent ballast tanks, provided that the filling line has no permanent connection to cargo tanks or piping and that non-return valves are fitted.

3. Bilge pumping arrangements for cargo pump rooms, pump rooms, void spaces, slop tanks, double bottom tanks and similar spaces should be situated entirely within the cargo area except for void spaces, double bottom tanks and ballast tanks were such spaces are separated from tanks containing cargo or residues of cargo by a double bulkhead.

306. Pump and pipeline identification (IBC Code 3.6)

Provisions should be made for the distinctive marking of pumps, valves and pipelines to identify the service and tanks which they serve.

307. Bow or stern loading and unloading arrangements (IBC Code 3.7)

1. Cargo piping may be fitted to permit bow or stern loading and unloading. Portable arrangements should not be permitted.

2. Bow or stern loading and unloading lines should not be used for the transfer of products required to be carried in type 1 ships. Bow and stern loading and unloading lines should not be used for the transfer of cargoes emitting toxic vapours required to comply with **1512. 1,** unless specifically approved by the Society.

3. In addition to **501.**, the following provisions apply:

(1) The piping outside the cargo area should be fitted at least 760 mm inboard on the open deck. Such piping should be clearly identified and fitted with a shutoff valve at its connec-

tion to the cargo piping system within the cargo area. At this location, it should also be capable of being separated by means of a removable spool piece and blank flanges when not in use.
(2) The shore connection should be fitted with a shutoff valve and a blank flange.
(3) The piping should be full penetration butt-welded, and fully radiographed. Flange connections in the piping should only be permitted within the cargo area and at the shore connection.
(4) Spray shields should be provided at the connections specified in (1) as well as collecting trays of sufficient capacity with means for the disposal of drainage.
(5) The piping should be self-draining to the cargo area and preferably into a cargo tank. Alternative arrangements for draining the piping may be accepted by the Society.
(6) Arrangements should be made to allow such piping to be purged after use and maintained gas-safe when not in use. The vent pipes connected with the purge should be located in the cargo area. The relevant connections to the piping should be provided with a shutoff valve and blank flange.

4. Entrances, air inlets and openings to accommodation, service and machinery spaces and control stations should not face the cargo shore connection location of bow or stern loading and unloading arrangements. They should be located on the outboard side of the superstructure or deckhouse at a distance of at least 4% of the length of the ship but not less than 3m from the end of the house facing the cargo shore connection location of the bow or stern loading and unloading arrangements. This distance, however, need not exceed 5m. Sidescuttles facing the shore-connection location and on the sides of the superstructure or deckhouse within the distance mentioned above should be of the fixed (non-opening) type. In addition, during the use of the bow or stern loading and unloading arrangements, all doors, ports and other openings on the corresponding superstructure or deckhouse side should be kept closed. Where, in the case of small ships, compliance with **302. 3** and this paragraph is not possible, the Society may approve relaxations from the above requirements.

5. Air pipes and other openings to enclosed spaces not listed in **307. 4** should be shielded from any spray which may come from a burst hose or connection.

6. Escape routes should not terminate within the coamings required by **307. 7** or within a distance of 3 m beyond the coamings.

7. Continuous coamings of suitable height should be fitted to keep any spills on deck and away from the accommodation and service areas.

8. Electrical equipment within the coamings required by **307. 7** or within a distance of 3 m beyond the coamings should be in accordance with the requirements of **Sec 10.**

9. Fire-fighting arrangements for the bow or stern loading and unloading areas should be in accordance with **1103. 16.**

10. Means of communication between the cargo control station and the cargo shore connection location should be provided and certified safe, if necessary. Provision should be made for the remote shutdown of cargo pumps from the cargo shore-connection location.

SECTION 4
Cargo Containment

401. Definitions (IBC Code 4.1)

1. "Independent tank" means a cargo containment envelope which is not contiguous with, or part of, the hull structure. An independent tank is built and installed so as to eliminate whenever possible (or in any event to minimize) its stressing as a result of stressing or motion of the adjacent hull structure. An independent tank is not essential to the structural completeness of the ship's hull.

2. "Integral tank" means a cargo containment envelope which forms part of the ship's hull and which may be stressed in the same manner and by the same loads which stress the contiguous hull structure and which is normally essential to the structural completeness of the ship's hull.

3. "Gravity tank" means a tank having a design pressure not greater than 0.07MPa gauge at the top of the tank. A gravity tank may be independent or integral. A gravity tank should be constructed and tested according to recognized standards taking account of the temperature of carriage and relative density of the cargo.

4. "Pressure tank" means a tank having a design pressure greater than 0.07 MPa gauge. A pressure tank should be an independent tank and should be of a configuration permitting the application of pressure vessel design criteria according to recognized standards.

402. Tank type requirements for individual products (IBC Code 4.2)

Requirements for both installation and design of tank types for individual products are shown in column "f" in the table of **Sec 17.**

SECTION 5
Cargo Transfer

501. Piping scantlings (IBC Code 5.1)

1. Subject to the conditions stated in **Par 4** the wall thickness (t) of pipes should not be less than:

$$t = \frac{t_0 + b + c}{1 - \frac{a}{100}} \quad (mm)$$

where:

t_0 = theoretical thickness

$t_0 = P \cdot D/(20\,K \cdot e + P) \quad (mm)$

with

P = design pressure (bar) referred to in **Par 2**

D = outside diameter (mm)

K = allowable stress(N/mm^2) referred to in **Par 5**

e = efficiency factor; equal to 1.0 for seamless pipes and for longitudinally or spirally welded pipes, delivered by manufacturers approved for making welded pipes, which are considered equivalent to seamless pipes wnen non-destructive testing on welds is carried out in accordance with recognized standards. In other cases, an efficiency factor of less than 1.0, in accordance with recognized standards, may be required depending on the manufacturing process.

b = allowance for bending (mm). The value of b should be chosen so that the calculated stress in the bend, due to internal pressure only, does not exceed the allowable stress. Where such justification is not given, b should be not less than:

$$b = \frac{D \cdot t_0}{2.5 r} \quad (mm)$$

with

r = mean radius of the bend (mm).

c = corrosion allowance (mm). If corrosion or erosion is expected, the wall thickness of piping should be increased over that required by the other design requirements.

a = negative manufacturing tolerance for thickness (%).

2. The design pressure P in the formula for t_o in **Par 1** is the maximum gauge pressure to which the system may be subjected in service, taking into account the highest set pressure on any relief valve on the system.

3. Piping and piping system components which are not protected by a relief valve, or which may be isolated from their relief valve, should be designed for at least the greatest of:

(1) for piping systems or components which may contain some liquid, the saturated vapour pressure at 45°C;

(2) the pressure setting of the associated pump discharge relief valve;

(3) the maximum possible total pressure head at the outlet of the associated pumps when a pump discharge relief valve is not installed.

4. The design pressure should not be less than 1.0 MPa gauge except for open-ended lines where it should be not less than 0.5 MPa gauge.

5. For pipes, the allowable stress to be considered in the formula for t_o in **Par 1** is the lower of the following values:

$$R_m/A \quad \text{or} \quad R_e/B$$

where:

R_m = specified minimum tensile strength at ambient temperature (N/mm^2)

R_e = specified minimum yield stress at ambient temperature (N/mm^2). If the stress-strain curve does not show a defined yield stress, the 0.2% proof stress applies.

A and B should have values of at least A = 2.7 and B = 1.8

6. (1) The minimum wall thickness should be in accordance with recognized standards.

(2) Where necessary for mechanical strength to prevent damage, collapse, excessive sag or buckling of pipes due to weight of pipes and content and to superimposed loads from supports, ship deflection or other causes, the wall thickness should be increased over that required by **Par 1** or, if this is impracticable or would cause excessive local stresses, these loads should be reduced, protected against or eliminated by other design methods.

(3) Flanges, valves and other fittings should be in accordance with recognized standards, taking into account the design pressure defined under **Par 2.**

(4) For flanges not complying with a standard the dimensions of flanges and associated bolts should be to the satisfaction of the Society.

502. Piping fabrication and joining details (IBC Code 5.2)

1. The requirements of this Article apply to piping inside and outside the cargo tanks. However, relaxations from these requirements may be accepted in accordance with recognized standards for open-ended piping and for piping inside cargo tanks except for cargo piping serving other cargo tanks.

2. Cargo piping should be joined by welding except:

(1) for approved connections to shutoff valves and expansion joints; and
(2) for other exceptional cases specifically approved by the Society.

3. The following direct connections of pipe lengths, without flanges may be considered:

(1) Butt-welded joints with complete penetration at the root may be used in all applications.
(2) Slip-on welded joints with sleeves and related welding having dimensions in accordance with recognized standards should only be used for pipes with an external diameter of 50mm or less. This type of joint should not be used when crevice corrosion is expected to occur.
(3) Screwed connections in accordance with recognized standards should only be used for accessory lines and instrumentation lines with external diameters of 25mm or less.

4. Expansion of piping should normally be allowed for by the provision of expansion loops or bends in the piping system.

(1) Bellows in accordance with recognized standards may be specially considered.
(2) Slip joints should not be used.

5. Welding, post-weld heat treatment and non-destructive testing should be performed in accordance with Recognized Standards.

503. Flange connections (IBC Code 5.3)

1. Flanges should be of the welded neck, slip-on or socket-welded type. However, socket-welded type flanges should not be used in nominal size above 50mm.

2. Flanges shou!d comply with recognized standards as to their type, manufacture and test.

504. Test requirements for piping (IBC Code 5.4)

1. The test requirements of this Article apply to piping inside and outside cargo tanks. However, relaxations from these requirements may be accepted in accordance with recognized standards for piping inside tanks and open-ended piping.

2. After assembly, each cargo piping system should be subject to a hydrostatic test to at least 1.5 times the design pressure. When piping systems or parts of systems are completely manufactured and equipped with all fittings, the hydrostatic test may be conducted prior to installation aboard the ship. Joints welded on board should be hydrostatically tested to at least 1.5 times the design pressure.

3. After assembly on board, each cargo piping system should be tested for leaks to a pressure depending on the method applied.

505. Piping arrangements (IBC Code 5.5)

1. Cargo piping should not be installed under deck between the outboard side of the cargo containment spaces and the skin of the ship unless clearances required for damage protection (see **206.**) are maintained; but such distances may be reduced where damage to the pipe would not cause release of cargo provided that the clearance required for inspection purposes is maintained.

2. Cargo piping, located below the main deck, may run from the tank it serves and penetrate tank bulkheads or boundaries common to longitudinally or transversally adjacent cargo tanks, ballast tanks, empty tanks, pump rooms or cargo pump rooms provided that inside the tank it serves it is fitted with a stop valve operable from the weather deck and provided cargo compatibility is assured in the event of piping failure. As an exception, where a cargo tank is adjacent to a cargo pump room, the stop valve operable from the weather deck may be situated on the tank bulkhead on the cargo pump room side, provided an additional valve is fitted between the bulkhead valve and the cargo pump. A totally enclosed hydraulically-operated valve located outside the cargo tank may, however, be accepted, provided that the valve is:

(1) designed to preclude the risk of leakage;
(2) fitted on the bulkhead of the cargo tank which it serves;
(3) suitably protected against mechanical damage;
(4) fitted at a distance from the shell, as required for damage protection; and
(5) operable from the weather deck.

3. In any cargo pump room where a pump serves more than one tank, a stop valve should be fitted in the line to each tank.

4. Cargo piping installed in pipe tunnels should also comply with the requirements of **Pars 1** and **2.** Pipe tunnels should satisfy all tank requirements for construction, location and ventilation and electrical hazard requirements. Cargo compatibility should be assured in the event of a piping failure. The tunnel should not have any other openings except to the weather deck and cargo pump room or pump room.

5. Cargo piping passing through bulkheads should be so arranged as to preclude excessive stresses at the bulkhead and should not utilize flanges bolted through the bulkhead.

506. Cargo transfer control systems (IBC Code 5.6)

1. For the purpose of adequately controlling the cargo, cargo transfer systems should be provided with:

(1) one stop valve capable of being manually operated on each tank filling and discharge line, located near the tank penetration; if an indi-

vidual deepwell pump is used to discharge the contents of a cargo tank, a stop valve is not required on the discharge line of that tank;
(2) one stop valve at each cargo hose connection;
(3) remote shutdown devices for all cargo pumps and similar equipment.

2. The controls necessary during transfer or transport of cargoes covered by this Chapter other than in cargo pump rooms which have been dealt with elsewhere in this Chapter should not be located below the weather deck.

3. For certain products, additional cargo transfer control requirements are shown in column "o" in the table of **Sec 17.**

507. Ship's cargo hoses (IBC Code 5.7)

1. Liquid and vapour hoses used for cargo transfer should be compatible with the cargo and suitable for the cargo temperature.

2. Hoses subject to tank pressure or the discharge pressure of pumps should be designed for a bursting pressure not less than 5 times the maximum pressure the hose will be subjected to during cargo transfer.

3. For cargo hoses installed on board ships on or after 1 July 2002, each new type of cargo hose, complete with end-fittings, should be prototype-tested at a normal ambient temperature with 200 pressure cycles from zero to at least twice the specified maximum working pressure. After this cycle pressure test has been carried out, the prototype test should demonstrate a bursting pressure of at least 5 times its specified maximum working pressure at the extreme service temperature. Hoses used for prototype testing should not be used for cargo service. Thereafter, before being placed in service, each new length of cargo hose produced should be hydrostatically tested at ambient temperature to a pressure not less than 1.5 times its specified maximum working pressure but not more than two fifths of its bursting pressure. The hose should be stencilled or otherwise marked with its specified maximum working pressure and, if used in other than ambient temperature services, its maximum and minimum service temperature as applicable. The specified maximum working pressure should not be less than 1.0 MPa gauge.

SECTION 6
Materials of Construction

601. General (IBC Code 6.1)

1. Structural materials used for tank construction, together with associated piping, pumps, valves, vents and their jointing materials, should be suitable at the temperature and pressure for the cargo to be carried in accordance with recognized standards. Steel is assumed to be the normal material of construction.

2. Where applicable the following should be taken into account in selecting the material of construction:
(1) notch ductility at the operating temperature;
(2) corrosive effect of the cargo;
(3) possibility of hazardous reactions between the cargo and the material of construction; and
(4) suitability of linings.

602. Special requirements for materials (IBC Code 6.2)

1. For certain products special requirements apply in respect of materials indicated by symbols in column "m" in the table of **Sec 17,** as stipulated in **Pars 2** to **4.**

2. The following materials of construction should not be used for tanks, pipelines, valves, fittings and other equipment, which may come into contact with the products or their vapour where referred to in column "m" in the table of **Sec 17**:

N1 Aluminium, copper, copper alloys, zinc, galvanized steel and mercury.
N2 Copper, copper alloys, zinc and galvanized steel.
N3 Aluminium, magnesium, zinc, galvanized steel and lithium.
N4 Copper and copper-bearing alloys.
N5 Aluminium, copper and alloys of either.
N6 Copper, silver, mercury, magnesium and other acetylide-forming metals and their alloys.
N7 Copper and copper-bearing alloys with greater than 1 % copper.
N8 Aluminium, zinc, galvanized steel and mercury.

3. Materials normally used in electrical apparatus, such as copper, aluminium and insulation, should as far as practicable be protected, e.g. by encapsulation, to prevent contact with vapours of products where referred to by Z in column "m" in the table of **Sec 17.**

4. The following materials of construction which may come into contact with certain products or their vapour should be used for tanks, pipelines, valves, fittings and other equipment, where referred to in column "m" in the table of **Sec 17** as follows:

Y1 Steel covered with a suitable protective lining or coating, aluminium or stainless steel.
Y2 Aluminium or stainless steel for product concentrations of 98% or more.
Y3 Special acid-resistant stainless steel for product concentrations of less than 98%.
Y4 Solid austenitic stainless steel.
Y5 Steel covered with suitable protective lin-

ing or coating or stainless steel.

5. Materials of construction having a melting point below 925°C, e.g. aluminium and its alloys, should not be used for external piping involved in cargo handling operations on ships intended for the carriage of products with flashpoints not exceeding 60°C (closed cup test) unless so specified in column "m" in the table of **Sec 17.** Short lengths of external pipes connected to cargo tanks may be fitted if they are provided with fire-resistant insulation.

SECTION 7
Cargo Temperature Control

701. General (IBC Code 7.1)

1. When provided, any cargo heating or cooling systems should be constructed, fitted and tested to the satisfaction of the Society. Materials used in the construction of temperature control systems should be suitable for use with the product intended to be carried.

2. Heating or cooling media should be of a type approved for use with the specific cargo. Consideration should be given to the surface temperature of heating coils or ducts to avoid dangerous reactions from localized overheating or overcooling of cargo. (see also **1513. 6**)

3. Heating or cooling systems should be provided with valves to isolate the system for each tank and to allow manual regulation of flow.

4. In any heating or cooling system, means should be provided to ensure that, when in any condition other than empty, a higher pressure can be maintained within the system than the maximum pressure head that could be exerted by the cargo tank contents on the system.

5. Means should be provided for measuring the cargo temperature.

(1) The means for measuring the cargo temperature should be of restricted or closed type, respectively, when a restricted or closed gauging device is required for individual substances as shown in column ''j'' in the table of **Sec 17.**

(2) A restricted temperature-measuring device is subject to the definition for a restricted gauging device in **1301. 1** (2), e.g. a portable thermometer lowered inside a gauge tube of the restricted type.

(3) A closed temperature measuring device is subject to the definition for closed gauging device in **1301. 1** (3), e.g. a remote-reading thermometer of which the sensor is installed in the tank.

(4) When overheating or overcooling could result in a dangerous condition, an alarm system which monitors the cargo temperature should be provided. (See also operational requirements in **1606.**)

6. When products for which **1512., 1512. 1** or **3** are listed in column "o" in the table of **Sec 17** are being heated or cooled, the heating or cooling medium should operate in a circuit:

(1) which is independent of other ship's services, except for another cargo heating or cooling system, and which does not enter the machinery space; or

(2) which is external to the tank carrying toxic products; or

(3) Where the medium is sampled to check for the presence of cargo before it is recirculated to other services of the ship or into the machinery space. The sampling equipment should be located within the cargo area and be capable of detecting the presence of any toxic cargo being heated or cooled. Where this method is used, the coil return should be tested not only at the commencement of heating or cooling of a toxic product, but also on the first occasion the coil is used subsequent to having carried an unheated or uncooled toxic cargo.

702. Additional requirements (IBC Code 7.2)

For certain products, additional requirements contained in **Sec 15** are shown in column "o" in the table of **Sec 17.**

SECTION 8
Cargo Tank Venting and Gas-freeing Arrangements

801. Application (IBC Code 8.1)

1. The requirements in this Section are to applied according to **101. 1.** Ships constructed on or after 1 July 1986 but before 1 January 1994 which fully comply with the requirements of the Rules applicable at that time may be regarded as complying with the requirements of regulation II-2/59 of SOLAS 74.

2. For ships to which this Chapter applies, the requirements of this Section should apply in lieu of regulation II-2/59.1 and 59.2 of the 1974 SOLAS Convention, as amended.

3. Ships constructed on or after 1 July 1986 but before 1 July 2002 should comply with the requirements of paragraph **803. 3** by the date of the first scheduled dry-docking after 1 July 2002, but not later than 1 July 2005. However, the Administration may approve relaxation of paragraph **803. 3** for ships of less than 500 gross tonnage which were constructed on or after 1 July 1986, but before 1 July 2002.

802. Cargo tank venting (IBC Code 8.2)

1. All cargo tanks should be provided with a venting system appropriate to the cargo being carried and these systems should be independent of the air pipes and venting systems of all other compartments of the ship. Tank venting systems should be designed so as to minimize the possibility of cargo vapour accumulating about the decks, entering accommodation, service and machinery spaces and control stations and in the case of flammable vapours entering or collecting in spaces or areas containing sources of ignition. Tank venting systems should be arranged to prevent entrance of water into the cargo tanks and at the same time, vent outlets should direct the vapour discharge upwards in the form of unimpeded jets.

2. The venting systems should be connected to the top of each cargo tank and as far as practicable the cargo vent lines should be self-draining back to the cargo tanks under all normal operational conditions of list and trim. Where it is necessary to drain venting systems above the level of any pressure/vacuum valve, capped or plugged drain cocks should be provided.

3. Provision should be made to ensure that the liquid head in any tank does not exceed the design head of the tank. Suitable high-level alarms, overflow control systems or spill valves, together with gauging and tank filling procedures may be accepted for this purpose. Where the means of limiting cargo tank overpressure includes an automatic closing valve, the valve should comply with the appropriate provisions of **1519.**

4. Tank venting systems should be designed and operated so as to ensure that neither pressure nor vacuum created in the cargo tanks during loading or unloading exceeds tank design parameters. The main factors to be considered in the sizing of a tank venting system are as follows:

(1) design loading and unloading rate;
(2) gas evolution during loading: this should be taken account of by multiplying the maximum loading rate by a factor of at least 1.25;
(3) density of the cargo vapour mixture;
(4) pressure loss in vent piping and across valves and fittings;
(5) pressure/vacuum settings of relief devices.

5. Tank vent piping connected to cargo tanks of corrosion-resistant material, or to tanks which are lined or coated to handle special cargoes as required by this Chapter, should be similarly lined or coated or constructed of corrosion-resistant material.

6. The master should be provided with the maximum permissible loading and unloading rates for each tank or group of tanks consistent with design of the venting systems.

803. Types of tank venting systems (IBC Code 8.3)

1. An open tank venting system is a system which offers no restriction except for friction losses to the free flow of cargo vapours to and from the cargo tanks during normal operations, An open venting system may consist of individual vents from each tank, or such individual vents may be combined into a common header or headers, with due regard to cargo segregation. In no case should shutoff valves be fitted either to the individual vents or to the header.

2. A controlled tank venting system is a system in which pressure and vacuum relief valves or pressure/vacuum valves are fitted to each tank to limit the pressure or vacuum in the tank. A controlled venting system may consist of individual vents from each tank or such individual vents on the pressure side only as may be combined into a common header or headers with due regard to cargo segregation. In no case should shutoff valves be fitted either above or below pressure or vacuum relief valves or pressure/vacuum valves. Provision may be made for bypassing a pressure or vacuum valve or pressure/vacuum valve under certain operating conditions provided that the requirement of **Par 6** is maintained and that there is suitable indication to show whether or not the valve is bypassed.

3. On ships constructed on or after 1 July 2002, controlled tank venting systems should consist of a primary and a secondary means of allowing full flow relief of vapour to prevent over-pressure or under-pressure in the event of failure of one means. Alternatively, the secondary means may consist of pressure sensors fitted in each tank with a monitoring system in the ship's cargo control room or position from which cargo operations are normally carried out. Such monitoring equipment should also provide an alarm facility which is activated by detection of over-pressure or under-pressure conditions within a tank.

4. The position of vent outlets of a controlled tank venting system should be arranged:

(1) at a height of not less than 6 m above the weather deck or above a raised walkway if fitted within 4 m of the raised walkway;
(2) at a distance of at least 10 m measured horizontally from the nearest air intake or opening to accommodation, service and machinery spaces and ignition sources.

5. The vent outlet height referred to in **4** (1) may be reduced to 3m above the deck or a raised walkway, as applicable, provided that high velocity venting valves of a type approved by the Society, directing the vapour/air mixture upwards in an unimpeded jet with an exit velocity of at least 30 m/s, are fitted.

6. Controlled tank venting systems fitted to tanks to be used for cargoes having a flashpoint not exceeding 60°C (closed cup test) should be provided with devices to prevent the passage of flame into the cargo tanks. The design, testing and locating of the devices should comply with the requirements of the Society, which should contain at least the standards adopted by the Organization.

7. In designing venting systems and in the selection of devices to prevent the passage of flame for incorporation into the tank venting system, due attention should be paid to the possibility of the blockage of these systems and fittings by, for example, the freezing of cargo vapour, polymer build up, atmospheric dust or icing up in adverse weather conditions. In this context it should be noted that flame arresters and flame screens are more susceptible to blockage. Provisions should be made such that the system and fittings may be inspected, operationally checked, cleaned or renewed as applicable.

8. Reference in **Pars 1** and **2** to the use of shutoff valves in the venting lines should be interpreted to extend to all other means of stoppage, including spectacle blanks and blank flanges.

804. Venting requirements for individual products (IBC Code 8.4)

Venting requirements for individual products are shown in column “g”, and additional requirements in column “o” in the table of **Sec 17.**

805. Cargo tank gas-freeing (IBC Code 8.5)

1. The arrangements for gas-freeing cargo tanks used for cargoes other than those for which open venting is permitted should be such as to minimize the hazards due to the dispersal of flammable or toxic vapours in the atmosphere and to flammable or toxic vapour mixtures in a cargo tank. Accordingly, gas-freeing operations should be carried out such that vapour is initially discharged:

(1) through the vent outlets specified in **803. 3** and **803. 4**; or
(2) through outlets at least 2 m above the cargo tank deck level with a vertical efflux velocity of at least 30 m/s maintained during the gas-freeing operation; or
(3) through outlets at least 2 m above the cargo tank deck level with a vertical efflux velocity of at least 20 m/s which are protected by suitable devices to prevent the passage of flame.

When the flammable vapour concentration at the outlets has been reduced to 30% of the lower flammable limit and, in the case of a toxic product, the vapour concentration does not present a significant health hazard, gas-freeing may thereafter be continued at cargo tank deck level.

2. The outlets referred to in **1** (2) and **1** (3) may be fixed or portable pipes.

3. In designing a gas-freeing system in conformity with **Par 1,** particularly in order to achieve the required exit velocities of **1** (2) and **1** (3), due consideration should be given to the following:

(1) materials of construction of system;
(2) time to gas-free;
(3) flow characteristics of fans to be used;
(4) the pressure losses created by ducting, piping, cargo tank inlets and outlets;
(5) the pressure achievable in the fan driving medium (e.g. water or compressed air);
(6) the densities of the cargo vapour/air mixtures for the range of cargoes to be carried.

SECTION 9
Environmental Control

901. General (IBC Code 9.1)

1. Vapour spaces within cargo tanks and, in some cases, spaces surrounding cargo tanks may require to have specially controlled atmospheres.

2. There are four different types of control for cargo tanks, as follows:

(1) Inerting—by filling the cargo tank and associated piping systems and, where specified in **Sec 15,** the spaces surrounding the cargo tanks, with a gas or vapour which will not support combustion and which will not react with the cargo, and maintaining that condition.
(2) Padding—by filling the cargo tank and associated piping systems with a liquid, gas or vapour which separates the cargo from the air, and maintaining that condition.
(3) Drying—by filling the cargo tank and associated piping systems with moisture-free gas or vapour with a dewpoint of -40°C or below at atmospheric pressure, and maintaining that condition.
(4) Ventilation—forced or natural.

3. Where inerting or padding of cargo tanks is required:

(1) An adequate supply of inert gas for use in filling and discharging the cargo tanks should be carried or should be manufactured on board unless a shore supply is available. In addition, sufficient inert gas should be available on the ship to compensate for normal losses during transportation.
(2) The inert gas system on board the ship should be able to maintain a pressure of at least 0.007 MPa gauge within the containment system at all times. In addition, the inert gas system should not raise the cargo tank pressure to more than the tank’s relief valve setting.
(3) Where padding is used, similar arrangements for supply of the padding medium should be made as required for inert gas in (1) and (2).

(4) Means should be provided for monitoring ullage spaces containing a gas blanket to ensure that the correct atmosphere is being maintained.
(5) Inerting or padding arrangements or both, where used with flammable cargoes, should be such as to minimize the creation of static electricity during the admission of the inerting medium.

4. Where drying is used and dry nitrogen is used as the medium, similar arrangements for supply of the drying agent should be made to those required in **Par 3.** Where agents are used as the drying medium on all air inlets to the tank, sufficient medium should be carried for the duration of the voyage, taking into consideration the diurnal temperature range and the expected humidity.

902. Environmental control requirements for individual products (IBC Code 9.2)

The required types of environmental control for certain products are shown in column "h" in the table of **Sec 17.**

SECTION 10 Electrical Installations

1001. General (IBC Code 10.1)

1. The provisions of this Section are applicable to ships carrying cargoes which are inherently, or due to their reaction with other substances, flammable or corrosive to the electrical equipment, and should be applied in conjunction with applicable electrical requirements of part D, chapter II-1 of the 1983 SOLAS amendments.

2. (1) Electrical installations should be such as to minimize the risk of fire and explosion from flammable products. Electrical installations complying with this Section should not be considered a source of ignition for the purposes of **802. 3**(2), having regard to **Par 4.**
(2) Where the specific cargo is liable to damage the materials normally used in electrical apparatus, due consideration should be given to the particular characteristics of the materials chosen for conductors, insulation, metal parts, etc. As far as necessary, these components should be protected to prevent contact with gases or vapours liable to be encountered.

3. The Society should take appropriate steps to ensure uniformity in the implementation and the application of the provisions of this Section in respect of electrical installations.

4. Electrical equipment and wiring should not be installed in the hazardous locations referred to in **1002.,** unless essential for operational purposes, when the exceptions listed in **1002. 3** are permitted.

5. Where electrical equipment is installed in hazardous locations, as permitted in this Section, it should be to the satisfaction of the Society and certified by the relevent authorities recognized by the Society for operation in the flammable atmosphere concerned, as indicated in column "i" in the table of **Sec 17.**

6. Absence of information on temperature class and apparatus group in column "i" in the table of **Sec 17** means that data are not currently available, and this should not be confused with the non-flammable (NF) notation describing some substances. For guidance, indication is given if the flashpoint of a substance is in excess of 60°C (closed cup test). In the case of heated cargo, carriage conditions might need to be established and the requirements of **1002. 2** applied.

1002. Hazardous locations and types of equipment and wiring (IBC Code 10.2)

1. The restrictions in this Article do not preclude the use of intrinsically safe systems and circuits in all hazardous locations including cargo piping. It is particularly recommended that intrinsically safe systems and circuits are used for measurement, monitoring, control and communication purposes.

2. Cargoes with a flashpoint exceeding 60°C (closed cup test):
(1) Cargo tanks and cargo piping are the only hazardous locations for such cargoes which have no qualification in column "o" in the table of **Sec 17.** Submerged cargo pump motors and their associated cables may, in exceptional circumstances for a specific cargo or for a clearly defined range of cargoes, be permitted by the Society, due consideration having been given to the chemical and physical characteristics of the products. Arrangements should be made to prevent the energizing of motors and cables in flammable gas-air mixtures and to de-energize the motors and cables in the event of low liquid level. Such a shutdown should be indicated by an alarm at the cargo control station.
(2) Where electrical equipment is located in a cargo pump room, due consideration should be given to the use of types of apparatus which ensure the absence of arcs or sparks and hot spots during normal operation, or which are of a certified safe type.
(3) Where the cargo is heated to within 15°C of its flashpoint value, the cargo pump room should be considered as a hazardous area as well as areas within 3 m of openings from tanks where the cargo is so heated, and within 3 m of the entrance or ventilation openings to cargo pump rooms. Electrical equipment

installed within these locations should be of a certified safe type.

(4) Where the cargo is heated above its flash-point value, the requirements of **Par 3** are applicable.

3. For cargoes with a flashpoint not exceeding 60°C (closed cup test) without qualification in column "o" in the table of **Sec 17,** the hazardous locations are given below. In addition to intrinsically safe systems and circuits, the only electrical installations permitted in hazardous locations are the following:

(1) Cargo tanks and cargo piping: No additional electrical equipment is permitted.

(2) Void spaces adjacent to, above or below integral tanks:
- (a) Through runs of cables. Such cables should be installed in heavy gauge steel pipes with gastight joints. Expansion bends should not be fitted in such spaces.
- (b) Electrical depth-sounding or log devices and impressed current cathodic protection system anodes or electrodes. These devices should be housed in gastight enclosures; associated cables should be protected as referred to in (a).

(3) Hold spaces containing independent cargo tanks:
- (a) Through runs of cables without any additional protection.
- (b) Lighting fittings with pressurized enclosure or of the flameproof type. The lighting system should be divided between at least two branch circuits. All switches and protective devices should interrupt all poles or phases and should be located in a non-hazardous location.
- (c) Electrical depth-sounding or log devices and impressed current cathodic protection system anodes or electrodes. These devices should be housed in gastight enclosures.

(4) Cargo pump rooms and pump rooms in the cargo area:
- (a) Lighting fittings with pressurized enclosures or of the flameproof type. The lighting system should be divided between at least two branch circuits. All switches and all protective devices should interrupt all poles or phases and should be located in a non-hazardous location.
- (b) Electrical motors for driving cargo pumps and any associated auxiliary pumps should be separated from these spaces by a gastight bulkhead or deck. Flexible couplings, or other means of maintaining alignment, should be fitted to the shafts between the driven equipment and its motors, and in addition, glands should be provided in accordance with recognized standards where the shafts pass through the bulkhead or deck. Such electical motors should be located in a compartment having positive pressure ventilation.
- (c) Flameproof general alarm audible indicator.

(5) Zones on open deck, or semi-enclosed spaces on open deck, within 3 m of any cargo tank outlet, gas or vapour outlet, cargo pipe flange, cargo valve or entrance and ventilation opening to cargo pump rooms; cargo area on open deck over all cargo tanks and cargo tank holds, including all ballast tanks and cofferdams within the cargo area, to the full width of the ship, plus 3 m fore and aft and up to a height of 2.4 m above the deck:
- (a) equipment of a certified safe type, adequate for open deck use;
- (b) through runs of cables.

(6) Enclosed or semi-enclosed spaces in which pipes containing cargoes are located; enclosed or semi-enclosed spaces immediately above cargo tanks (e.g. between decks) or having bulkheads above and in line with cargo tank bulkheads; enclosed or semi-enclosed spaces immediately above cargo pump rooms or above vertical cofferdams adjoining cargo tanks, unless separated by a gastight deck and suitably ventilated; and compartments for cargo hoses:
- (a) Lighting fittings of a certified safe type. The lighting system should be divided between at least two branch circuits. All switches and protective devices should interrupt all poles or phases and should be located in a non-hazardous location.
- (b) Through runs of cables.

(7) Enclosed or semi-enclosed spaces having a direct opening into any hazardous location referred to above should have electrical installations complying with the requirements for the space or zone into which the opening leads.

1003. Bonding (IBC Code 10.3)

Independent cargo tanks should be electrically bonded to the hull. All gasketed cargo pipe joints and hose connections should be electrically bonded.

1004. Electrical requirements for individual products (IBC Code 10.4)

Electrical requirements for individual products are shown in column "i" in the table of **Sec 17.**

SECTION 11
Fire Protection and Fire Extinction

1101. Application (IBC Code 11.1)

1. The requirements for tankers in chapter II-2 of the 1983 SOLAS amendments should apply to ships covered by this Chapter, irrespective of tonnage, including ships of less than 500 tons gross tonnages, except that:

(1) regulations 60, 61, 62 and 63 should not apply;
(2) regulation 56.2, i.e. the requirements for location of the main cargo control station, need not apply;
(3) regulation 4, as applicable to cargo ships, and regulation 7 should apply as they would apply to tankers of 2,000 tons gross tonnage and over;
(4) the provisions of **1103.** should apply in lieu of regulation 61; and
(5) the provisions of **1102.** should apply in lieu of regulation 63.

2. Notwithstanding the provisions of **Par 1,** ships engaged solely in the carriage of products which are non-flammable (entry NF in column "i" of the table of minimum requirements) need not comply with part D of chapter II-2 of the 1983 SOLAS amendments, provided that they comply with part C of that chapter, except that regulation 53 need not apply to such ships and **1102.** and **1103.** hereunder need not apply.

3. For ships engaged solely in the carriage of products with flashpoint above 60°C (entry "yes" in column "i" of the table of minimum requirements) reguirements of chapter II-2 of the 1983 SOLAS amendments may apply as specified in regulation II-2/55.4 in lieu of the provisions of this Section.

1102. Cargo pump rooms (IBC Code 11.2)

1. The cargo pump room of any ship should be provided with a fixed fire-extinguishing system as follows:

(1) a carbon dioxide system as specified in regulation II-2/5.1 and .2 of the 1983 SOLAS amendments. A notice should be exhibited at the controls stating that the system is only to be used for fire-extinguishing and not for inerting purposes, due to the electrostatic ignition hazard. The alarms referred to in regulation II-2/5.1.6 of the 1983 SOLAS amendments should be safe for use in a flammable cargo vapour-air mixture. For the purpose of this requirements, an extinguishing system should be provided which would be suitable for machinery spaces. However, the amount of gas carried should be sufficient to provide a quantity of free gas equal to 45% of the gross volume of the cargo pump room in all cases; or
(2) a halogenated hydrocarbon system as specified in regulation II-2/5.1 and .3 of the 1983 SOLAS amendments. A notice should be exhibited at the controls stating that the system is only to be used for fire-extinguishing and not for inerting purposes, due to the electrostatic ignition hazard. The alarms referred to in regulation II-2/5.1.6 of the 1983 SOLAS amendments should be safe for use in a flammable cargo vapour-air mixture. For the purpose of this requirement, an extinguishing system should be provided which would be suitable for machinery spaces but utilizing the following minimum design quantities based on the gross volume of the cargo pump room:

Halon 1301	7%
Halon 1211	5.5%
Halon 2402	0.3 kg/m^3

2. Cargo pump rooms of ships which are dedicated to the carriage of a restricted number of cargoes should be protected by an appropriate fire-extinguishing system approved by the Society.

3. A fire-extinguishing system consisting of either a fixed pressure water-spray system or a high-expansion foam system could be provided for a cargo pump room if cargoes will be carried which are not suited to extinguishment by carbon dioxide or equivalent media. The International Certificate of Fitness for the Carriage of Dangerous Chemicals in Bulk should reflect this conditional requirement.

1103. Cargo area (IBC Code 11.3)

1. Every ship should be provided with a fixed deck foam system in accordance with the requirements of **Pars 2** to **12.**

2. Only one type of foam concentrate should be supplied, and it should be effective for the maximum possible number of cargoes intended to be carried. For other cargoes for which foam is not effective or is incompatible, additional arrangements to the satisfaction of the Society should be provided. Regular protein foam should not be used.

3. The arrangements for providing foam should be capable of delivering foam to the entire cargo tanks deck area as well as into any cargo tank, the deck of which is assumed to be ruptured.

4. The deck foam system should be capable of simple and rapid operation. The main control station for the system should be suitably located outside of the cargo area, adjacent to the accommodation spaces and readily accessible and operable in the event of fires in the areas protected.

5. The rate of supply of foam solution should be not less than the greatest of the following:

(1) 2 l/min per square metre of the cargo tanks deck area, where cargo tanks deck area means the maximum breadth of the ship times the total longitudinal extent of the cargo tank spaces;
(2) 20 l/min per square metre of the horizontal sectional area of the single tank having the largest such area;
(3) 10 l/min per square metre of the area protected by the largest monitor, such area being entirely forward of the monitor, but not less than 1,250 l/min. For ships of less than 4,000 tonnes deadweight, the minimum capacity of the monitor should be to the satisfaction of the Society.

6. Sufficient foam concentrate should be supplied to ensure at least 30 min of foam generation when using the highest of the solution rates stipulated in **5** (1) to (3).

7. Foam from the fixed foam system should be supplied by means of monitors and foam applicators. At least 50% of the foam rate required in **Par 5.** (1) or (2) should be delivered from each monitor. The capacity of any monitor should be at least 10 l/min of foam solution per square metre of deck area protected by that monitor, such area being entirely forward of the monitor. Such capacity should be not less than 1,250 l/min. For ships of less than 4,000 tonnes deadweight, the minimum capacity of the monitor should be to the satisfaction of the Society.

8. The distance from the monitor to the farthest extremity of the protected area forward of that monitor should be not more than 75% of the monitor throw in still air conditions.

9. A monitor and hose connection for a foam applicator should be situated both port and starboard at the poop front or accommodation spaces facing the cargo area.

10. Applicators should be provided for flexibility of action during fire-fighting operations and to cover areas screened from the monitors. The capacity of any applicator should be not less than 400 l/min and the applicator throw in still air conditions should be not less than 15 m. The number of foam applicators provided should be not less than four. The number and disposition of foam main outlets should be such that foam from at least two applicators can be directed to any part of the cargo tanks deck area.

11. Valves should be provided in the foam main, and in the fire main where this is an integral part of the deck foam system, immediately forward of any monitor position to isolate damaged sections of those mains.

12. Operation of a deck foam system at its required output should permit the simultaneous use of the minimum required number of jets of water at the required pressure from the fire main.

13. Ships which are dedicated to the carriage of a restricted number of cargoes should be protected by alternative provisions to the satisfaction of the Society when they are just as effective for the products concerned as the deck foam system required for the generality of flammable cargoes.

14. Suitable portable fire-extinguishing equipment for the products to be carried should be provided and kept in good operating order.

15. Where flammable cargoes are to be carried all sources of ignition should be excluded from hazardous locations referred to in **1002.**

16. Ships fitted with bow or stern loading and unloading arrangements should be provided with one additional foam monitor meeting the requirements of **Par 7** and one additional applicator meeting the requirements of **Par 10.** The additional monitor should be located to protect the bow or stern loading and unloading arrangements. The area of the cargo line forward or aft of the cargo area should be protected by the above-mentioned applicator.

1104. Special requirements (IBC Code 11.4)

Fire-extinguishing media determined to be effective for certain products are listed in column “l” in the table of **Sec 17.**

SECTION 12
Mechanical Ventilation in the Cargo Area

For ships to which this Chapter applies, the requirements of this Section replace the requirements of regulation II-2/ 59.3 of the 1983 SOLAS amendments. However, for products addressed under **1101. 2** and **1101. 3,** except acids and products for which **1517.** apply, regulation II-2/59.3 of the 1983 SOLAS amendments may apply in lieu of the provisions of this Section.

1201. Spaces normally entered during cargo handling operations (IBC Code 12.1)

1. Cargo pump rooms and other enclosed spaces which contain cargo handling equipment and similar spaces in which work is performed on the cargo should be fitted with mechanical ventilation systems, capable of being controlled from outside such spaces.

2. Provision should be made to ventilate such spaces prior to entering the compartment and operating the equipment and a warning notice requiring the use of such ventilation should be placed outside the compartment.

3. Mechanical ventilation inlets and outlets should be arranged to ensure sufficient air movement through the space to avoid the accumulation of toxic or flammable vapours or both (taking into account their vapour densities) and to ensure sufficient oxygen to provide a safe working environment, but in no case should the ventilation system have a capacity of less than 30 changes of air per hour based upon the total volume of the space. For certain products, increased ventilation rates for cargo pump rooms are prescribed in **1517.**

4. Ventilation systems should be permanent and should normally be of the extraction type. Extraction from above and below the floor plates should be possible. In rooms housing motors driving cargo pumps, the ventilation should be of the positive pressure type.

5. Ventilation exhaust ducts from spaces within the cargo area should discharge upwards in locations at least 10m in the horizontal direction from ventilation intakes and openings to accommodation, service and machinery spaces and control stations and other spaces outside the cargo area.

6. Ventilation intakes should be so arranged as to minimize the possibility of recycling hazardous vapours from any ventilation discharge opening.

7. Ventilation ducts should not be led through accommodation, service and machinery spaces or other similar spaces.

8. Electric motors driving fans should be placed outside the ventilation ducts if the carriage of flammable products is intended. Ventilation fans and fan ducts, in way of fans only, for hazardous locations referred to in **Sec 10** should be of non-sparking construction defined as:

(1) impellers or housing of nonmetallic construction, due regard being paid to the elimination of static electricity;
(2) impellers and housing of nonferrous materials;
(3) impellers and housing of austenitic stainless steel; and
(4) ferrous impellers and housing with not less than 13 mm design tip clearance.

Any combination of an aluminium or magnesium alloy fixed or rotating component and a ferrous fixed or rotating component, regardless of tip clearance, is considered a sparking hazard and should not be used in these places.

9. Sufficient spare parts should be carried for each type of fan on board, required by this Section.

10. Protection screens of not more than 13 mm square mesh should be fitted in outside openings of ventilation ducts.

1202. Pump rooms and other enclosed spaces normally entered (IBC Code 12.2)

Pump rooms and other enclosed spaces normally entered, which are not covered by **1201. 1,** should be fitted with mechanical ventilation systems, capable of being controlled from outside such spaces and complying with the requirements of **1201. 3,** except that the capacity should not be less than 20 changes of air per hour, based upon the total volume of the space. Provision should be made to ventilate such spaces prior to entering.

1203. Spaces not normally entered (IBC Code 12.3)

Double bottoms, cofferdams, duct keels, pipe tunnels, hold spaces and other spaces where cargo may accumulate, should be capable of being ventilated to ensure a safe environment when entry into the spaces is necessary. Where a permanent ventilation system is not provided for such spaces, approved means of portable mechanical ventilation should be provided. Where necessary owing to the arrangement of spaces, for instance hold spaces, essential ducting for such ventilation should be permanently installed. For permanent installations, the capacity of 8 air changes per hour should be provided and for portable systems the capacity of 16 air changes per hour. Fans or blowers should be clear of personnel access openings, and should comply with **1201. 8.**

SECTION 13
Instrumentation

1301. Gauging (IBC Code 13.1)

1. Cargo tanks should be fitted with one of the following types of gauging devices:

(1) Open device—which makes use of an opening in the tanks and may expose the gauger to the cargo or its vapour. An example of this is the ullage opening.
(2) Restricted device—which penetrates the tank and which, when in use, permits a small quantity of cargo vapour or liquid to be exposed to the atmosphere. When not in use, the device is completely closed. The design should ensure that no dangerous escape of tank contents (liquid or spray) can take place in open-

ing the device.

(3) Closed device—which penetrates the tank, but which is part of a closed system and keeps tank contents from being released. Examples are the float-type systems, electronic probe, magnetic probe and protected sight glass. Alternatively an indirect device which does not penetrate the tank shell and which is independent of the tank may be used. Examples are weighing of cargo, pipe flow meter.

2. Gauging devices should be independent of the equipment required under **1519.**

3. Open gauging and restricted gauging should be allowed only where:

(1) open venting is allowed by this Chapter; or
(2) means are provided for relieving tank pressure before the gauge is operated.

4. Types of gauging for individual products are shown in column "j" in the table of **Sec 17.**

1302. Vapour detection (IBC Code 13.2)

1. Ships carrying toxic or flammable products or both should be equipped with at least two instruments designed and calibrated for testing for the specific vapours in question. If such instruments are not capable of testing for both toxic concentrations and flammable concentrations, then two separate sets of instruments should be provided.

2. Vapour detection instruments may be portable or fixed. If a fixed system is installed, at least one portable instrument should be provided.

3. When toxic vapour detection equipment is not available for some products which require such detection, as indicated in column "k" in the table of **Sec 17,** the Society may exempt the ship from the requirement, provided an appropriate entry is made on the International Certificate of Fitness for the Carriage of Dangerous Chemicals in Bulk. When granting such an exemption, the Society should recognize the necessity for additional breathing air supply and an entry should be made on the International Certificate of Fitness for the Carriage of Dangerous Chemicals in Bulk drawing attention to the provisions of **1402. 4** and **1604. 2** (2).

4. Vapour detection requirements for individual products are shown in column ''k'' in the table of **Sec 17.**

SECTION 14
Personnel Protection

1401. Protective equipment (IBC Code 14.1)

1. For the protection of crew members who are engaged in loading and discharging operations, the ship should have on board suitable protective equipment consisting of large aprons, special gloves with long sleeves, suitable footwear, coveralls of chemical-resistant material, and tight-fitting goggles or face shields or both. The protective clothing and equipment should cover all skin so that no part of the body is unprotected.

2. Work clothes and protective equipment should be kept in easily accessible places and in special lockers. Such equipment should not be kept within accommodation spaces, with the exception of new, unused equipment and equipment which has not been used since undergoing a thorough cleaning process. The Society may, however, approve storage rooms for such equipment within accommodation spaces if adequately segregated from living spaces such as cabins, passageways dining rooms, bathrooms, etc.

3. Protective equipment should be used in any operation which may entail danger to personnel.

1402. Safety equipment (IBC Code 14.2)

1. Ships carrying cargoes for which **1512., 1512. 1** or **3** is listed in column "o" in the table of **Sec 17** should have on board sufficient but not less than three complete sets of safety equipment each permitting personnel to enter a gas-filled compartment and perform work there for at least 20 min. Such equipment should be in addition to that required by regulation II-2/17 of the 1983 SOLAS amendments.

2. One complete set of safety equipment should consist of:

(1) one self-contained air-breathing apparatus (not using stored oxygen);
(2) protective clothing, boots, gloves and tight-fitting goggles;
(3) fireproof lifeline with belt resistant to the cargoes carried; and
(4) explosion-proof lamp.

3. For the safety equipment required in **Par 1,** all ships should carry the following, either:

(1) one set of fully charged spare air bottles for each breathing apparatus;
(2) a special air compressor suitable for the supply of high-pressure air of the required purity.
(3) a charging manifold capable of dealing with sufficient spare breathing apparatus air bottles for the breathing apparatus; or
(4) fully charged spare air bottles with a total free air capacity of at least 6,000 l for each breathing apparatus on board in excess of the requirements of regulation II-2/17 of the 1983 SOLAS amendments.

4. A cargo pump room of ships carrying cargoes which are subject to the requirements of **1518.** or cargoes for which in column "k" in the table of **Sec 17** toxic vapour detection equipment is required but is not available should have either:

(1) a low-pressure line system with hose connections suitable for use with the breathing apparatus required by **Par 1.** This system should provide sufficient high-pressure air capacity to supply, through pressure reduction devices, enough low-pressure air to enable two men to work in a gas-dangerous space for at least 1 h without using the air bottles of the breathing apparatus. Means should be provided for recharging the fixed air bottles and breathing apparatus air bottles from a special air compressor suitable for the supply of high-pressure air of the required purity; or
(2) an equivalent quantity of spare bottled air in lieu of the low-pressure air line.

5. At least one set of safety equipment as required by **Par 2** should be kept in a suitable clearly marked locker in a readily accessible place near the cargo pump room. The other sets of safety equipment should also be kept in suitable, clearly marked, easily accessible, places.

6. The breathing apparatus should be inspected at least once a month by a responsible officer, and the inspection recorded in the ship's log-book. The equipment should be inspected and tested by an expert at least once a year.

7. A stretcher which is suitable for hoisting an injured person up from spaces such as the cargo pump room should be placed in a readily accessible location.

8. Ships intended for the carriage of certain cargoes should be provided with suitable respiratory and eye protection sufficient for every person on board for emergency escape purposes, subject to the following:

(1) filter type respiratory protection is unacceptable;
(2) self-contained breathing apparatus should have normally at least a duration of service of 15 min;
(3) emergency escape respiratory protection should not be used for fire-fighting or cargo handling purposes and should be marked to that effect.

Individual cargoes to which the provisions of this paragraph apply are indicated in column "n" in the table of **Sec 17.**

9. The ships should have on board medical first-aid equipment including oxygen resuscitation equipment and antidotes for cargoes carried, based on the guidelines developed by IMO.

10. Suitably marked decontamination showers and an eyewash should be available on deck in convenient locations. The showers and eyewash should be operable in all ambient conditions.

SECTION 15
Special Requirements

The provisions of this Section are applicable where specific reference is made in column "o" in the table of **Sec 17.** These requirements are additional to the general requirements of this Chapter.

1501. Acetone cyanohydrin and lactronitrile solution (80% or less) (IBC Code 15.1)

Acetone cyanohydrin and lactronitrile solution (80% or less) should be stabilized with an inorganic acid to prevent decomposition. A certificate of stabilization should be provided by the manufacturer, and kept on board, specifying:

(1) name and amount of stabilizer added;
(2) date stabilizer was added and duration of effectiveness;
(3) any temperature limitations qualifying the stabilizer's effective lifetime;
(4) the action to be taken should the length of voyage exceed the effective lifetime of the stabilizer.

1502. Ammonium nitrate solution, 93% or less (IBC Code 15.2)

1. The ammonium nitrate solution should contain at least 7% by weight of water. The acidity (pH) of the cargo when diluted with ten parts of water to one part of cargo by weight should be between 5.0 and 7.0. The solution should not contain more than 10 ppm chloride ions, 10 ppm ferric ions, and should be free of other contaminants.

2. Tanks and equipment for ammonium nitrate solution should be independent of tanks and equipment containing other cargoes or combustible products. Equipment which may in service, or when defective, release combustible products into the cargo, e.g. lubricants, should not be used. Tanks should not be used for seawater ballast.

3. Except where expressly approved by the Society, ammonium nitrate solutions should not be transported in tanks which have previously contained other cargoes unless tanks and associated equipment have been cleaned to the satisfaction of the Society.

4. The temperature of the heat exchanging medium in the tank heating system should not exceed 160°C. The heating system should be provided with a control system to keep the cargo at a bulk mean temperature of 140°C. High-temperature alarms at 145°C and 150°C and a low-temperature alarm at 125°C should be provided. Where the temperature of the heat exchanging medium exceeds 160°C an alarm should also be given. Temperature alarms and controls should be located on the navigating bridge.

5. If the bulk mean cargo temperature reaches 145°C, a cargo sample should be diluted with ten parts of distilled or demineralized water to one part of cargo by weight and the acidity (pH) should be determined by means of a narrow range indicator paper or stick. Acidity (pH) measurements should then be taken every 24 h. If the acidity (pH) is found to be below 4.2, ammonia gas should be injected into the cargo until the acidity (pH) of 5.0 is reached.

6. A fixed installation should be provided to inject ammonia gas into the cargo. Controls for this system should be located on the navigating bridge. For this purpose, 300 kg of ammonia per 1,000 tonnes of ammonium nitrate solution should be available on board.

7. Cargo pumps should be of the centrifugal deepwell type or of the centrifugal type with water-flushed seals.

8. Vent piping should be fitted with approved weatherhoods to prevent clogging. Such weatherhoods should be accessible for inspection and cleaning.

9. Hot work on tanks, piping and equipment which have been in contact with ammonium nitrate solution should only be done after all traces of ammonium nitrate have been removed, inside as well as outside.

1503. Carbon disulphide (IBC Code 15.3)

Carbon disulphide may be carried either under water pad or under suitable inert gas pad as specified in the following paragraphs.

1. Provision should be made to maintain a water pad in the cargo tank during loading, unloading and transit. In addition, an inert gas pad should be maintained in the ullage space during transit.

2. All openings should be in the top of the tank, above the deck.

3. Loading lines should terminate near the bottom of the tank.

4. A standard ullage opening should be provided for emergency sounding.

5. Cargo piping and vent lines should be independent of piping and vent lines used for other cargo.

6. Pumps may be used for discharging cargo, provided they are of the deepwell or hydraulically driven submersible types. The means of driving a deepwell pump should not present a source of ignition for carbon disulphide and should not employ equipment that may exceed a temperature of 80°C.

7. If a cargo discharge pump is used, it should be inserted through a cylindrical well extending from the tank top to a point near the tank bottom. A water pad should be formed in this well before attempting pump removal unless the tank has been certified as gas-free.

8. Water or inert gas displacement may be used for discharging cargo, provided the cargo system is designed for the expected pressure and temperature.

9. Safety relief valves should be of stainless steel construction.

10. Because of its low ignition temperature and close clearances required to arrest its flame propagation, only intrinsically safe system and circuits are permitted in the hazardous location described in **1002. 3.**

11. Carbon disulphide should be carried in independent tanks with a design pressure of not less than 0.06 MPa gauge.

12. All openings should be located on the top of the tank, above the deck.

13. Gaskets used in the containment system should be of a material which does not react with, or dissolve in, carbon disulphide.

14. Threaded joints should not be permitted in the cargo containment system, including the vapour lines.

15. Prior to loading, the tank(s) should be inerted with suitable inert gas until the oxygen level is 2% by volume or lower. Means should be provided to automatically maintain a positive pressure in the tank using suitable inert gas during loading, transport and discharge. The system should be able to maintain this positive pressure between 0.01 and 0.02 MPa gauge, and should be remotely monitored and fitted with over/under-pressure alarms.

16. Hold spaces surrounding an independent tank carrying carbon disulphide should be inerted by a suitable inert gas until the oxygen level is 2% or less. Means should be provided to monitor and maintain this condition throughout the voyage. Means should also be provided to sample these spaces for carbon disulphide vapour.

17. Carbon disulphide should be loaded, transported and discharged in such a manner that venting to the atmosphere does not occur. If carbon disulphide vapour is returned to shore during loading or to the ship during discharge, the vapour return system should be independent of all other containment systems.

18. Carbon disulphide should be discharged only by submerged deepwell pumps or by a suitable inert gas displacement. The submerged deepwell pumps should be operated in a way that prevents heat build-up in the pump. The pump should also be equipped with a temperature sensor in the pump housing with remote readout and alarm in the cargo control room. The alarm should be set at 80°C. The pump should also be fitted with an automatic shut-down device, if the tank pressure falls below atmospheric pressure during the discharge.

19. Air should not be allowed to enter the cargo tank, cargo pump or lines while carbon disulphide is contained in the system.

20. No other cargo handling, tank cleaning or deballasting should take place concurrent with loading or discharge of carbon disulphide.

21. A water spray system of sufficient capacity should be provided to blanket effectively the area surrounding the loading manifold, the exposed deck piping associated with product handling and the tank domes. The arrangement of piping and nozzles should be such as to give an uniform distribution rate of 10 $l/m^2\ /min$. Remote manual operation should be arranged such that remote starting of pumps supplying the water-spray system and remote operation of any normally closed valves in the system can be carried out from a suitable location outside the cargo area adjacent to the accommodation spaces and readily accessible and operable in the event of fire in the areas protected. The water-spray system should be capable of both local and remote manual operation, and the arrangement should ensure that any spilled cargo is washed away. Additionally, a water hose with pressure to the nozzle when atmospheric temperature permits, should be connected ready for immediate use during loading and unloading operations.

22. No cargo tanks should be more than 98% liquid-full at the reference temperature (R).

23. The maximum volume (V_L) of cargo to be loaded in a tank should be:

$$V_L = 0.98 V \rho_R / \rho_L$$

where:

- V_L : volume of the tank
- ρ_R : relative density of cargo at the reference temperature (R)
- ρ_L : relative density of cargo at the loading temperature
- R : reference temperature, i.e. the temperature at which the vapour pressure of the cargo corresponds to the set pressure of the pressure relief valve.

24. The maximum allowable tank filling limits for each cargo tank should be indicated for each loading temperature which may be applied, and for the applicable maximum reference temperature, on a list approved by the Administration. A copy of the list should be permanently kept on board by the master.

25. Zones on open deck, or semi-enclosed spaces on open deck within three metres of a tank outlet, gas or vapour outlet, cargo pipe flange or cargo valve of a tank certified to carry carbon disulphide, should comply with the electrical equipment requirements specified for carbon disulphide in column "i" in the table of **Sec 17.** Also, within the specified zone, no other heat sources, like steam piping with surface temperatures in excess of 80°C should be allowed.

26. Means should be provided to ullage and sample the cargo without opening the tank or disturbing the positive suitable inert gas blanket.

27. The product should be transported only in accordance with a cargo handling plan that has been approved by the Administration. Cargo handling plans should show the entire cargo piping system. A copy of the approved cargo handling plan should be available on board. The International Certificate of Fitness for the Carriage of Dangerous Chemicals in Bulk should be endorsed to include reference to the approved cargo handling plan.

1504. Diethyl ether (IBC Code 15.4)

1. Unless inerted, natural ventilation should be provided for the voids around the cargo tanks while the vessel is under way. If a mechanical ventilation system is installed, all blowers should be of non-sparking construction. Mechanical ventilation equipment should not be located in the void spaces surrounding the cargo tanks.

2. Pressure relief valve settings should not be less than 0.02 MPa gauge for gravity tanks.

3. Inert gas displacement may be used for discharging cargo from pressure tanks provided the cargo system is designed for the expected pressure.

4. In view of the fire hazard, provision should be made to avoid any ignition source or heat generation or both in the cargo area.

5. Pumps may be used for discharging cargo, provided that they are of a type designed to avoid liquid pressure against the shaft gland or are of a hydraulically operated submerged type and are suitable for use with the cargo.

6. Provision should be made to maintain the inert gas pad in the cargo tank during loading, unloading and transit.

1505. Hydrogen peroxide solutions (IBC Code 15.5)

1. Hydrogen peroxide solutions over 60% but not over 70%

(1) Hydrogen peroxide solutions over 60% but not over 70% should be carried in dedicated ships only and no other cargoes should be

carried.

(2) Cargo tanks and associated equipment should be either pure aluminium (99.5%) or solid stainless steel (304L, 316, 316L or 316Ti), and passivated in accordance with approved procedures. Aluminium should not be used for piping on deck. All nonmetallic materials of construction for the containment system should neither be attacked by hydrogen peroxide nor contribute to its decomposition.

(3) Pump rooms should not be used for cargo transfer operations.

(4) Cargo tanks should be separated by cofferdams from oil fuel tanks or any other space containing flammable or combustible materials.

(5) Tanks intended for the carriage of hydrogen peroxide should not be used for seawater ballast.

(6) Temperature sensors should be installed at the top and bottom of the tank. Remote temperature readouts and continuous monitoring should be located on the navigating bridge. If the temperature in the tanks rises above 35°C, visible and audible alarms should be activated on the navigating bridge.

(7) Fixed oxygen monitors (or gas sampling lines) should be provided in void spaces adjacent to tanks to detect leakage of the cargo into these spaces. Remote readouts, continuous monitoring (if gas-sampling lines are used, intermittent sampling is satisfactory) and visible and audible alarms similar to those for the temperature sensors should also be located on the navigating bridge. The visible and audible alarms should be activated if the oxygen concentration in these void spaces exceeds 30% by volume. Two portable oxygen monitors should also be available as back-up systems.

(8) As a safeguard against uncontrolled decomposition, a cargo jettisoning system should be installed to discharge the cargo overboard. The cargo should be jettisoned if the temperature rise of the cargo exceeds a rate of 2°C per hour over a 5 h period or when the temperature in the tank exceeds 40°C.

(9) Cargo tank venting systems should have pressure/vacuum relief valves for normal controlled venting, and rupture discs or a similar device for emergency venting, should tank pressure rise rapidly as a result of uncontrolled decomposition. Rupture discs should be sized on the basis of tank design pressure, tank size and anticipated decomposition rate.

(10) A fixed water-spray system should be provided for diluting and washing away any concentrated hydrogen peroxide solution spilled on deck. The areas covered by the water-spray should include the manifold/hose connections and the tank tops of those tanks designated for carrying hydrogen peroxide solutions. The minimum application rate should satisfy the following criteria:

(a) The product should be diluted from the original concentration to 35% by weight within 5 min of the spill.

(b) The rate and estimated size of the spill should be based upon maximum anticipated loading and discharge rates, the time required to stop flow of cargo in the vent of tank overfill or a piping/hose failure, and the time necessary to begin application of dilution water with actuation at the cargo control location or on the navigating bridge.

(11) Hydrogen peroxide solutions should be stabilized to prevent decomposition. A certificate of stabilization should be provided by the manufacturer, and kept on board, specifying:

(a) name and amount of stabilizer added;

(b) date stabilizer was added and duration of effectiveness;

(c) any temperature limitations qualifying the stabilizer's effective lifetime;

(d) the action to be taken should the length of voyage exceed the effective lifetime of the stabilizer.

(12) Only those hydrogen peroxide solutions which have a maximum decomposition rate of 1% per year at 25°C should be carried. Certification from the shipper that the product meets this standard should be presented to the master and kept on board. A technical representative of the manufacturer should be on board to monitor the transfer operations and have the capability tc test the stability of the peroxide. He should certify to the master that the cargo has been loaded in a stable condition.

(13) Protective clothing that is resistant to hydrogen peroxide solutions should be provided for each crew member involved in cargo transfer operations. Protective clothing should include nonflammable coveralls, suitable gloves, boots and eye protection.

2. Hydrogen peroxide solutions over 8% but not over 60% by weight

(1) The ship's shell plating should not form any boundaries of tanks containing this product.

(2) Hydrogen peroxide should be carried in tanks thoroughly and effectively cleaned of all traces of previous cargoes and their vapours or ballast. Procedures for inspection, cleaning, passivation and loading of tanks should be in accordance with MSC/Circ. 394. A certificate should be on board the vessel indicating that the procedures in the circular have been followed. The passivation requirement may be waived by the Society for domestic shipments of short duration. Particular care in this respect is essential to ensure the safe carriage of

hydrogen peroxide.

(a) When hydrogen peroxide is carried no other cargoes should be carried simultaneously.

(b) Tanks which have contained hydrogen peroxide may be used for other cargoes after cleaning in accordance with the procedures outlined in MSC/Circ. 394.

(c) Consideration in design should provide minimum internal tank structure, free draining, no entrapment and ease of visual inspection.

(3) Cargo tanks and associated equipment should be either pure aluminium (99.5%) or solid stainless steel of types suitable for use with hydrogen peroxide (e.g. 304, 304*L*, 316, 316*L*, 316*Ti*). Aluminium should not be used for piping on deck. All nonmetallic materials of construction for the containment system should neither be attacked by hydrogen peroxide nor contribute to its decomposition,

(4) Cargo tanks should be separated by a cofferdam from fuel oil tanks or any other space containing materials incompatible with hydrogen peroxide.

(5) Temperature sensors should be installed at the top and bottom of the tank. Remote temperature readouts and continuous monitoring should be located on the navigating bridge. If the temperature in the tank rises above 35°C, visible and audible alarms should activate on the navigating bridge.

(6) Fixed oxygen monitors (or gas-sampling lines) should be provided in void spaces adjacent to tanks to detect leakage of the cargo into these spaces. The enhancement of flammability by oxygen enrichments should be recognized. Remote readouts, continuous monitoring (if gas-sampling lines are used, intermittent sampling is satisfactory) and visible and audible alarms similar to those for the temperature sensors should also be located on the navigating bridge. The visible and audible alarms should activate if the oxygen concentration in these void spaces exceeds 30% by volume. Two portable oxygen monitors should also be available as back-up systems.

(7) As a safeguard against uncontrolled decomposition, a cargo jettisoning system should be installed to discharge the cargo overboard. The cargo should be jettisoned if the temperature rise of the cargo exceeds a rate of 2°C per hour over a five-hour period or when the temperature in the tank exceeds 40°C.

(8) Cargo tank venting systems with filtration should have pressure/vacuum relief valves for normal controlled venting, and a device for emergency venting, should have for tank pressure rise rapidly as a result of an uncontrolled decomposition rate, as stipulated in (7). These venting systems should be designed in such a manner that there is no introduction of seawater into the cargo tank even under heavy sea conditions. Emergency venting should be sized on the basis of tank design pressure and tank size.

(9) A fixed water-spray system should be provided for diluting and washing away any concentrated solution spilled on deck. The areas covered by the water-spray should include the manifold/hose connections and the tank tops of those tanks designated for the carriage of hydrogen peroxide solutions. The minimum application rate should satisfy the following criteria:

(a) The product should be diluted from the original concentration to 35% by weight within 5 minutes of the spill.

(b) The rate and estimated size of the spill should be based upon maximum anticipated loading and discharge rates, the time required to stop flow of the cargo in the event of tank overfill or a piping/hose failure, and the time necessary to begin application of dilution water with actuation at the cargo control location or on the navigating bridge.

(10) Hydrogen peroxide should be stabilized to prevent decomposition. A certificate of stabilization should be provided by the manufacturer, and kept on board, specifying:

(a) name and amount of stabilizer added;

(b) date stabilizer was added and duration of effectiveness;

(c) any temperature limitations qualifying the stabilizer's effective lifetime;

(d) the action to be taken should the product become unstable during the voyage.

(11) Only those hydrogen peroxide solutions which have a maximum decomposition rate of 1% per year at 25°C should be carried. Certification from the shipper that the product meets this standard should be presented to the master and kept on board. A technical representative of the manufacturer should be on board to monitor the transfer operations and have the capability to test the stability of the hydrogen peroxide. He should certify to the master that the cargo has been loaded in a stable condition.

(12) Protective clothing that is resistant to hydrogen peroxide should be provided for each crew member involved in cargo transfer operations. Protective clothing should include coveralls that are nonflammable, suitable gloves, boots and eye protection.

(13) During transfer of hydrogen peroxide the related piping system should be separated from all other systems. Cargo hoses used for transfer of hydrogen peroxide should be marked "FOR HYDROGEN PEROXIDE TRANSFER ONLY".

1506. Motor fuel anti-knock compounds (containing lead alkyls) (IBC Code 15.6)

1. Tanks used for these cargoes should not be used for the transportation of any other cargo except those commodities to be used in the manufacturer of motor fuel anti-knock compounds containing lead alkyls.

2. If a cargo pump room is located on deck level according to **1518.,** the ventilation arrangements should be in compliance with **1517.**

3. Entry into cargo tanks used for the transportation of these cargoes is not permitted unless approved by the Society.

4. Air analysis should be made for lead content to determine if the atmosphere is satisfactory prior to allowing personnel to enter the cargo pump room or void spaces surrounding the cargo tank.

1507. Phosphorus, yellow or white (IBC Code 15.7)

1. Phosphorus should, at all times, be loaded, carried and discharged under a water pad of 760 mm minimum depth. During discharge operations, arrangements should be made to ensure that water occupies the volume of phosphorus discharged. Any water discharged from a phosphorus tank should be returned only to a shore installation.

2. Tanks should be designed and tested to a minimum equivalent water head of 2.4 m above the top of the tank, under designed loading conditions, taking into account the depth, relative density and method of loading and discharge of the phosphorus.

3. Tanks should be so designed as to minimize the interfacial area between the liquid phosphorus and its water pad.

4. A minimum ullage space of 1% should be maintained above the water pad. The ullage space should be filled with inert gas or naturally ventilated by two cowled standpipes terminating at different heights but at least 6 m above the deck and at least 2 m above the pump house top.

5. All openings should be at the top of cargo tanks, and fittings and joints attached thereto should be of materials resistant to phosphorus pentoxide.

6. Phosphorus should be loaded at a temperature not exceeding 60°C.

7. Tank heating arrangements should be external to tank and have a suitable method of temperature control to ensure that the temperature of the phosphorus does not exceed 60°C. A high-temperature alarm should be fitted.

8. A water drench system acceptable to the Society should be installed in all void spaces surrounding the tanks. The system should operate automatically in the event of an escape of phosphorus.

9. Void spaces referred to in **Par 8** should be provided with effective means of mechanical ventilation which should be capable of being sealed off quickly in an emergency.

10. Loading and discharge of phosphorus should be governed by a central system on the ship which, in addition to incorporating high-level alarms, should ensure that no overflow of tanks is possible and that such operations can be stopped quickly in an emergency from either ship or shore.

11. During cargo transfer, a water hose on deck should be connected to a water supply and kept flowing throughout the operation so that any spillage of phosphorus may be washed down with water immediately.

12. Ship-to-shore loading and discharge connections should be of a type approved by the Society.

1508. Propylene oxide and mixtures of ethylene oxide/propylene oxide with an ethylene oxide content of not more than 30% by weight (IBC Code 15.8)

1. Products transported under the provisions of this Article should be acetylene-free.

2. Unless cargo tanks are properly cleaned, these products should not be carried in tanks which have contained as one of the three previous cargoes any products known to catalyse polymerization, such as:

(1) mineral acids (e.g. sulphuric, hydrochloric, nitric);
(2) carboxylic acids and anhydrides (e.g. formic, acetic);
(3) halogenated carboxylic acids (e.g. chloracetic);
(4) sulphonic acids (e.g. benzene sulphonic);
(5) caustic alkalis (e.g. sodium hydroxide, potassium hydroxide);
(6) ammonia and ammonia solutions;
(7) amines and amine solutions;
(8) oxidizing substances.

3. Before loading, tanks should be thoroughly and effectively cleaned, to remove all traces of previous cargoes from tanks and associated pipework, except where the immediately prior cargo has been propylene oxide or ethylene oxide/propylene oxide mixtures. Particular care should be taken in the case of ammonia in tanks made of steel other than stainless steel.

4. In all cases, the effectiveness of cleaning procedures for tanks and associated pipework should be checked by suitable testing or inspection to ascertain that no traces of acidic or alkaline materials remain that might create a hazardous situation in the presence of these products.

5. Tanks should be entered and inspected prior to each initial loading of these products to ensure freedom from contamination, heavy rust deposits and visible structural defects. When cargo tanks are in continuous service for these products, such inspections should be performed at intervals of not more than 2 years.

6. Tanks for the carriage of these products should be of steel or stainless steel construction.

7. Tanks for the carriage of these products may be used for other cargoes after thorough cleaning of tanks and associated pipework systems by washing or purging.

8. All valves, flanges, fittings and accessory equipment should be of a type suitable for use with the products and should be constructed of steel or stainless steel in accordance with recognized standards. Discs or disc faces, seats and other wearing parts of valves should be made of stainless steel containing not less than 11% chromium.

9. Gaskets should be constructed of materials which do not react with, dissolve in, or lower the autoignition temperature of these products and which are fire-resistant and possess adequate mechanical behaviour. The surface presented to the cargo should be polytetrafluoroethylene (PTFE), or materials giving a similar degree of safety by their inertness. Spirally wound stainless steel with a filler of PTFE or similar fluorinated polymer may be accepted.

10. Insulation and packing, if used, should be of a material which does not react with, dissolve in, or lower the autoignition temperature of these products.

11. The following materials and generally found unsatisfactory for gaskets, packing and similar uses in containment systems for these products and would require testing before being approved by the Society:

(1) Neoprene or nature rubber, if it comes into contact with the products.
(2) Asbestos, or binders used with asbestos.
(3) Materials containing oxides of magnesium, such as mineral wools.

12. Threaded joints should not be permitted in the cargo liquid and vapour lines.

13. Filling and discharge piping should extend to within 100 mm of the bottom of the tank or any sump pit.

14. The containment system for a tank containing these products should have a valved vapour return connection.

15. The products should be loaded and discharged in such a manner that venting of the tanks to atmosphere does not occur. If vapour return to shore is used during tank loading, the vapour return system connected to a containment system for the product should be independent of all other containment systems.

16. During discharge operations, the pressure in the cargo tank should be maintained above 0.07 bar gauge.

17. Tanks carrying these products should be vented independently of tanks carrying other products. Facilities should be provided for sampling the tank contents without opening the tank to atmosphere.

18. The cargo should be discharged only by deepwell pumps, hydraulically operated submerged pumps, or inert gas displacement. Each cargo pump should be arranged to ensure that the product does not heat significantly if the discharge line from the pump is shut off or otherwise blocked.

19. Cargo hoses used for transfer of these products should be marked "FOR ALKYLENE OXIDE TRANSFER ONLY".

20. Cargo tanks, void spaces and other enclosed spaces, adjacent to an integral gravity cargo tank carrying propylene oxide, should either contain a compatible cargo (those cargoes specified in **Par 2** are examples of substances considered incompatible) or be inerted by injection of a suitable inert gas. Any hold space in which an independent cargo tank is located should be inerted. Such inerted spaces and tanks should be monitored for these products and oxygen. Portable sampling equipment is satisfactory. The oxygen content of these spaces should be maintained below 2%.

21. In no case should air be allowed to enter the cargo pump or piping system while these products are contained within the system.

22. Prior to disconnecting shore-lines, the pressure in liquid and vapour lines should be relieved through suitable valves installed at the loading header. Liquid and vapour from these lines should not be discharged to atmosphere.

23. Propylene oxide may be carried in pressure tanks or in independent or integral gravity tanks. Ethylene oxide/propylene oxide mixtures should be carried in independent gravity tanks or pressure tanks. Tanks should be designed for the maximum pressure expected to be encountered during loading, conveying and discharging cargo.

24. Tanks for the carriage of propylene oxide with a design pressure less than 0.6 bar gauge and tanks for the carriage of ethylene oxide/propylene oxide mixtures with a design pressure less than 1.2 bar gauge should have a cooling system to maintain the cargo below the reference temperature.

25. The refrigeration requirement for tanks with a design pressure less than 0.6 bar gauge may be waived by the Society for ships operating in restricted areas or on voyages of restricted duration, and account may be taken in such cases of any insulation of the tanks. The area and times of year for which such carriage would be permitted should be included in the conditions of carriage on the International Certificate of Fitness for the Carriage of Dangerous Chemicals in Bulk.

26. Any cooling system should maintain the liquid temperature below the boiling temperature at the containment pressure. At least two complete cooling plants automatically regulated by variations within the tanks should be provided. Each cooling plant should be complete with the necessary auxiliaries for proper operation. The control system should also be capable of being manually operated. An alarm should be provided to indicate malfunctioning of the temperature controls. The capacity of each cooling system should be sufficient to maintain the temperature of the liquid cargo below the reference temperature of the system.

27. An alternative arrangement may consist of three cooling plants, any two of which should be sufficient to maintain the liquid temperatures below the reference temperature.

28. Cooling media which are separated from the products by a single wall only should be nonreactive with the products.

29. Cooling systems requiring compression of the products should not be used.

30. Pressure relief valve settings should not be less than 0.02 MPar gauge and for pressure tanks not greater than 0.7 MPa gauge for the carriage of propylene oxide and not greater than 0.53 MPa gauge for the carriage of propylene oxide/ethylene oxide mixtures.

31. The piping system for tanks to be loaded with these products should be separated from piping systems for all other tanks, including empty tanks. If the piping system for the tanks to be loaded is not independent, the required piping separation should be accomplished by the removal of spool pieces, valves, or other pipe sections, and the installation of blank flanges at these locations. The required separation applies to all liquid and vapour piping, liquid and vapour vent lines and any other possible connections, such as common inert gas supply lines.

32. These products may be transported only in accordance with cargo handling plans that have been approved by the Society. Each intended loading arrangement should be shown on a separate cargo handling plan. Cargo handling plans should show the entire cargo piping system and the locations for installation of blank flanges needed to meet the above piping separation requirements. A copy of each approved cargo handling plan should be maintained on board the ship. The International Certificate of Fitness for the Carriage of Dangerous Chemicals in Bulk should be endorsed to include reference to the approved cargo handling plans.

33. Before each initial loading of these products and before every subsequent return to such service, certification verifying that the required piping separation has been achieved should be obtained from a responsible person acceptable to the port Administration and carried on board the ship. Each connection between a blank flange and a pipeline flange should be fitted with a wire and seal by the responsible person to ensure that inadvertent removal of the blank flange is impossible.

34. (1) No cargo tanks should be more than 98% liquid-full at the reference temperature.

(2) The maximum volume (V_L) of cargo to be loaded in a tank should be:

$$V_L = 0.98\, V \frac{\rho_R}{\rho_L}$$

where

V = volume of the tank

ρ_R = relative density of cargo at the reference temperature

ρ_L = relative density of cargo at the loading temperature and pressure.

(3) The maximum allowable tank filling limits for each cargo tank should be indicated for each loading temperature which may be applied, and for the applicable maximum reference temperature, on a list to be approved by the Society. A copy of the list should be permanently kept on board by the master.

35. The cargo should be carried under a suitable protective padding of nitrogen gas. An automatic nitrogen make-up system should be installed to prevent the tank pressure falling below 0.07 bar gauge in the event of product temperature fall due to ambient conditions or maloperation of refrigeration systems. Sufficient nitrogen should be available on board to satisfy the demand of the automatic pressure control. Nitrogen of commercially pure quality (99.9% by volume) should be used for padding. A battery of nitrogen bottles connected to the cargo tanks through a pressure reduction valve satisfies the intention of the expression “automatic” in this context.

36. The cargo tank vapour space should be tested prior to and after loading to ensure that the oxygen content is 2% by volume or less.

37. A water-spray system of sufficient capacity should be provided to blanket effectively the area surrounding the loading manifold, the exposed deck piping associated with product handling and the tank domes. The arrangement of piping and nozzles should be such as to give a uniform distribution rate of 10 l/min per square metre. Remote manual operation should be arranged such that remote starting of pumps supplying the water-spray system and remote operation of any normally closed valves in the system can be carried out from a suitable location outside the cargo area, adjacent to the accommodation spaces and readily accessible and operable in the event of fire in the areas protected. The water-spray system should be capable of both local and remote manual operation and the arrangement should ensure that any spilled cargo is washed away. Additionally, a water hose with pressure to the nozzle, when atmospheric temperatures permit, should be connected ready for immediate use during loading and unloading operations.

38. A remotely operated, controlled closing-rate, shutoff valve should be provided at each cargo hose connection used during cargo transfer.

1509. Sodium chlorate solution, 50% or less (IBC Code 15.9)

1. Tanks and associated equipment which have contained this product may be used for other cargoes after thorough cleaning by washing or purging.

2. In the event of spillage of this product, all spilled liquid should be thoroughly washed away without delay. To minimize fire risk, spillage should not be allowed to dry out.

1510. Sulphur, Molten (IBC Code 15.10)

1. Cargo tank ventilation should be provided to maintain the concentration of hydrogen sulphide below one half of its lower explosive limit throughout the cargo tank vapour space for all conditions of carriage, i.e. below 1.85% by volume.

2. Where mechanical ventilation systems are used for maintaining low gas concentrations in cargo tanks, an alarm system should be provided to give warning if the system fails.

3. Ventilation systems should be so designed and arranged as to preclude depositing of sulphur within the system.

4. Openings to void spaces adjacent to cargo tanks should be so designed and fitted as to prevent the entry of water, sulphur or cargo vapour.

5. Connections should be provided to permit sampling and analysing of vapour in void spaces.

6. Cargo temperature controls should be provided to ensure that the temperature of the sulphur does not exceed 155°C.

1511. Acids (IBC Code 15.11)

1. The ship's shell plating should not form any boundaries of tanks containing mineral acids.

2. Proposals for lining steel tanks and related piping systems with corrosion-resistant materials may be considered by the Society. The elasticity of the lining should not be less than that of the supporting boundary plating.

3. Unless constructed wholly of corrosion-resistant materials or fitted with an approved lining, the plating thickness should take into account the corrosivity of the cargo.

4. Flanges of the loading and discharge manifold connections should be provided with shields, which may be portable, to guard against the danger of the cargo being sprayed; and in addition, drip trays should also be provided to guard against leakage on to the deck.

5. Because of the danger of evolution of hydrogen when these substances are being carried, the electrical arrangements should comply with **1002. 3** (1) through (4), (6) and (7). The certified safe type equipment should be suitable for use in hydrogen-air mixtures. Other sources of ignition should not be permitted in such spaces.

6. Substances subjected to the requirements of this Article should be segregated from oil fuel tanks, in addition to the segregation requirements in **301. 1.**

7. Provision should be made for suitable apparatus to detect leakage of cargo into adjacent spaces.

8. The cargo pump room bilge pumping and drainage arrangements should be of corrosion-resistant materials.

1512. Toxic products (IBC Code 15.12)

1. Exhaust openings of tank vent systems should be located:

(1) at a height of B/3 or 6 m, whichever is greater, above the weather deck or, in the case of a deck tank, the access gangway;
(2) not less than 6 m above the fore-and-aft gangway, if fitted within 6 m of the gangway; and
(3) 15 m from any opening or air intake to any accommodation and service spaces;
(4) the vent height may be reduced to 3 m above the deck or fore-and-aft gangway, as applicable, provided high-velocity vent valves of a type approved by the Society, directing the vapour-air mixture upwards in an unimpeded jet with an exit velocity of at least 30 m/s, are fitted.

2. Tank venting systems should be provided with a connection for a vapour return line to the shore installation.

3. Products should:

(1) not be stowed adjacent to oil fuel tanks;

(2) have separate piping systems; and
(3) have tank vent systems separate from tanks containing nontoxic products.
(see also **307. 2**)

4. Cargo tank relief valve settings should be a minimum of 0.02 MPa gauge.

1513. Cargoes protected by additives (IBC Code 15.13)

1. Certain cargoes with a reference in column "o" in the table of **Sec 17** by the nature of their chemical make-up, tend, under certain conditions of temperature, exposure to air or contact with a catalyst, to undergo polymerization, decomposition, oxidation or other chemical changes. Mitigation of this tendency is carried out by introducing small amounts of chemical additives into the liquid cargo or by controlling the cargo tank environment.

2. Ships carrying these cargoes should be so designed as to eliminate from the cargo tanks and cargo handling system any material of construction or contaminants which could act as a catalyst or destroy the inhibitor.

3. Care should be taken to ensure that these cargoes are sufficiently protected to prevent deleterious chemical change at all times during the voyage. Ships carrying such cargoes should be provided with a certificate of protection from the manufacturer and kept during the voyage specifying:

(1) the name and amount of additive present;
(2) whether the additive is oxygen dependent;
(3) date additive was put in the product and duration of effectiveness;
(4) any temperature limitations qualifying the additives' effective lifetime; and
(5) the action to be taken should the length of voyage exceed the effective lifetime of the additives.

4. Ships using the exclusion of air as the method of preventing oxidation of the cargo should comply with **901. 3.**

5. A product containing an oxygen dependent additive should be carried without inertion (in tanks of a size not greater than 3,000 m^3). Such cargoes should not be carried in a tank requiring inertion under the requirements of SOLAS chapter II-2.

6. Venting systems should be of a design that eliminates blockage from polymer build-up. Venting equipment should be of a type that can be checked periodically for adequacy of operation.

7. Crystallization or solidification of cargoes normally carried in the molten state can lead to depletion of inhibitor in parts of the tank contents. Subsequent remelting can thus yield pockets of uninhibited, liquid with the accompanying risk of dangerous polymerization. To prevent this, care should be taken to ensure that at no time are such cargoes allowed to crystallize or solidify, either wholly or partially, in any part of the tank. Any required heating arrangements should be such as to ensure that in no part of the tank does cargo become overheated to such an extent that any dangerous polymerization can be initiated. If the temperature from steam coils would induce overheating, an indirect low-temperature heating system should be used.

1514. Cargoes with a vapour pressure greater than 0.1013 MPa absolute at 37.8°C (IBC Code 15.14)

1. For a cargo referenced in column "o" in the table of **Sec 17** to this Article, a mechanical refrigeration system should be provided unless the cargo system is designed to withstand the vapour pressure of the cargo at 45°C. Where the cargo system is designed to withstand the vapour pressure of the cargo at 45°C, and no refrigeration system is provided, a notation should be made in the conditions of carriage on the International Certificate of Fitness for the Carriage of Dangerous Chemicals in Bulk to indicate the required relief valve setting for the tanks.

2. A mechanical refrigeration system should maintain the liquid temperature below the boiling temperature at the cargo tank design pressure.

3. When ships operate in restricted areas and at restricted times of the year, or on voyages of limited duration, the Society involved may agree to waive requirements for a refrigeration system. A notation of any such agreement, listing geographic area restrictions and times of the year, or voyage duration limitations, should be included in the conditions of carriage on the International Certificate for the Carriage of Dangerous Chemicals in Bulk.

4. Connections should be provided for returning expelled gases to shore during loading.

5. Each tank should be provided with a pressure gauge which indicates the pressure in the vapour space above the cargo.

6. Where the cargo needs to be cooled, thermometers should be provided at the top and bottom of each tank.

7. (1) No cargo tanks should be more than 98% liquid-full at the reference temperature (R).
(2) The maximum volume (V_L) of cargo to be loaded in a tank should be:

$$V_L = 0.98\, V \frac{\rho_R}{\rho_L}$$

where

V = volume of the tank
ρ_R = relative density of cargo at the reference temperature (R)
ρ_L = relative density of cargo at the loading temperature
R = reference temperature corresponding to the vapour pressure of the cargo at the set pressure of the pressure relief valve.

(3) The maximum allowable tank filling limits for each cargo tank should be indicated for each loading temperature which may be applied, and for the applicable maximum reference temperature, on a list approved by the Society. A copy of the list should be permanently kept on board by the master.

1515. Cargoes with low ignition temperature and wide flammability range (IBC Code 15.15)

Deleted.

1516. Cargo contamination (IBC Code 15.16)

1. Where column "o" in the table of **Sec 17** refers to this Article, alkaline or acidic materials, such as caustic soda or sulphuric acid, should not be allowed to contaminate the cargo.

2. Where column "o" in the table of **Sec 17** refers to this Article, water should not be allowed to contaminate this cargo. In addition, the following provisions apply:

(1) Air inlets to pressure/vacuum relief valves of tanks containing the cargo should be situated at least 2 m above the weather deck.
(2) Water or steam should not be used as the heat transfer media in a cargo temperature control system required by **Sec 7.**
(3) The cargo should not be carried in cargo tanks adjacent to permanent ballast or water tanks unless the tanks are empty and dry.
(4) The cargo should not be carried in tanks adjacent to slop tanks or cargo tanks containing ballast or slops or other cargoes containing water which may react in a dangerous manner. Pumps, pipes or vent lines serving such tanks should beseparate from similar equipment serving tanks containing the cargo. Pipelines from slop tanks or ballast lines should not pass through tanks containing the cargo unless encased in a tunnel.

1517. Increased ventilation requirements (IBC Code 15.17)

For certain products, the ventilation system as described in **1201.3** should have a minimum capacity of at least 45 changes of air per hour based upon the total volume of space. The ventilation system exhaust ducts should discharge at least 10 m away from openings into accommodation spaces, work areas or other similar spaces, and intakes to ventilation systems, and at least 4 m above the tank deck.

1518. Special cargo pump room requirements (IBC Code 15.18)

For certain products, the cargo pump room should be located on the deck level or cargo pumps should be located in the cargo tank. The Society may give special consideration to cargo pump rooms below deck.

1519. Overflow control (IBC Code 15.19)

1. The provisions of this Article are applicable where specific reference is made in column "o" in the table of **Sec 17,** and are in addition to the requirements for gauging devices.

2. In the event of a power failure on any system essential for safe loading, an alarm should be given to the operators concerned.

3. Loading operations should be terminated at once in the event of any system essential for safe loading becoming inoperative.

4. Level alarms should be capable of being tested prior to loading.

5. The high-level alarm system required under **Par 6** should be independent of the overflow control system required by **Par 7** and should be independent of the equipment required by **1301.**

6. Cargo tanks should be fitted with a visual and audible high-level alarm which complies with **Pars 1** to **5** and which indicates when the liquid level in the cargo tank approaches the normal full condition.

7. A tank overflow control system required by this Article should:

(1) come into operation when the normal tank loading procedures fail to stop the tank liquid level exceeding the normal full condition;
(2) give a visual and audible tank overflow alarm to the ship's operator; and
(3) provide an agreed signal for sequential shutdown of onshore pumps or valves or both and of the ship's valves. The signal, as well as the pump and valve shutdown, may be dependent on operator's intervention. The use of shipboard automatic closing valves should be permitted only when specific approval has been obtained from the Society and the port Administrations concerned.

8. The loading rate (LR) of the tank should not exceed:

$$LR = \frac{3{,}600\ U}{t} \qquad (m^3/h)$$

where

U = ullage volume (m^3) at operating signal level;

t = time (s) needed from the initiating signal to fully stopping the cargo flow into the tank, being the sum of times needed for each step in sequential operations such as operator's responses to signals, stopping pumps and closing valves;

and should also take into account the pipeline system design pressure.

1520. Alkyl(C_7-C_9) nitrates, all isomers (IBC Code 15.20)

1. The carriage temperature of the cargo should be maintained below 100°C to prevent the occurrence of a self-sustaining, exothermic decomposition reaction.

2. The cargo may not be carried in independent pressure vessels permanently affixed to the vessel's deck unless:

(1) the tanks are sufficiently insulated from fire; and
(2) the vessel has a water deluge system for the tanks such that the cargo temperature is maintained below 100°C and the temperature rise in the tanks does not exceed 1.5°C/hour for a fire of 650°C (1200°F).

1521. Temperature sensors (IBC Code 15.21)

Temperature sensors should be used to monitor the cargo pump temperature to detect overheating due to pump failures.

SECTION 16
Operational Requirements

1601. Maximum allowable quantity of cargo per tank (IBC Code 16.1)

1. The quantity of a cargo required to be carried in a type 1 ship should not exceed 1,250 m^3 in any one tank.

2. The quantity of a cargo required to be carried in a type 2 ship should not exceed 3,000 m^3 in any one tank.

3. Tanks carrying liquids at ambient temperatures should be so loaded as to avoid the tank becoming liquid-full during the voyage, having due regard to the highest temperature which the cargo may reach.

1602. Cargo information (IBC Code 16.2)

1. A copy of this Chapter, or national regulations incorporating the provisions of this Chapter, should be on board every ship covered by this Chapter.

2. Any cargo offered for bulk shipment should be indicated in the shipping documents by the correct technical name. Where the cargo is a mixture, an analysis indicating the dangerous components contributing significantly to the total hazard of the product should be provided, or a complete analysis if this is available. Such an analysis should be certified by the manufacturer or by an independent expert acceptable to the Society.

3. Information should be on board, and available to all concerned, giving the necessary data for the safe carriage of the cargo. Such information should include a cargo stowage plan to be kept in an accessible place, indicating all cargo on board, including each dangerous chemical carried:

(1) a full description of the physical and chemical properties, including reactivity necessary for the safe containment of the cargo;
(2) action to be taken in the event of spills or leaks;
(3) countermeasures against accidental personal contact;
(4) fire-fighting procedures and fire-fighting media;
(5) procedures for cargo transfer, tank cleaning, gas-freeing and ballasting;
(6) for those cargoes required to be stabilized or inhibited in accordance with **1501., 1505. 1** (11) or **1513. 3,** the cargo should be refused if the certificate required by these paragraphs is not supplied.

4. If sufficient information necessary for the safe transportation of the cargo is not available, the cargo should be refused.

5. Cargoes which evolve highly toxic imperceptible vapours should not be transported unless perceptible additives are introduced into the cargo.

6. Where column "o" in the table of **Sec 17** refers to this paragraph, the cargo's viscosity at 20°C should be specified on a shipping document and if the cargo's viscosity exceeds 25 $mPa.s$ at 20°C, the temperature at which the cargo has a viscosity of 25 $mPa.s$ should be specified in the shipping document.

7. Where column "o" in the table of **Sec 17** refers to this paragraph, the cargo's viscosity at 20°C should be specified on a shipping document and if the cargo's viscosity exceeds 60 $mPa.s$ at 20°C, the temperature at which the cargo has a viscosity of 60 $mPa.s$ should be specified in the shipping document.

8. Where column "o" in the table of **Sec 17** refers to this paragraph and the possibility exists that it will be unloaded within a Special Area, the cargo's viscosity at 20°C should be specified on a shipping document and if the cargo's viscosity exceeds 25 $mPa.s$ at 20°C, the temperature at which the cargo has a viscosity of 25 $mPa.s$ should be specified in the shipping document.

9. Where column "o" in the table of **Sec 17** refers to this paragraph, the cargo's melting point should be indicated in the shipping document.

1603. Personnel training (IBC Code 16.3)

1. All personnel should be adequately trained in the use of protective equipment and have basic training in the procedures appropriate to their duties, necessary under emergency conditions.

2. Personnel involved in cargo operations should be adequately trained in handling procedures.

3. Officers should be trained in emergency procedures to deal with conditions of leakage, spillage or fire involving the cargo, based on the guidelines developed by IMO, and a sufficient number of them should be instructed and trained in essential first aid for cargoes carried.

1604. Opening of and entry into cargo tanks (IBC Code 16.4)

1. During handling and carriage of cargoes producing flammable or toxic vapours, or both, or when ballasting after the discharge of such cargo, or when loading or unloading cargo, cargo tank lids should always be kept closed. With any hazardous cargo, cargo tank lids, ullage and sighting ports and tank washing access covers should be open only when necessary.

2. Personnel should not enter cargo tanks, void spaces around such tanks, cargo handling spaces or other enclosed spaces unless:

(1) the compartment is free of toxic vapours and not deficient in oxygen; or

(2) personnel wear breathing apparatus and other necessary protective equipment, and the entire operation is under the close supervision of a responsible officer.

3. Personnel should not enter such spaces when the only hazard is of a purely flammable nature, except under the close supervision of a responsible officer.

1605. Stowage of cargo samples (IBC Code 16.5)

1. Samples which have to be kept on board should be stowed in a designated space situated in the cargo area or, exceptionally, elsewhere, subject to the approval of the Society.

2. The stowage space should be:

(1) cell-divided in order to avoid shifting of the bottles at sea;

(2) made of material fully resistant to the different liquids intended to be stowed; and

(3) equipped with adequate ventilation arrangements.

3. Samples which react with each other dangerously should not be stowed close to each other.

4. Samples should not be retained on board longer than necessary.

1606. Cargoes not to be exposed to excessive heat (IBC Code 16.6)

1. Where the possibility exists of a dangerous reaction of a cargo such as polymerization, decomposition, thermal instability or evolution of gas, resulting from local overheating of the cargo in either the tank or associated pipelines, such cargo should be loaded and carried adequately segregated from other products whose temperature is sufficiently high to initiate a reaction of such cargo (see **701. 5**(4)).

2. Heating coils in tanks carrying this product should be blanked off or secured by equivalent means.

3. Heat-sensitive products should not be carried in deck tanks which are not insulated.

4. In order to avoid elevated temperatures, this cargo should not be carried in deck tanks.

1607. Additional operational requirements (IBC Code 16.7)

This Chapter contains additional operational requirements in:

301. 1	**1503. 8**	**1508. 29**
301. 2 (1)	**1504. 6**	**1508. 31**
301. 2 (2)	**1505.**	**1508. 32**
301. 4	**1506. 1**	**1508. 33**
305. 2	**1506. 3**	**1508. 34** (1)
307. 4	**1506. 4**	**1508. 34** (2)
701. 2	**1507. 1**	**1508. 34** (3)
701. 6 (3)	**1507. 6**	**1508. 35**
803. 6	**1507. 11**	**1508. 36**
901. 4	**1508. 1**	**1508. 37**
902.	**1508. 2**	**1509.**
1103.2	**1508. 3**	**1510. 1**
1104.	**1508. 4**	**1511. 4**
1201.2	**1508. 5**	**1511. 6**
1202.	**1508. 7**	**1512. 3** (1)
1302.1	**1508. 15**	**1513.**
1302.2	**1508. 16**	**1514. 7** (1)
1302.3	**1508. 17**	**1514. 7** (2)
1302.4	**1508. 19**	**1514. 7** (3)
Sec 14	**1508. 20**	**1516.**
1501.	**1508. 21**	**1519. 8**
1503.1	**1508. 22**	
1503.7	**1508. 28**	

1608. Additional measures for the protection of the marine environment

1. General (IBC Code 16A.1)

The requirements of this Article apply to ships carrying products noted as category A, B or C noxious liquid substances in **Sec 17.**

2. Condition of carriage (IBC Code 16A.2)

(1) The conditions of carriage of products listed in the International Certificate of Fitness for the Carriage of Dangerous Chemicals in Bulk should reflect the requirements of regulation 5A of Annex II of MARPOL 73/78.

(2) A category B substance with a melting point equal to or greater than 15°C should not be carried in a cargo tank any boundary of which is formed by the ship's shell plating and should only be carried in a cargo tank fitted with a cargo heating system.

3. Procedures and arrangements manual (IBC Code 16A.3)

(1) Each ship should be provided with a Procedures and Arrangements Manual developed for the ship in accordance with the provisions of the Standards for Procedures and Arrangements and approved by the Society.

(2) Each ship should be fitted with equipment and arrangements identified in its Procedures anc Arrangements Manual.

SECTION 17
Summary of Minimum Requirements

Mixtures of noxious liquid substances presenting pollution hazards only and which are provisionally assessed under regulation 3 (4) of Annex II of MARPOL 73/78, may be carried under the requirements of this Chapter applicable to the appropriate position of the entry in this Section for noxious liquids, not otherwise specified.

EXPLANATORY NOTES

Product name (column a)

The product names are not identical with the names given in previous issues of the Rules, the IBC Code or the BCH Code (for explanation see index of chemicals).

UN number (column b)

The number relating to each product shown in the recommendations proposed by the United Nations Committee of Experts on the Transport of Dangerous Goods. UN numbers, where available, are given for information only.

Pollution category (column c)

The letter A, B, C or D means the pollution category assigned to each product under Annex II of MARPOL 73/78. "III" means the product was evaluated and found to fall outside the categories A, B, C or D.

Pollution category in brackets indicates that the product is provisionally categorized and that further data are necessary to complete the evaluation of their pollution hazards. Until the hazard evaluation is completed, the pollution category assigned is used.

Hazards (column d)

S means that the product is included in the Rules because of its safety hazards;

P means that the product is included in the Rules because of its pollution hazards; and

S/P means that the product is included in the Rules because of both its safety and pollution hazards.

Ship type (column e)

1 = ship type 1 (**201. 2**)
2 = ship type 2 (**201. 2**)
3 = ship type 3 (**201. 2**)

Tank type (column f)

1 = independenttank (**401. 1**)
2 = integral tank (**401. 2**)
G = gravity tank (**401. 3**)
P = pressure tank (**401. 4**)

Tank vents (column g)

Open: open venting
Cont.: controlled venting
SR: safety relief valve

Tank environmental control (column h)

Inert: inerting (**901. 2**(1))
Pad: liquid or gas padding (**901. 2**(2))
Dry: drying (**901. 2**(3))
Vent: natural or forced ventilation (**901. 2**(4))
No: indicates nil requirements

Electrical equipment (column i)

T1 to T6: temperature classes
IIA, IIB or IIC: apparatus groups
Temperature classes and apparatus groups as defined in International Electrotechnical Commission Publication 79 (part 1, appendix D, parts 4, 8 and 12). A blank indicates that data are currently not available.
NF: nonflammable product (**1001. 6**)
Yes: flashpoint exceeding 60°C (closed cup test) (**1001. 6**)
No: flashpoint not exceeding 60°C (closed cup test) (**1001. 6**)

Gauging (column j)

O: open gauging (**1301. 1** (1))
R: restricted gauging (**1301. 1** (2))
C: closed gauging (**1301. 1** (3))

I: indirect gauging (**1301. 1** (3))

Vapour detection (column k)

F: flammable vapours
T: toxic vapours
No: indicates nil requirements

Fire protection (column *l*)

A: alcohol-resistant foam or multi-purpose foam
B: regular foam, encompasses all foams that are not of an alcohol-resistant type, including fluoroprotein and aqueous-film-forming foam (AFFF)
C: water-spray
D: dry chemical
Dry chemical powder systems when used may require an additional water system for boundary cooling. This is normally provided in sufficient quantities by the standard fire main system required by regulation II-2/4 of the 1974 SOLAS Convention as amended.
No: no special requirements under this chapter

Materials of construction (column m)

N: see **602. 2.**
Z: see **602. 3.**
Y: see **602. 4.**
A blank indicates no special guidance given for materials of construction

Respiratory and eye protection (column n)

E: see **1402. 8**
No: no special requirements under this Chapter

Table 7.6.1(1) Summary of Minimum Requirements

a	b	c	d	e	f	g	h	i'	i''	i'''	j	k	l	m	n	o
Product name	UN number	Pollution category	Hazards	Ship type	Tank type	Tank vents	Tank environmental control	Electrical equipment			Gauging	Vapour detection	Fire Protection	Materials of construction	Respiratory and eye protection	Special requirements (See **Sec 15**)
								Class	Group	Flashpoint> 60° C						
Acetic acid		D	S	3	2G	Cont.	No	T1	IIA	No	R	F	A	Y1,Z	E	1511.2,. to 1511.4., 1511.6. to 8., 1519.6.
Acetic anhydride	1715	D	S	2	2G	Cont.	No	T2	IIA	No	R	F-T	A	Y1	E	1511.2,. to 4., 1511.6. to 8., 1519.6.
Acetochlor		A	P	2	2G	Open	No			Yes	O	No	A		No	1519.6.
Acetone cyanohydrin	1541	A	S/P	2	2G	Cont.	No	T1	IIA	Yes	C	T	A	Y1	E	1501., 1512., 1517. to 1519., 1606.1. to 3.
Acetonitrile	1648	III	S	2	2G	Cont.	No	T2	IIA	No	R	F-T	A		No	1512., 1519.6
Acrylamide solution (50% or less)	2074	D	S	2	2G	Open	No		NF		C	No	No		No	1512.3., 1513., 1516.1., 1519.6., 1606.1
Acrylic acid	2218	D	S	3	2G	Cont.	No	T2	IIA	No	R	F-T	A	Y1	No	1513., 1519.6., 1606.1.
Acrylonitrile	1093	B	S/P	2	2G	Cont.	No	T1	IIB	No	C	F-T	A	N3,Z	E	1512., 1513., 1517., 1519.
Adiponitrile	2205	D	S	3	2G	Cont.	No		IIB	Yes	R	T	A		No	
Alachlor technical (90% or more)		B	S/P	3	2G	Open	No			Yes	O	No	A,C	Y1	No	1519.6., 1602.6., 1602.9., 1608.2.(2)
Alcohol (C_{12}-C_{15}) poly (1-6) ethoxylates		A	P	2	2G	Open	No			Yes	O	No	A		No	1519.6.
Alcohol (C_{12}-C_{15}) poly (7-19) ethoxylates		B	P	3	2G	Open	No			Yes	O	No	A		No	1519.6., 1602.6.
Alcohol (C_{12}-C_{15}) poly (20*) ethoxylates		C	P	3	2G	Open	No			Yes	O	No	A		No	
Alcohol (C_6-C_{17}) (secondary) poly (3-6) ethoxylates		A	P	2	2G	Open	No			Yes	O	No	A		No	1519.6
Alcohol (C_6-C_{17}7) (secondary) poly (7-12) ethoxylates		B	P	3	2G	Open	No			Yes	O	No	A		No	1519.6., 1602.6., 1602.9.
Alkane(C_{14}-C_{17}) sulfonic acid, sodium salt 60-65% in water		B	P	3	2G	Open	No		NF		O	No	No		No	1602.6.
Alkanes (C_6-C_9)		(C)	P	3	2G	Cont.	No			No	R	F	A		No	1519.6.
Alkaryl polyethers (C_9-C_{20})		B	P	3	2G	Open	No			Yes	O	No	A,B		No	1519.6., 1602.6.
Alkyl acrylate-vinyl pyridine copolymer in toluene		C	P	3	2G	Cont.	No			No	R	F	A		No	1519.6.
Alkyl benzene, alkylindane, alkylindene mixture(each C_{12}-C_{17})		A	P	2	2G	Open	No			Yes	O	No	A		No	1519.6.
Alkyl (C_3-C_4) benzenes		A	P	3	2G	Cont.	No			No	R	F	A		No	1519.6
Alkyl (C_5-C_8) benzenes		A	P	2	2G	Open	No			Yes	O	No	A		No	1519.6
Alkyl benzene sulphonic acid	2584, 2586	C	S/P	3	2G	Open	No			Yes	O	No	A		No	1602.7., 1602.8.
Alkyl benzene sulphonic acid, sodium salt solution		C	P	3	2G	Open	No		NF		O	No	No		No	1602.7. to 1602.9.

Table 7.6.1(2) Summary of Minimum Requirements

a	b	c	d	e	f	g	h	i'	i"	i'''	j	k	l	m	n	o
Product name	UN number	Pollution category	Hazards	Ship type	Tank type	Tank vents	Tank environmental control	Electrical equipment: Class	Electrical equipment: Group	Electrical equipment: Flashpoint> 60° C	Gauging	Vapour detection	Fire Protection	Materials of construction	Respiratory and eye protection	Special requirements (See **Sec 15**)
Alkyl (C_7-C_9) nitrates		B	S/P	2	2G	Open	No			Yes	Open	No	A,B		No	1519.6., 1520., 1606.1. to 3.
Alkyl(C_7-C_{11}) phenol poly(4-12) ethoxylate		B	P	3	2G	Open	No			Yes	O	No	A		No	1519., 1602.6., 1602.9.
Allyl alcohol	1098	B	S/P	2	2G	Cont.	No	T2	IIB	No	C	F-T	A		E	1512., 1517., 1519.
Allyl chloride	1100	B	S/P	2	2G	Cont.	No	T2	IIA	No	C	F-T	A		E	1512., 1517., 1519.
Alluminium chloride (30% or less) /Hydrochloric acid(20% or less)solution		D	S	3	1G	Cont.	No		NF		R	T	No		E(f)	1511.
2- (2-Aminoethoxy) ethanol	3055	D	S	3	2G	Open	No			Yes	O	No	A,D	N2	No	1519.6.
Aminoethyl ethanolamine		(D)	S	3	2G	Open	No	T2	IIA	Yes	O	No	A	N1	No	
N-Aminoethylpiperazine	2815	D	S	3	2G	Cont.	No			Yes	R	T	A	N2	No	1519.6.
2-Amino-2-methyl-1-propanol (90% or less)		D	S	3	2G	Open	No			Yes	O	No	A	N1	No	
Ammonia aqueous (28% or less)	2672 (m)	C	S/P	3	2G	Cont.	No		NF		R	T	A,B, C	N4	E(a)	
Ammonium bisulphite solution(70% or less)		D	S	3	2G	Cont.	No		NF		R	T	No	Y5	No	1516.1., 1606.1. to 3.
Ammonium nitrate solution (93% or less)		D	S	2	1G	Open	No		NF		O	No	No	Y4	No	1502., 1511.4., 1511.6., 1518., 1519.6.
Ammonium sulphide solution(45% or less)	2683	B	S/P	2	2G	Cont.	No			No	C	F-T	A	N1	E	1512., 1516.1, 1517., 1519., 1606.1. to 3.
Ammonium thiocyanate (25% or less)/Ammonium thiosulphate(20% or less) solution		(C)	P	3	2G	Open	No		NF		O	No	No		No	
Ammonium thiosulphate solution(60% or less)		(C)	P	3	2G	Open	No		NF		O	No	No		No	1602.9.
Amyl acetate (all isomers)	1104	C	P	3	2G	Cont.	No			No	R	F	A		No	1519.6
Aniline	1547	C	S/P	2	2G	Cont.	No	T1	IIA	Yes	C	T	A		No	1512., 1517., 1519.
Aviation alkylates (C_8 paraffins and isoparaffins BPT 95-120°C) (bb)		(C)	P	3	2G	Cont.	No			No	R	F	B		No	1519.6.
Benzene and mixtures having 10% benzene or more ①	1114 (t)	C	S/P	3	2G	Cont.	No	T1	IIA	No	C	F-T	A,B		No	1512.1., 1517., 1519.6., 1602.9
Benzene sulphonyl chloride	2225	D	S	3	2G	Cont.	No			Yes	R	T	A,D	N1	No	1519.6
Benzyl acetate		C	P	3	2G	Open	No			Yes	O	No	A		No	
Benzyl alcohol		C	P	3	2G	Open	No			Yes	O	No	A		No	
Benzyl chloride	1738	B	S/P	2	2G	Cont.	No	T1	IIA	Yes	C	T	A,B		E	1512., 1513., 1517., 1519.
Bromochloromethane		D	S	3	2G	Cont.	No		NF		R	T	No	N3	No	
Butene oligomer		B	P	3	2G	Open	No			Yes	O	No	A		No	1519.6.
Butyl acetate (all isomers)	1123	C	P	3	2G	Cont.	No			No	R	F	A		No	1519.6.
Butyl acrylate(all isomers)	2348	B	S/P	2	2G	Cont.	No	T2	IIB	No	R	F-T	A		No	1513., 1519.6., 1606.1., 1606.2.

Table 7.6.1(3) Summary of Minimum Requirements

a	b	c	d	e	f	g	h	i'	i"	i"'	j	k	l	m	n	o
Product name	UN number	Pollution category	Hazards	Ship type	Tank type	Tank vents	Tank environmental control	Electrical equipment Class	Group	Flashpoint> 60° C	Gauging	Vapour detection	Fire Protection	Materials of construction	Respiratory and eye protection	Special requirements (See **Sec 15**)
Butylamine (all isomers)	1125, 1214	C	S/P	2	2G	Cont.	No			No	R	F-T	A	N1	E	1512., 1517., 1519.6
Butylbenzene (all isomers)	2709	A	P	3	2G	Cont.	No			No	R	F	A		No	1519.6.
Butyl benzyl phthalate		A	P	2	2G	Open	No			Yes	O	No	A		No	1519.6.
Butyl butyrate (all isomers)		B	P	3	2G	Cont.	No			No	R	F	A		No	1519.6.
Butyl/Decyl/Cetyl/Eicosyl methacrylate mixture		D	S	3	2G	Cont.	No			Yes	R	No	A,D		No	1513., 1606.1., 1606.2.
1. 2-Butylene oxide	3022	C	S/P	3	2G	Cont.	Inert	T2	IIB	No	R	F	A,C	Z	No	1508.1. to 7., 12., 13., 17., 19., to 21., 23., 31. to 35., 37., 1519. 6.
n-Butyl ether	1149	C	S/P	3	2G	Cont.	Inert	T4	IIB	No	R	F-T	A		No	1504.6., 1512., 1519.6.
Butyl methacrylate		D	S	3	2G	Cont.	No		IIA	No	R	F-T	A,D		No	1513., 1519.6., 1606.1., 1606.2.
n-Butyl propionate	1914	C	P	3	2G	Cont.	No			No	R	F	A		No	1519.6.
Butyraldehyde (all isomers)	1129	C	S/P	3	2G	Cont.	No	T3	IIA	No	R	F-T	A		No	1516.1., 1519.6.
Butyric acid	2820	D	S	3	2G	Cont.	No			Yes	R	No	A	Y1	No	1511.2. to 1511.4., 1511.6. to 1511.8.
Calcium alkyl (C_9) phenol sulphide/polyolefin phosphorosulphide mixture		A	P	2	2G	Open	No			Yes	O	No	A,B		No	1519.6.
Calcium hypochlorite solution(15% or less)		C	S/P	3	2G	Cont.	No		NF		R	No	No	N5	No	1516.1.
Calcium hypochlorite solution(more than 15%)		B	S/P	3	2G	Cont.	No		NF		R	No	No	N5	No	1516.1., 1519.6.
Calcium long chain alkyl salicylate (C_{13}*)		C	P	3	2G	Open	No			Yes	O	No	A,B		No	1602.7., 1602.8.
Camphor oil		B	S/P	2	2G	Cont.	No		IIA	No	R	F	A,B		No	1519.6.
Carbolic oil		A	S/P	2	2G	Cont.	No			Yes	C	F-T	A		No	1512., 1519.
Carbon disulphide	1131	B	S/P	2	1G	Cont.	pad +Inert	T6	IIC	No	C	F-T	C		E	1503., 1512., 1519.
Carbon tetrachloride	1846	B	S/P	3	2G	Cont.	No		NF		C	T	No	Z	E	1512., 1517., 1519.6.
Cashew nut shell oil (untreated)		D	S	3	2G	Cont.	No			Yes	R	T	A,B		No	
Cetyl/Eicosyl methacrylate mixture		III	S	3	2G	Open	No			Yes	O	No	A,D		No	1513., 1606.1., 1606.2.
Chloroacetic acid (80% or less)	1750	C	S/P	2	2G	Cont.	No		NF		C	No	No	Y5	No	1511.2., 4., 6. to 8., 1512.3., 1519., 1602.9.
Chlorinated paraffins(C_{10}-C_{13})		A	P	1	2G	Open	No			Yes	O	No	A		No	1519.

Table 7.6.1(4) Summary of Minimum Requirements

a	b	c	d	e	f	g	h	i'	i''	i'''	j	k	l	m	n	o
Product name	UN number	Pollution category	Hazards	Ship type	Tank type	Tank vents	Tank environmental control	Electrical equipment: Class	Electrical equipment: Group	Electrical equipment: Flashpoint> 60° C	Gauging	Vapour detection	Fire Protection	Materials of construction	Respiratory and eye protection	Special requirements (See **Sec 15**)
Chlorobenzene	1134	B	S/P	3	2G	Cont.	No	T1	IIA	No	R	F-T	A,B		No	1519.6
Chloroform	1888	B	S/P	3	2G	Cont.	No		NF		R	T	No		E	1512., 1519.6.
Chlorohydrins (crude)		(D)	S	2	2G	Cont.	No		IIA	No	C	F-T	A		No	1512., 1519.
4-Chloro-2-methylphenoxyacetic acid, dimethylamine salt solution		(C)	P	3	2G	Open	No		NF		O	No	No	N1	No	
o-Chloronitrobenzene	1578	B	S/P	2	2G	Cont.	No			Yes	C	T	A,B, D		No	1512., 1517. to 1519., 1602.6., 1602.9., 1608.2.(2)
2- or 3-Chloropropionic acid	2511 (n)	(C)	S/P	3	2G	Open	No			Yes	O	No	A	Y1	No	1511.2. to 4., 1511.6. to 8., 1602.7 to 9.
Chlorosulphonic acid	1754	C	S/P	1	2G	Cont.	No		NF		C	T	No		E	1511.2. to 8., 1512., 1516.2., 1519.
m-Chlorotoluene	2238	B	S/P	3	2G	Cont.	No			No	R	F-T	A,B		No	1519.6.
o-Chlorotoluene	2238	A	S/P	3	2G	Cont.	No			No	R	F-T	A,B		No	1519.6.
p-Chlorotoluene	2238	B	S/P	2	2G	Cont.	No			No	R	F-T	A,B		No	1519.6., 1602.9.
Chlorotoluenes (mixed isomers)	2238	A	S/P	2	2G	Cont.	No			No	R	F-T	A,B		No	1519.6.
Coal tar		A	S/P	2	2G	Cont.	No	T2	IIA	Yes	R	No	B,D		No	1519.6.
Coal tar naphtha solvent		B	S/P	3	2G	Cont.	No	T3	IIA	No	R	F-T	A,D		No	1519.6
Coal tar pitch (molten)		D	S	3	1G	Cont.	No	T2	IIA	Yes	R	No	B,D		No	1519.6.
Cobalt naphthenate in solvent naphtha		A	S/P	2	2G	Cont.	No			No	R	F-T	A,D		No	1519.6.
Coconut oil fatty acid		C	P	3	2G	Open	No			Yes	O	No	A		No	1602.7. to 1602.9.
Creosote (coal tar)		A	S/P	2	2G	Open	No	T2	IIA	Yes	O	No	A,D		No	1519.6.
Creosote (wood)		A	S/P	2	2G	Open	No	T2	IIA	Yes	O	No	A,D		No	1519.6.
Cresols (all isomers)	2076	A	S/P	2	2G	Open	No	T1	IIA	Yes	O	No	A,B		No	1519.6.
Cresylic acid, dephenolized		A	S/P	2	2G	Open	No			Yes	O	No	A,B		No	1519.6
Cresylic acid, sodium salt solution		A	S/P	2	2G	Open	No			Yes	O	No	No	N8	No	1519.6
Crotonaldehyde	1143	A	S/P	2	2G	Cont.	No	T3	IIB	No	R	F-T	A		E	1512., 1516.1., 1517., 1519.6.
1, 5, 9-Cyclododecatriene		A	S/P	1	2G	Cont.	No			Yes	R	T	A	N2	No	1513., 1519., 1606.1., 1606.2.
Cycloheptane (bb)	2241	(C)	P	3	2G	Cont.	No			No	R	F	A		No	1519.6.
Cyclohexane (bb)	1145	(C)	P	3	2G	Cont.	No			No	R	F	A		No	1519.6., 1602.9.
Cyclohexanone	1915	D	S	3	2G	Cont.	No	T2	IIA	No	R	F-T	A	No	No	1519.6.
Cyclohexanone, Cyclohexanol mixture		D	S	3	2G	Cont.	No			Yes	R	F-T	A	No	No	
Cyclohexyl acetate	2243	(B)	P	3	2G	Cont.	No			No	R	F	A		No	1519.6.

Table 7.6.1(5) Summary of Minimum Requirements

a	b	c	d	e	f	g	h	i'	i''	i'''	j	k	l	m	n	o
Product name	UN number	Pollution category	Hazards	Ship type	Tank type	Tank vents	Tank environmental control	Electrical equipment: Class	Electrical equipment: Group	Electrical equipment: Flashpoint> 60° C	Gauging	Vapour detection	Fire Protection	Materials of construction	Respiratory and eye protection	Special requirements (See **Sec 15**)
Cyclohexylamine	2357	C	S/P	3	2G	Cont.	No	T3	IIA	No	R	F-T	A,C	N1	No	1519.6
1, 3-Cyclopentadiene dimer (molten)		B	P	2	2G	Cont.	No			No	R	F	A		No	1519.6.,1602.6.,1602.9.,1608.2. (2)
Cyclopentane (bb)	1146	(C)	P	3	2G	Cont.	No			No	R	F	A		No	1519.6.
Cyclopentene	2246	(B)	P	3	2G	Cont.	No			No	R	F	A		No	1519.6.
p-Cymene (bb)	2046	C	P	3	2G	Cont.	No			No	R	F	A		No	1519.6.
Decanoic acid		C	P	3	2G	Open	No			Yes	O	No	A		No	1602.7 to 1602.9.
Decene		B	P	3	2G	Cont.	No			No	R	F	A		No	1519.6.
Decyl acetate		(B)	P	3	2G	Open	No			Yes	O	No	A		No	1519.6.
Decyl acrylate		A	S/P	2	2G	Open	No	T3	IIA	Yes	O	No	A,C, D	N2	No	1513.,1519.6.,1606.1., 1606.2.
Decyl alcohol(all isomers)		B	P	3	2G	Open	No			Yes	O	No	A		No	1519.6.,1602.9(s)
Decyloxytetrahydro-thiophene dioxide		A	S/P	2	2G	Cont.	No			Yes	R	T	A		No	1519.6.
Dibromomethane		C	S/P	2	2G	Cont.	No		NF		R	T	No	N3	No	1512.3., 1519.
Dibutylamine		C	S/P	3	2G	Cont.	No	T2	IIA	No	R	F-T	A,C, D	N4	No	1519.6.
Dibutyl hydrogen phosphonate		B	P	3	2G	Open	No			Yes	O	No	A		No	1519.6.,1602.6.
Dibutyl phthalate		A	P	2	2G	Open	No			Yes	O	No	A		No	1519.6.
Dichlorobenzene (all isomers)		B	S/P	2	2G	Cont.	No	T1	IIA	Yes	R	T	A,B, D	N5	No	1519.6.,1602.6.(x),1602.9.(y),1608.2.(2)(z)
3,4-Dichloro-1-butene		B	S/P	3	2G	Cont.	No			No	C	F-T	A,B,C		E	1512.3., 1517., 1519.6.
1, 1-Dichloroethane	2362	D	S	3	2G	Cont.	No	T2	IIA	No	R	F-T	A		E	1519.6.
Dichloroethyl ether	1916	B	S/P	2	2G	Cont.	No	T2	IIA	No	R	F-T	A	N5	No	1519.6.
1, 6-Dichlorohexane		B	S/P	2	2G	Cont.	No			No	R	T	A,B		No	1519.6.
2, 2-Dichloroisopropyl ether	2490	C	S/P	2	2G	Cont.	No			Yes	R	T	A,C, D	N5	No	1512.,1517.,1519.
Dichloromethane	1593	D	S	3	2G	Cont.	No	T1	IIA	Yes	R	T	No		No	
2, 4-Dichlorophenol	2021	A	S/P	2	2G	Cont.	Dry			Yes	R	T	A	N1	No	1519.6.
2, 4-Dichlorophenoxyacetic acid, diethanolamine salt solution		A	S/P	3	2G	Open	No		NF		O	No	No	N1	No	1519.6.
2, 4-Dichlorophenoxyacetic acid, dimethylamine salt solution(70% or less)		A	S/P	3	2G	Open	No		NF		O	No	No	N1	No	1519.6.
2, 4-Dichlorophenoxyacetic acid, triisopropanolamine salt solution		A	S/P	3	2G	Open	No		NF		O	No	No	N1	No	1519.6.
1, 1-Dichloropropane		C	S/P	2	2G	Cont.	No			No	R	F-T	A,B	Z	No	1512.,1519.6.
1, 2-Dichloropropane	1279	C	S/P	2	2G	Cont.	No	T1	IIA	No	R	F-T	A,B	Z	No	1512.,1519.6.

Table 7.6.1(6) Summary of Minimum Requirements

a	b	c	d	e	f	g	h	i'	i''	i'''	j	k	l	m	n	o
Product name	UN number	Pollution category	Hazards	Ship type	Tank type	Tank vents	Tank environmental control	Electrical equipment			Gauging	Vapour detection	Fire Protection	Materials of construction	Respiratory and eye protection	Special requirements (See **Sec 15**)
								Class	Group	Flashpoint> 60° C						
1, 3-Dichloropropane		D	S	2	2G	Cont.	No	T1	IIA	No	R	F-T	A,B		No	1512.,1519.6.
1, 3-Dichloropropene	2047	B	S/P	2	2G	Cont.	No	T2	IIA	No	C	F-T	A,B		E	1512.,1517. to 1519.
Dichloropropene/ Dichloropropane mixtures		B	S/P	2	2G	Cont.	No			No	C	F-T	A,B, D		E	1512.,1517. to 1519.
2, 2-Dichloropropionic acid		D	S	3	2G	Cont.	Dry			Yes	R	No	A	Y5	No	1511.2.,1511.4.,1511.6. to 1511.8.
Diethanolamine		D	S	3	2G	Open	No	T1	IIA	Yes	O	No	A	N2	No	
Diethylamine	1154	C	S/P	3	2G	Cont.	No	T2	IIA	No	R	F-T	A	N1	E	1512.,1519.6.
Diethylaminoethanol	2686	C	S/P	3	2G	Cont.	No	T2	IIA	No	R	F-T	A,C	N1	No	1519.6.
2, 6-Diethylaniline		C	S/P	3	2G	Open	No			Yes	O	No	B,C, D	N4	No	1519.6.,1602.9.
Diethylbenzene	2049	A	P	3	2G	Cont.	No			No	R	F	A		No	1519.6.
Diethylenetriamine	2079	D	S	3	2G	Open	No	T2	IIA	Yes	O	No	A	N2	No	
Diethyl ether*	1155	III	S	2	1G	Cont.	Inert	T4	IIB	No	C	F-T	A	N7	E	1504.,1514.,1519.
Di-(2-ethylhexyl) phosphoric acid	1902	C	S/P	3	2G	Open	No			Yes	O	No	A,D	N2	No	
Diethyl phthalate		C	P	3	2G	Open	No			Yes	O	No	A		No	
Diethyl sulphate	1594	(B)	S/P	2	2G	Cont.	No			Yes	C	T	A	N3	No	1519.6.
Diglycidyl ether of bisphenol A		B	P	3	2G	Open	No			Yes	O	No	A		No	1519.6.,1602.6.
Diglycidyl ether of bisphenol F		B	P	3	2G	Open	No			Yes	O	No	A		No	1519.6.,1602.6.
Di-n-hexyl adipate		B	P	3	2G	Open	No			Yes	O	No	A		No	1519.6.
Diisobutylamine	2361	(C)	S/P	2	2G	Cont.	No			No	R	F-T	A,C, D	N1	No	1512.3.,1519.6.
Diisobutylene	2050	B	P	3	2G	Cont.	No			No	R	F	A		No	1519.6.
Diisobutyl phthalate		B	P	3	2G	Open	No			Yes	O	No	A		No	1519.6.,1602.6.
Diisopropanolamine		C	S/P	3	2G	Open	No	T2	IIA	Yes	O	No	A	N2	No	1602.7. to1602.9.
Diisopropylamine	1158	C	S/P	2	2G	Cont.	No	T2	IIA	No	C	F-T	A	N2	E	1512.,1519.
Diisopropylbenzene (all isomers)		A	P	2	2G	Open	No			Yes	O	No	A		No	1519.6.
N, N-Dimethylacetamide solution(40% or less)		D	S	3	2G	Cont.	No			Yes	R	T	B	N4	No	1512.1.,1517.
Dimethyl adipate		B	P	3	2G	Open	No			Yes	O	No	A		No	1519.6., 1602.9.
Dimethylamine solution (45% or less)	1160	C	S/P	3	2G	Cont.	No	T2	IIA	No	R	F-T	A,C, D	N1	E	1512.,1519.6.
Dimethylamine solution (greater than 45% but not greater than 55%)	1160	C	S/P	2	2G	Cont.	No			No	C	F-T	A,C, D	N1	E	1512.,1517.,1519.

Table 7.6.1(7) Summary of Minimum Requirements

a	b	c	d	e	f	g	h	i'	i"	i'''	j	k	l	m	n	o
Product name	UN number	Pollution category	Hazards	Ship type	Tank type	Tank vents	Tank environmental control	Electrical equipment Class	Group	Flashpoint> 60° C	Gauging	Vapour detection	Fire Protection	Materials of construction	Respiratory and eye protection	Special requirements (See **Sec 15**)
Dimethylamine solution (greater than 55% but not greater than 65%)	1160	C	S/P	2	2G	Cont.	No			No	C	F-T	A,C, D	N1	E	1512.,1514.,1517.,1519.
N, N-Dimethylcyclohexylamine	2264	C	S/P	2	2G	Cont.	No			No	R	F-T	A,C	N1	No	1512.,1517.,1519.6.
Dimethylethanolamine	2051	D	S	3	2G	Cont.	No	T3	IIA	No	R	F-T	A,D	N2	No	1519.6.
Dimethylformamide	2265	D	S	3	2G	Cont.	No	T2	IIA	No	R	F-T	A,D		No	1519.6.
Dimethyl glutarate		C	P	3	2G	Open	No			Yes	O	No	A		No	
Dimethyl hydrogen phosphite		(B)	S/P	3	2G	Cont.	No			Yes	R	T	A,D		No	1512.1.
Dimethyl octanoic acid		(C)	P	3	2G	Open	No			Yes	O	No	A		No	1602.8.,1602.9.
Dimethyl phthalate		C	P	3	2G	Open	No			Yes	O	No	A		No	
Dimethyl succinate		C	P	3	2G	Open	No			Yes	O	No	A		No	1602.9.
Dinitrotoluene (molten)	1600	A	S/P	2	2G (o)	Cont.	No			Yes	C	T	A		No	1512.,1517.,1519.,1521.
1, 4-Dioxane	1165	D	S	2	2G	Cont.	No	T2	IIB	No	C	F-T	A		No	1512.,1519.
Dipentene	2052	C	P	3	2G	Cont.	No			No	R	F	A		No	1519.6.
Diphenyl		A	P	1	2G	Open	No			Yes	O	No	B		No	1519.
Diphenylamine, reaction product with 2, 2, 4-Trimethylpentene		(A)	S/P	1	2G	Open	No			Yes	O	No	A		No	1519.
Diphenylamines, alkylated		A	P	2	2G	Open	No			Yes	O	No	A		No	1519.6.
Diphenyl/Diphenyl ether mixtures		A	P	1	2G	Open	No			Yes	O	No	B		No	1519.
Diphenyl ether		A	P	3	2G	Open	No			Yes	O	No	A		No	1519.6.
Diphenyl ether/Diphenyl phenyl ether mixture		A	P	3	2G	Open	No			Yes	O	No	A		No	1519.6.
Diphenylmethane diisocyanate	2489	(B)	S/P	2	2G	Cont.	Dry			Yes (b)	C	T (b)	A,B, C(c), D	N5	No	1512.,1516.2.,1517.,1519.6. ,1602.6.,1602.9.,1608.2.(2)
Diphenylol propaneepichlorohydrin resins		B	P	3	2G	Open	No			Yes	O	No	A		No	1519.6.,1602.6.
Di-n-propylamine	2383	C	S/P	3	2G	Cont.	No			No	R	F-T	A	N2	No	1512.3.,1519.6.
Dodecene (all isomers)		(B)	P	3	2G	Open	No			Yes	O	No	A		No	1519.6.
Dodecyl alcohol		B	P	3	2G	Open	No			Yes	O	No	A		No	1519.6.,1602.6.,1602.9., 1608.2.(2)
Dodecylamine/Tetradecylamine mixture		A	S/P	2	2G	Cont.	No			Yes	R	T	A,D	N2	No	1519.6.
Dodecyldimethylamine/Tetradecyl dimethylamine mixture		A	S/P	2	2G	Open	No			Yes	O	No	B,C, D	N4	No	1519.6.

Table 7.6.1(8) Summary of Minimum Requirements

a	b	c	d	e	f	g	h	i'	i''	i'''	j	k	l	m	n	o
Product name	UN number	Pollution category	Hazards	Ship type	Tank type	Tank vents	Tank environmental control	Electrical equipment			Gauging	Vapour detection	Fire Protection	Materials of construction	Respiratory and eye protection	Special requirements (See **Sec 15**)
								Class	Group	Flashpoint> 60° C						
Dodecyl diphenyl ether disulphonate solution		A	S/P	2	2G	Open	No		NF		O	No	No		No	1519.6.
Dodecyl methacrylate		III	S	3	2G	Open	No			Yes	O	No	A		No	1513.
Dodecyl/Pentadecyl methacry-late mixture		III	S	3	2G	Open	No			Yes	O	No	A,D		No	1513.,1606.1.,1606.2.
Dodecyl phenol		A	P	1	2G	Open	No			Yes	O	No	A		No	1519.
Drilling brines (containing Zinc salts)		B	P	3	2G	Open	No			Yes	O	No	No		No	1519.6.
Epichlorohydrin	2023	A	S/P	2	2G	Cont.	No		IIB	No	C	F-T	A		E	1512.,1517.,1519.
Ethanolamine	2491	D	S	3	2G	Open	No	T2	IIA	Yes	O	F-T	A	N2	No	
2-Ethoxyethyl acetate	1172	C	P	3	2G	Cont.	No			No	R	F	A		No	1519.6.
Ethyl acrylate	1917	A	S/P	2	2G	Cont.	No	T2	IIB	No	R	F-T	A		E	1513.,1519.6.,1606.1., 1606.2.
Ethylamine	1036	(C)	S/P	2	1G	Cont.	No	T2	IIA	No	C	F-T	C,D	N2	E	1512.,1514.,1519.6.
Ethylamine solutions (72% or less)	2270	(C)	S/P	2	2G	Cont.	No			No	C	F-T	A,C	N1	E	1512.,1514.,1517.,1519.
Ethyl amyl ketone	2271	C	P	3	2G	Cont.	No			No	R	F	A		No	1519.6.
Ethylbenzene	1175	B	P	3	2G	Cont.	No			No	R	F	A		No	1519.6.
N-Ethylbutylamine		(C)	S/P	3	2G	Cont.	No			No	R	F-T	A	N1	No	1512.3.,1519.6.
Ethyl butyrate	1180	C	P	3	2G	Cont.	No			No	R	F	A		No	1519.6.
Ethylcyclohexane (bb)		(C)	P	3	2G	Cont.	No			No	R	F	A		No	1519.6.
N-Ethylcyclohexylamine		D	S	3	2G	Cont.	No			No	R	F-T	A	N1	No	1519.6.
Ethylene chlorohydrin	1135	C	S/P	2	2G	Cont.	No	T2	IIA	No	C	F-T	A,D		E	1512.,1517.,1519.
Ethylene cyanohydrin		(D)	S	3	2G	Open	No		IIB	Yes	O	No	A		No	
Ethylenediamine	1604	C	S/P	2	2G	Cont.	No	T2	IIA	No	R	F-T	A	N2	No	1519.6.,1602.9.
Ethylene dibromide	1605	B	S/P	2	2G	Cont.	No		NF		C	T	No		E	1512.,1519.6.,1602.9.
Ethylene dichloride	1184	B	S/P	2	2G	Cont.	No	T2	IIA	No	R	F-T	A,B	N4	No	1519.
Ethylene glycol butyl ether acetate		(C)	P	3	2G	Open	No			Yes	O	No	A		No	
Ethylene glycol diacetate		C	P	3	2G	Open	No			Yes	O	No	A		No	
Ethylene glycol methyl ether acetate		C	P	3	2G	Open	No			Yes	O	No	A		No	
Ethylene glycol monoalkyl ethers		D	S	3	2G	Cont.	No			No	R	F	A		No	1519.6.
Ethylene oxide/Propylene oxide mixture with an ethylene oxide content of not more than 30% in weight*	2983	C	S/P	2	1G	Cont.	Inert	T2	IIB	No	C	F-T	A,C		No	1508.,1512.,1514.,1519.

Table 7.6.1(9) Summary of Minimum Requirements

a	b	c	d	e	f	g	h	i'	i"	i'"	j	k	l	m	n	o
Product name	UN number	Pollution category	Hazards	Ship type	Tank type	Tank vents	Tank environmental control	Electrical equipment			Gauging	Vapour detection	Fire Protection	Materials of construction	Respiratory and eye protection	Special requirements (See **Sec 15**)
								Class	Group	Flashpoint> 60° C						
Ethyl -3-ethoxypropionate		C	P	3	2G	Cont.	No			No	R	No	A		No	1519.6.
2-Ethylhexyl acrylate		B	S/P	3	2G	Open	No	T3	IIB	Yes	O	No	A		No	1513.,1519.6.,1606.1., 1606.2.
2-Ethylhexylamine	2276	B	S/P	2	2G	Cont.	No			No	R	F-T	A	N2	No	1512.,1519.6.
Ethylidene norbornene		B	S/P	3	2G	Cont.	No			No	R	F-T	A,D	N4	No	1512.1.,1516.1.,1519.6.
Ethyl methacrylate	2277	(D)	S	3	2G	Cont.	No	T2	IIA	No	R	F-T	A,D		No	1513.,1519.6.,1606.1.,1606.2.
o-Ethylphenol		(A)	S/P	3	2G	Open	No	T1	IIA	Yes	O	No	B		No	1519.6.
2-Ethyl-3-propylacrolein		A	S/P	3	2G	Cont.	No		IIA	No	R	F-T	A		No	1519.6.
Ethyltoluene		(B)	P	3	2G	Cont.	No			No	R	F	A		No	1519.6.
Ferric chloride solutions	2582	C	S/P	3	2G	Open	No		NF		O	No	No		No	1511.,1519.6.,1602.9.
Ferric nitrate/nitric acid solution		C	S/P	2	2G	Cont.	No		NF		R	T	No		E	1511.,1519.
Fluorosilicic acid(20-30%) in water solution	1778	C	S/P	3	1G	Cont.	No		NF		R	T	No		E	1511.
Formaldehyde solutions (45% or less)	1198 (d), 2209	C	S/P	3	2G	Cont.	No	T2	IIB	No	R	F-T	A		E (e)	1516.1.,1519.6.,1602.9.
Formic acid	1779	D	S	3	2G	Cont.	No	T1	IIA	No	R	T (v)	A	Y2, Y3	E	1511.2. to 4., 1511.6. to 8.,1519.6.
Fumaric adduct of rosin, water dispersion		B	P	3	2G	Open	No			Yes	O	No	No		No	1519.6.,1602.6.
Furfural	1199	C	S/P	3	2G	Cont.	No	T2	IIB	No	R	F-T	A		No	1516.1.,1519.6.
Furfuryl alcohol	2874	C	P	3	2G	Open	No			Yes	O	No	A		No	
Glutaraldehyde solutions (50% or less)		D	S	3	2G	Open	No		NF		O	No	No		No	1516.1.
Glycidyl ester of C_{10} trialkylacetic acid		B	P	3	2G	Open	No			Yes	O	No	A		No	1519.6.
Heptane (all isomers) (bb)	1206	(C)	P	3	2G	Cont.	No			No	R	F	A		No	1519.6.
Heptanol (all isomers) (q)		C	P	3	2G	Cont.	No			No	R	F	A		No	1519.6.
Heptene(all isomers) (bb)		C	P	3	2G	Cont.	No			No	R	F	A		No	1519.6.
Heptyl acetate		(B)	P	3	2G	Open	No			Yes	O	No	A		No	1519.6.
Hexamethylenediamine solution	1783	C	S/P	3	2G	Cont.	No			Yes	R	T	A	N2	No	1519.6.,1602.9.
Hexamethyleneimine	2493	C	S/P	2	2G	Cont.	No			No	R	F-T	A,C	N1	No	1519.6.
Hexane (all isomers) (bb)	1208	(C)	P	3	2G	Cont.	No			No	R	F	A		No	1519.6.
Hexene (all isomers) (bb)		(C)	P	3	2G	Cont.	No			No	R	F	A		No	1519.6.
Hexyl acetate	1233	B	P	3	2G	Cont.	No			No	R	F	A		No	1519.6.
Hydrochloric acid	1789	D	S	3	1G	Cont.	No		NF		R	T	No		E (f)	1511.

Table 7.6.1(10) Summary of Minimum Requirements

a	b	c	d	e	f	g	h	i'	i''	i'''	j	k	l	m	n	o
Product name	UN number	Pollution category	Hazards	Ship type	Tank type	Tank vents	Tank environmental control	Electrical equipment: Class	Electrical equipment: Group	Electrical equipment: Flashpoint> 60° C	Gauging	Vapour detection	Fire Protection	Materials of construction	Respiratory and eye protection	Special requirements (See **Sec 15**)
Hydrogen peroxide solutions (over 8% but not over 60%)	2014, 2984	C	S/P	3	2G	Cont.	No		NF		C	No	No		No	1505.2., 1518., 1519.6.
Hydrogen peroxide solutions (over 60% but not over 70%)	2015	C	S/P	2	2G	Cont.	No		NF		C	No	No		No	1505.1., 1519.6.
2-Hydroxyethyl acrylate		B	S/P	2	2G	Cont.	No			Yes	C	T	A		No	1512., 1513., 1519.6., 1606.1., 1606.2.
2-Hydroxy-4-(methylthio) butanoic acid		C	P	3	2G	Open	No			Yes	O	No	A		No	1602.7., 1602.8.
Icosa(oxypropane-2,3-diyl)s		B	P	3	2G	Open	No			Yes	O	No	A		No	1519.6., 1602.6.
Isophoronediamine	2289	D	S	3	2G	Cont.	No			Yes	R	T	A	N2	No	
Isophorone diisocyanate	2290	B	S/P	2	2G	Cont.	Dry			Yes	C	T	AB,D	N5	No	1512., 1516.2, 1517., 1519.6
Isoprene*	1218	C	S/P	3	2G	Cont.	No	T3	IIB	No	R	F	B		No	1513., 1514., 1519.6, 1606.1, 1606.2.
Isopropanolamine		C	S/P	3	2G	Open	No	T2	IIA	Yes	O	F-T	A	N2	No	1602.8., 1602.9.
Isopropylamine*	1221	C	S/P	2	2G	Cont.	No	T2	IIA	No	C	F-T	C,D	N2	E	1512., 1514., 1519.
iso-Propylamine(70% or less) solution		C	S/P	2	2G	Cont	No			No	C	F-T	C,D	N1	E	1512., 1519.
Isopropylcyclohexane (bb)		(C)	P	3	2G	Cont.	No			No	R	F	A		No	1519.6., 1602.7., 1602.8.
Isopropyl ether	1159	D	S	3	2G	Cont.	Inert			No	R	F	A		No	1504.6., 1513.3., 1519.6.
Lactonitrile solution (80% or less)		B	S/P	2	1G	Cont.	No			Yes	C	T	A,C, D	Y1	E	1501., 1512., 1517. to 1519., 1602.6, 1606.1. to 3.
Lauric acid		B	P	3	2G	Open	No			Yes	O	No	A		No	1519.6., 1602.6., 1602.9., 1608.2.(2)
Liquid chemical wastes		A	S/P	2	2G	Cont.	No			No	C	F-T	A		E	1512., 1519.6., 2005.1.
Long chain alkaryl polyether (C_{11}-C_{20})		C	P	3	2G	Open	No			Yes	O	No	A,B		No	1602.7., 1602.8
Long chain polyetheramine in alkyl (C_2-C_4) benzenes		C	P	3	2G	Cont.	No			No	R	F	A		No	1519.6., 1602.7., 1602.8.
Long chain polyetheramine in aromatic solvent		C	P	3	2G	Cont.	No			No	R	F	A		No	1519.6, 1602.7., 1602.8.
Magnesium long chain alkyl salicylate (C_{11}*)		C	P	3	2G	Open	No			Yes	O	No	A,B		No	1602.7., 1602.8.
Maleic anhydride	2215	D	S	3	2G	Cont.	No			Yes	R	No	A(g), C		No	
Mercaptobenzothiazol, sodium salt solution		B	S/P	3	2G	Open	No		NF		O	No	No	N1	No	1519.6., 1602.9.
Mesityl oxide	1229	D	S	3	2G	Cont.	No	T2	IIB	No	R	F-T	A		No	1519.6.
Metam sodium solution		A	S/P	2	2G	Open	No		NF		O	No	No	N1	No	1519.6.
Methacrylic acid	2531	D	S	3	2G	Cont.	No			Yes	R	T	A	Y1	No	1513., 1606.1.

Table 7.6.1(11) Summary of Minimum Requirements

a	b	c	d	e	f	g	h	i'	i''	i'''	j	k	l	m	n	o
Product name	UN number	Pollution category	Hazards	Ship type	Tank type	Tank vents	Tank environmental control	Electrical equipment: Class	Electrical equipment: Group	Electrical equipment: Flashpoint> 60° C	Gauging	Vapour detection	Fire Protection	Materials of construction	Respiratory and eye protection	Special requirements (See **Sec 15**)
Methacrylic resin in Ethylene dichloride		B	S/P	2	2G	Cont.	No	T2	IIA	No	R	F-T	A,B	N4	No	1519.,1602.6.
Methacrylonitrile	3079	D	S	2	2G	Cont.	No			No	C	F-T	A	N4,Z	E	1512.,1513.,1517.,1519.
N-(2-Methoxy-1-methyl ethyl)-2-ethyl-6-methyl chloroacetanilide		B	P	3	2G	Open	No			Yes	O	No	A		No	1519.6.
Methyl acrylate	1919	B	S/P	2	2G	Cont.	No	T1	IIB	No	R	F-T	A		E	1513.,1519.6.,1606.1., 1606.2.
Methylamine solutions (42% or less)	1235	C	S/P	2	2G	Cont.	No			No	C	F-T	A,C, D	N1	E	1512.,1517.,1519.
Methylamyl acetate	1233	(C)	P	3	2G	Cont.	No			No	R	F	A		No	1519.6.
Methylamyl alcohol	2053	(C)	P	3	2G	Cont.	No			No	R	F	A		No	1519.6.
Methyl butyrate	1237	(C)	P	3	2G	Cont.	No			No	R	F	A		No	1519.6.
Methylcyclohexane (bb)	2296	(C)	P	3	2G	Cont.	No			No	R	F	A		No	1519.6.
Methylcyclopentadiene dimer		(B)	P	3	2G	Cont.	No			No	R	F	B		No	1519.6.
Methyl diethanolamine		D	S	3	2G	Open	No			Yes	O	No	A	N2	No	
2-Methyl-6-ethyl aniline		C	S/P	3	2G	Open	No			Yes	O	No	A,D		No	
2-Methyl-5-ethyl pyridine	2300	(B)	S/P	3	2G	Open	No		IIA	Yes	O	No	A,D	N4	No	1519.6.
Methyl formate	1243	D	S	2	2G	Cont.	No			No	R	F-T	A		E	1512.,1514.,1519.
Methyl heptyl ketone		B	P	3	2G	Cont.	No			No	R	F	A		No	1519.6.
2-Methyl -2-hydroxy-3butyne		III	S	3	2G	Cont.	No		IIA	No	R	F-T	A,B, D	N6	No	1519.6.
Methyl methacrylate	1247	D	S	2	2G	Cont.	No	T2	IIA	No	R	F-T	A		No	1513.,1519.6.,1606.1., 1606.2.
Methyl naphthalene (molten)		A	S/P	2	2G	Cont.	No			Yes	R	No	A,D		No	1519.6.
2-Methylpyridine	2313	D	S	2	2G	Cont.	No			No	C	F	A	N4	No	1512.3.,1519.6.
3-Methylpyridine	2313	C	S/P	2	2G	Cont.	No			No	C	F	A,C	N4	No	1512.3.,1519.
4-Methylpyridine	2313	D	S	2	2G	Cont.	No			No	C	F-T	A	N4	No	1512.3.,1519.,1602.9.
Methyl salicylate		(B)	P	3	2G	Open	No			Yes	O	No	A		No	1519.6.
alpha-Methylstyrene	2303	A	S/P	3	2G	Cont.	No	T1	IIB	No	R	F-T	A,D ④		No	1513.,1519.6.,1606.1., 1606.2.
Morpholine	2054	D	S	3	2G	Cont.	No	T2	IIA	No	R	F	A	N2,Z	No	1519.6.
Motor fuel anti-knock compounds (containing lead alkyls)	1649	A	S/P	1	1G	Cont.	No	T4	IIA	No	C	F-T	A,C		E	1506.,1512.,1518.,1519.
Naphthalene (molten)	2304	A	S/P	2	2G	Cont.	No	T1	IIA	Yes	R	No	A,D		No	1519.6.
Naphthenic acids		A	P	2	2G	Open	No			Yes	O	No	A		No	1519.6.
Neodecanoic acid		C	P	3	2G	Open	No			Yes	O	No	A		No	1602.8.
Nitrating acid(mixture of sulphuric and nitric acids)	1796	(C)	S/P	2	2G	Cont.	No		NF		C	T	No		E	1511.,1516.2.,1517.,1519.

Table 7.6.1(12) Summary of Minimum Requirements

a	b	c	d	e	f	g	h	i'	i"	i'"	j	k	l	m	n	o
Product name	UN number	Pollution category	Hazards	Ship type	Tank type	Tank vents	Tank environmental control	Electrical equipment Class	Group	Flashpoint> 60°C	Gauging	Vapour detection	Fire Protection	Materials of construction	Respiratory and eye protection	Special requirements (See **Sec 15**)
Nitric acid(less than 70%)	2031	C	S/P	2	2G	Cont.	No		NF		R	T	No		E	1511.,1519.
Nitric acid(70% and over)	2031,2032 (h)	C	S/P	2	2G	Cont.	No		NF		C	T	No		E	1511.,1519.
Nitrobenzene	1662	B	S/P	2	2G	Cont.	No	T1	IIA	Yes	C	T	A,D		No	1512.,1517. to 1519., 1602.9.
Nitroethane		(D)	S	3	2G	Cont.	No		IIB	No	R	F-T	A(u)	N4	No	1516.1., 1519.6., 1606.1., 1606.2., 1606.4.
Nitroethane(80%)/Nitropropane(20%)		D	S	3	2G	Cont.	No		IIB	No	R	F-T	A(u)	N4	No	1516.1., 1519.6., 1606.1. to 3.
o-Nitrophenol (molten)	1663	B	S/P	2	2G	Cont.	No			Yes	C	T	A,D		No	1512.,1519.6.,1602.6., 1602.9.,1608.2.(2)
1-or 2-Nitropropane	2608	D	S	3	2G	Cont.	No	T2	IIB	No	R	F-T	A		No	1519.6.
Nitropropane (60%) / Nitroethane (40%) mixture		D	S	3	2G	Cont.	No			No	R	F-T	A (u)	N4	No	1519.6.
o- or p-Nitrotoluenes	1664	B	S/P	2	2G	Cont.	No		IIB	Yes	C	T	A,B		No	1512.,1517.,1519.,1602.9.
Nonane(all isomers) (bb)	1920	(C)	P	3	2G	Cont.	No			No	R	F	B,C		No	1519.6.
Nonene (ail isomers)		B	P	3	2G	Cont.	No			No	R	F	A		No	1519.6.
Nonyl acetate		(C)	P	3	2G	Open	No			Yes	O	No	A		No	1519.6.
Nonyl alcohol (all isomers)		(C)	P	3	2G	Open	No			Yes	O	No	A		No	
Nonyl phenol		A	P	2	2G	Open	No			Yes	O	No	A		No	1519.6.
Nonyl phenol poly(4+) -ethoxylates		B	P	3	2G	Open	No			Yes	O	No	A		No	1519.6.,1602.6.,1602.9., 1608.2.(2)(aa)
Noxious liquid, N.F., (1) n.o.s. (trade name , contains)S.T. 1, Cat. A③		A	P	1	2G	Open	No			Yes	O	No	A		No	1519.
Noxious liquid, F., (2) n.o.s. (trade name, contains) S.T. 1, Cat. A③		A	P	1	2G	Cont.	No			No	R	F	A		No	1519.
Noxious liquid, N.F., (3) n.o.s. (trade name . contains) S.T. 2, Cat. A③		A	P	2	2G	Open	No			Yes	O	No	A		No	1519.6.
Noxious liquid, F., (4) n.o.s. (trade name, contains S.T. 2, Cat. A③		A	P	2	2G	Cont.	No			No	R	F	A		No	1519.6.
Noxious I iquid. N.F., (5) n.o.s. (trade name,contains) S.T. 2, Cat. B③		B	P	2	2G	Open	No			Yes	O	No	A		No	1519.6.,(1602.6.,1602.9.)⑤
Noxious liquid, N.F., (6) n.o.s. (trade name , contains) ST.2, Cat. B③, m.p. 15°C+		B	P	2	2G	Open	No			Yes	O	No	A		No	1519.6.,(1602.6.)⑤, 1602.9.,1608.2(2)
Noxious liquid, F., (7) n.o.s. (trade name , contains) S.T. 2, Cat. B③		B	P	2	2G	Cont.	No			No	R	F	A		No	1519.6.,(1602.6.,1602.9.)⑤

Table 7.6.1(13) Summary of Minimum Requirements

a	b	c	d	e	f	g	h	i'	i''	i'''	j	k	l	m	n	o
								Electrical equipment								
Product name	UN number	Pollution category	Hazards	Ship type	Tank type	Tank vents	Tank environmental control	Class	Group	Flashpoint> 60° C	Gauging	Vapour detection	Fire Protection	Materials of con-struction	Respiratory and eye protection	Special requirements (See **Sec 15**)
Noxious liquid, F., (8) n.o.s. (trade name, contains) S.T. 2, Cat. B③, m. p, 15°C+		B	P	2	2G	Cont.	No			No	R	F	A		No	1519.6.,(1602.6.)⑤, 1602.9.,1608.2(2)
Noxious liquid, N.F., (9) n.o. s. (trade name, contains) S.T. 3, Cat. A③		A	P	3	2G	Open	No			Yes	O	No	A		No	1519.6.
Noxiousliquid, F., (10) n,o.s. (trade name, contains) S.T. 3, Cat. A③		A	P	3	2G	Cont.	No			No	R	F	A		No	1519.6.
Noxious liquid, N.F., (11) n.o. s. (trade name, contains) S. T. 3, Cat. B③		B	P	3	2G	Open	No			Yes	O	No	A		No	1519.6., (1602.6.,1602.9)⑤
Noxious liquid, N.F., (12) n.o, s. (trade name, contains)S.T. 3, Cat. B③, m.p. 15°C+		B	P	3	2G	Open	No			Yes	O	No	A		No	1519.6.,(1602.6.)⑤, 1602.9.,1608.2(2)
Noxiousliquid, F., (13) n,o.s. (trade name, contains) S.T. 3, Cat. B③		B	P	3	2G	Cont.	No			No	R	F	A		No	1519.6., (1602.6.,1602.9)⑤
Noxious l iquid, F., (14) n o.s. (trade name, contains) S.T. 3, Cat. B③, m.p. 15°C		B	P	3	2G	Cont.	No			No	R	F	A		No	1519.6.,(1602.6)⑤, 1602.9.,1608.2.(2)
Noxious liquid, N.F., (15) n.o. s. (trade name, contains) S.T. 3, Cat. C③		C	P	3	2G	Open	No			Yes	O	No	A		No	(1602.7. to 1602.9)⑤
Noxious l iquid, F., (16) n,o. s. (trade name, contains) S.T. 3, Cat. C③		C	P	3	2G	Cont.	No			No	R	F	A		No	(1602.7. to 1602.9)⑤
Octane(all isomers) (bb)	1262	(C)	P	3	2G	Cont.	No			No	R	F	A		No	1519.6.
Octanol (all isomers)		C	P	3	2G	Open	No			Yes	O	No	A		No	
Octene (all isomers)		B	P	3	2G	Cont.	No			No	R	F	A		No	1519.6.
n-Octyl acetate		C	P	3	2G	Open	No			Yes	O	No	A		No	
Octyl aldehydes	1191	(B)	P	3	2G	Cont.	No			No	R	F	A		No	1519.6.,1602.9.
Olefin mixtures(C_5-C_7) (bb)		C	P	3	2G	Cont.	No			No	R	F	A		No	1519.6.
Olefin mixtures (C_5~C_{15})		B	P	3	2G	Cont.	No			No	R	F	A		No	1519.6.
alpha-Olefins (C_6-C_{18}) mixtures		B	P	3	2G	Cont.	No			No	R	F	A		No	1519.6.,1602.6.,1602.9.
Oleum	1831	C	S/P	2	2G	Cont.	No	NF			C	T	No		E	1511.2. to 8.,1512.1., 1516.2.,1517.,1519., 1602.7.,1602.8.
Oleylamine		A	S/P	2	2G	Cont.	No			Yes	R	T	A		No	1519.6.
Palm kernel acid oil		C	P	3	2G	Open	No			Yes	O	No	A,B		No	1602.7. to 9.

Table 7.6.1(14) Summary of Minimum Requirements

a	b	c	d	e	f	g	h	i'	i"	i'''	j	k	l	m	n	o
Product name	UN number	Pollution category	Hazards	Ship type	Tank type	Tank vents	Tank environmental control	Electrical equipment Class	Group	Flashpoint> 60° C	Gauging	Vapour detection	Fire Protection	Materials of construction	Respiratory and eye protection	Special requirements (See **Sec 15**)
Paraldehyde	1246	C	S/P	3	2G	Cont.	No	T3	IIB	No	R	F	A		No	1519.6.,1602.9.
Pentachloroethane	1669	B	S/P	2	2G	Cont.	No		NF		R	T	No		No	1512.,1517.,1519.6.
1, 3-Pentadiene		C	S/P	3	2G	Cont.	No			No	R	F-T	A,B		No	1513.,1519.6.,1606.1. to 3.
Pentane (all isomers)* (bb)	1265	(C)	P	3	2G	Cont.	No			No	R	F	A		No	1514.,1519.6.
Pentene (all isomers)* (bb)		C	P	3	2G	Cont.	No			No	R	F	A		No	1514.,1519.6.
n-Pentyl propionate		C	P	3	2G	Cont.	No			No	R	F	A		No	1519.6.
Perchloroethylene	1897	B	S/P	3	2G	Cont.	No		NF		R	T	No		No	1512.1.,1512.2.,1519.6.
Phenol	2312	C	S/P	2	2G	Cont.	No	T1	IIA	Yes	C	T	A		No	1512.,1519.,1602.7. to 1602.9.
1-Phenyl-1-xylyl ethane (bb)		C	P	3	2G	Open	No			Yes	O	No	A,B		No	
Phosphoric acid	1805	D	S	3	2G	Open	No		NF		O	No	No		No	1511.1. to 1511.4., 1511.6. to 1511.8.
Phosphorus, yellow or white	1381, 2447	A	S/P	1	1G	Cont.	pad+ (Veut or Inert)			No (k)	C	No	C		E	1507.,1519.
Phthalic anhydride(molten)	2214	C	S/P	3	2G	Cont.	No	T1	IIA	Yes	R	No	A,D		No	1602.7. to 1602.9.
alpha-Pinene	2368	A	P	3	2G	Cont.	No			No	R	F	A		No	1519.6.
beta-Pinene		B	P	3	2G	Cont.	No			No	R	F	A		No	1519.6.
Pine oil	1272	C	P	3	2G	Open	No			Yes	O	No	A		No	1602.7.,1602.8.
Poly (2^+) cyclic aromatics		A	P	2	2G	Cont.	No			Yes	R	No	A,D		No	1519.6.
Polyalkyl (C_{18}-C_{22}) acrylate in Xylene		C	P	3	2G	Cont.	No			N0	R	F	A		No	1519.6.,1602.7.,1602.8.
Polyalkylene oxide polyol		C	P	3	2G	Open	No			Yes	O	No	A		No	1602.7.,1602.8.
Polyethylene polyamines	2734 (i), 2735	(C)	S/P	3	2G	Open	No			Yes	O	No	A	N2	No	1602.9.
Polyferric sulphate solution		(C)	S/P	3	2G	Open	No		NF		O	No	No	Y4	No	
Polymethylene polyphenyl Isocyanate	2206 (i), 2207	D	S	2	2G	Cont.	Dry			Yes (b)	C	T (b)	A	N5	No	1512.,1516.2.,1519.6.
Polyolefinamine in alkyl (C_2-C_4) benzenes		(C)	P	3	2G	Cont.	No			No	R	F	A		No	1519.6.,1602.7.,1602.8.
Polyolefinamine in aromatic solvent		(C)	P	3	2G	Cont.	No			No	R	F	A		No	1519.6.,1602.7.,1602.8.
Polyolefin phosphorosulphide barium derivative (C_{28}-C_{250})		C	P	3	2G	Open	No			Yes	O	No	A,B		No	1602.7.,1602.8.
Potassium chloride solution (10% or more)		C	P	3	2G	Open	No		NF		O	No	No		No	

Table 7.6.1(15) Summary of Minimum Requirements

a	b	c	d	e	f	g	h	i'	i"	i'''	j	k	l	m	n	o
Product name	UN number	Pollution category	Hazards	Ship type	Tank type	Tank vents	Tank environmental control	Electrical equipment: Class	Electrical equipment: Group	Electrical equipment: Flashpoint> 60° C	Gauging	Vapour detection	Fire Protection	Materials of construction	Respiratory and eye protection	Special requirements (See **Sec 15**)
Potassium hydroxide solution	1814	C	S/P	3	2G	Open	No		NF		O	No	No	N8	No	1602.9.
Potassium oleate		(C)	P	3	2G	Open	No			Yes	O	No	A		No	1519.6.
n-Propanolamine		C	S/P	3	2G	Open	No			Yes	O	No	A,D	N2	No	1602.9.
beta-Propiolactone		D	S	2	2G	Cont.	No		IIA	Yes	R	T	A		No	
Propionaldehyde	1275	C	S/P	3	2G	Cont.	No			No	R	F-T	A		E	1516.1.,1517.,1519.6.
Propionic acid	1848	D	S	3	2G	Cont.	No	T1	IIA	No	R	F	A	Y1	E	1511.2. to 4., 1511.6. to 8., 1519.6.
Propionic anhydride	2496	C	S/P	3	2G	Cont.	No	T2	IIA	Yes	R	T	A	Y1	No	
Propionitrile	2404	C	S/P	2	1G	Cont.	No	T1	IIB	No	C	F-T	A,D		E	1512.,1517. to 1519.
n-Propylamine	1277	C	S/P	2	2G	Cont.	Inert	T2	IIA	No	C	F-T	A,D	N2	E	1512.,1519.
Propylbenzene(all isomers)		A	P	3	2G	Cont.	No			No	R	F	A		No	1519.6.
n-Propyl chloride	1278	D	S	3	2G	Cont.	No			No	R	F	A,B		No	1519.6.
Propylene dimer(bb)		(C)	P	3	2G	Cont.	No			No	R	F	A		No	1519.6.
Propylene oxide*	1280	C	S/P	2	2G	Cont.	Inert	T2	IIB	No	C	F-T	A,C	Z	No	1508.,1512.1.,1514.,1519.
Propylene tetramer	2850	B	P	3	2G	Cont.	No			No	R	F	A		No	1519.6.
Propylene trimer	2057	B	P	3	2G	Cont.	No			No	R	F	A		No	1519.6.
Pyridine	1282	D	S	3	2G	Cont.	No	T1	IIA	No	R	F	A	N4	No	1519.6.
Rosin		B	P	3	2G	Open	No			Yes	O	No	A		No	1519.6.,1602.6.,1602.9., 1608.2.(2)
Rosin soap (disproportionat-ed) solution		B	P	3	2G	Open	No			Yes	O	No	A		No	1519.6.
Sodium aluminate solution	1819	D	S	3	2G	Open	No		NF		O	No	No	N1	No	
Sodium borohydride (15% or less)/Sodium hydroxide solution		C	S/P	3	2G	Open	No		NF		O	No	No	N1	No	1602.7.
Sodium chlorate solution (50% or less)	2428	III	S	3	2G	Open	No		NF		O	No	No		No	1509.,1516.1.,1519.6.
Sodium dichromate solution (70% or less)		C	S/P	2	2G	Open	No		NF		C	No	No	N2	No	1512.3.,1519.
Sodium hydrogen sulphide (6% or less) /Sodium carbonate (3% or less) solution		B	P	3	2G	Open	No		NF		O	No	No		No	1519.6.
Sodium hydrogen sulphite solution(45% or less)	2693	D	S	3	2G	Open	No		NF		O	No	No		No	
Sodium hydrosulphide solution (45% or less)	2949	B	S/P	3	2G	Cont.	Vent or Pad (gas)		NF		R	T	No		No	1516.1.,1519.6.,1602.9.

Table 7.6.1(16) Summary of Minimum Requirements

a	b	c	d	e	f	g	h	i'	i''	i'''	j	k	l	m	n	o
Product name	UN number	Pollution category	Hazards	Ship type	Tank type	Tank vents	Tank environmental control	Electrical equipment			Gauging	Vapour detection	Fire Protection	Materials of construction	Respiratory and eye protection	Special requirements (See **Sec 15**)
								Class	Group	Flashpoint> 60° C						
Sodium hydrosulphide/ Ammonium sulphide solution		B	S/P	2	2G	Cont.	No			No	C	F-T	A	N1	E	1512., 1514., 1516.1., 1517., 1519., 1606.1. to 3.
Sodium hydroxide solution	1824	D	S	3	2G	Open	No		NF		O	No	No	N8	No	
Sodium hypochlorite solution(15% or less)	1791	C	S/P	3	2G	Cont.	No		NF		R	No	No	N5	No	1516.1.
Sodium nitrite solution		B	S/P	2	2G	Open	No		NF		O	No	No		No	1512.3.(1), 1512.3.(2), 1516.1., 1519.
Sodium petroleum sulfonate		B	S/P	2	2G	Open	No			Yes	O	No	A		No	1519.6., 1602.6.
Sodium silicate solution		C	P	3	2G	Open	No		NF		O	No	No		No	
Sodium sulphide solution (15% or less)		B	S/P	3	2G	Cont.	No		NF		C	T	No	N5	No	1516.1,1519.6.,1602.9.
Sodium sulphide solution (25% or less)		C	P	3	2G	Open	No		NF		O	No	No		No	1516.1., 1519.6., 1602.9.
Sodium tartrates/sodium succinates solution		D	S	3	2G	Open	No			Yes	O	No	A,B	Y5	No	
Sodium thiocyanate solution (56% or less)		(B)	P	3	2G	Open	No			Yes	O	No	No		No	1519.6.
Styrene monomer	2055	B	S/P	3	2G	Cont.	No	T1	IIA	No	R	F	A,B	N4,Z	No	1513.,1519.6.,1606.1., 1606.2.
Sulpho hydrocarbon long chain (C_{18}+) alkylamine mixture		B	P	3	2G	Open	No			Yes	O	No	A,B		No	1519.6.,1602.6.
Sulphur (molten)	2488	III	S	3	1G	Open	Vent or Pad (gas)	T3		Yes (1)	O	F-T	No		No	1510.
Sulphuric acid	1830	C	S/P	3	2G	Open	No		NF		O	No	No		No	1511.,1516.2.,1602.8., 1602.9.
Sulphuric acid, spent	1832	C	S/P	3	2G	Open	No		NF		O	No	No		No	1511.,1516.2.,1602.8., 1602.9.
Tall oil(crude and distilled)		B	P	3	2G	Open	No			Yes	O	No	A		No	1519.6.,1602.6.,1602.9., 1608.2.(2)
Tall oil fatty acid barium salt		B	S/P	3	2G	Open	No			Yes	O	No	A		No	1519.6.,1602.6.
Tall oil fatty acid (resin acids less than 20%)		(C)	P	3	2G	Open	No			Yes	O	No	A		No	1602.7. to 602.9.
Tall oil soap (disproportionated) solution		B	P	3	2G	Open	No			Yes	O	No	A		No	1519.6.,1602.6.,1602.9.
Tetrachloroethane	1702	B	S/P	3	2G	Cont.	No		NF		R	T	No		No	1512.,1517.,1519.6.
Tetraethylene pentamine	2320	D	S	3	2G	Open	No			Yes	O	No	A	N1	No	
Tetrahydrofuran	2056	D	S	3	2G	Cont.	No	T3	IIB	No	R	F-T	A		No	1519.6.

Table 7.6.1(17) Summary of Minimum Requirements

a	b	c	d	e	f	g	h	i'	i''	i'''	j	k	l	m	n	o
Product name	UN number	Pollution category	Hazards	Ship type	Tank type	Tank vents	Tank environmental control	Electrical equipment			Gauging	Vapour detection	Fire Protection	Materials of con-struction	Respiratory and eye protection	Special requirements (See **Sec 15**)
								Class	Group	Flashpoint> 60° C						
Tetrahydronaphthalene (bb)		C	P	3	2G	Open	No			Yes	O	No	A		No	
Tetramethylbenzene (all iso-mers)		A	P	3	2G	Open	No			Yes	O	No	A		No	1602.9.,1608.2.(2)
Toluene (bb)	1294	C	P	3	2G	Cont.	No			No	R	F	A		No	1519.6.
Toluenediamine	1709	C	S/P	2	2G	Cont.	No			Yes	C	T	A,D	N1	E	1512.,1517.,1519.,1602.7., 1602.9.
Toluene diisocyanate	2078	C	S/P	2	2G	Cont.	Dry	T1	IIA	Yes	C	F-T	A, C(c), D	N4	E	1512.,1516.2.,1517.,1519., 1602.9.
o-Toluidine	1708	C	S/P	2	2G	Cont.	No			Yes	C	T	A		No	1512.,1517.,1519.
Tributyl phosphate		B	P	3	2G	Open	No			Yes	O	No	A		No	1519.6.
1, 2, 4-Trichlorobenzene	2321	B	S/P	2	2G	Cont.	No			Yes	R	T	A,B		No	1519.6.,1602.9.,1608.2.(2)
1,1, 1-Trichloroethane	2831	C	P	3	2G	Open	No			Yes	O	No	A		No	
1,1, 2-Trichloroethane		C	S/P	3	2G	Cont.	No		NF		R	T	No		No	1512.1.,1519.6.
Trichloroethylene	1710	C	S/P	3	2G	Cont.	No	T2	IIA	Yes	R	T	No		No	1512.,1516.1.,1517.,1519.6.
1, 2, 3-Trichloropropane		C	S/P	2	2G	Cont.	No			Yes	C	T	A,B, D		No	1512.,1517.,1519.
1,1, 2-Trichloro1, 2, 2-Trifluoroethane		C	P	3	2G	Open	No		NF		O	No	No		No	
Tricresyl phosphate (containing less than 1% ortho-isomer)		A	P	2	2G	Open	No			Yes	O	No	A		No	1519.6.
Tricresyl phosphate (containing 1% or more ortho-isomer)	2574 (i)	A	S/P	1	2G	Cont.	No	T2	IIA	Yes	C	No	A,B		No	1512.3.,1519.
Tridecanoic acid		B	P	3	2G	Open	No			Yes	O	No	A		No	1519.6.,1602.6.,1602.9., 1608.2.(2)
Triethanolamine		D	S	3	2G	Open	No		IIA	Yes	O	No	A	N1	No	
Triethylamine	1296	C	S/P	2	2G	Cont.	No	T2	IIA	No	R	F-T	A,C	N2	E	1512.,1519.6
Triethylbenzene		A	P	2	2G	Open	No			Yes	O	No	A		No	1519.6.
Triethylenetetram ine	2259	D	S	3	2G	Open	No	T2	IIA	Yes	O	No	A	N1	No	
Triethyl phosphite	2323	B	S/P	3	2G	Cont.	No			No	R	F-T	A,B		No	1512.1.,1519.6.
Triisopropilated phenyl phos-phate		A	P	2	2G	Open	No			Yes	O	No	A		No	1519.6.
Trimethylacetic acid		D	S	3	2G	Cont.	No			Yes	R	No	A	Y1	No	1511.2. to 1511.8.
Trimethylamine solution (30% or less)	1297	C	S/P	2	2G	Cont.	No			No	C	F-T	A,C	N1	E	1512.,1514.,1519.,1602.9.
Trimethyl benzene (all isomers)		A	P	3	2G	Cont.	No			No	R	F	A		No	1519.6.
Trimethylhexamethylenediamine (2, 2, 4- and 2, 4, 4-isomers)	2327	D	S	3	2G	Open	No			Yes	O	No	A,C	N1	No	1519.6.

Table 7.6.1(18) Summary of Minimum Requirements

a	b	c	d	e	f	g	h	i'	i''	i'''	j	k	l	m	n	o
Product name	UN number	Pollution category	Hazards	Ship type	Tank type	Tank vents	Tank environmental control	Electrical equipment			Gauging	Vapour detection	Fire Protection	Materials of construction	Respiratory and eye protection	Special requirements (See **Sec 15**)
								Class	Group	Flashpoint> 60° C						
Trimethylhexamethylenediisocyanate (2, 2, 4- and 2, 4, 4-isomers)	2328	B	S/P	2	2G	Cont.	Dry			Yes	C	T	A, C(c)		No	1512.,1516.2.,1517.,1519.6.
2, 2, 4-Trimethyl-1, 3pentane-diol-1 -isobutyrate		C	P	3	2G	Open	No			Yes	O	No	A		No	
Trimethyl phosphite	2329		S	3	2G	Cont.	No			No	R	F-T	A,D		No	1512.1.,1516.2.,1519.6.
1, 3, 5-Trioxane		D	S	3	2G	Cont.	No			No	R	F	A,D		No	1519.6.
Trixylyl phosphate		A	P	1	2G	Open	No			Yes	O	No	A		No	1519.
Turpentine	1299	B	P	3	2G	Cont.	No			No	R	F	A		No	1519.6.
Undecanoic acid		B	P	3	2G	Open	No			Yes	O	No	A		No	1602.6.,1602.9.
1 -Undecene		B	P	3	2G	Open	No			Yes	O	No	A		No	1519.6.
Undecyl alcohol		B	P	3	2G	Open	No			Yes	O	No	A		No	1519.6.,1602.9.,1608.2.(2)(r)
Urea/Ammonium nitrate solution(containing aqua ammonia		C	S/P	3	2G	Cont.	No		NF		R	T	A	N4	No	
Valeraldehyde (all isomers)	2058	C	S/P	3	2G	Cont.	Inert	T3	IIB	No	R	F-T	A		No	1504.6.,1516.1.,1519.6.
Vinyl acetate	1301	C	S/P	3	2G	Cont.	No	T2	IIA	No	R	F	A		No	1513.,1519.6., 1606.1.,1606.2.
Vinyl ethyl ehter	1302	C	S/P	2	1G	Cont.	Inert	T3	IIB	No	C	F-T	A	N6	E	1504.,1513.,1514.,1519., 1606.1.,1606.2.
Vinylidene chloride*	1303	D	S	2	2G	Cont.	Inert	T2	IIA	No	R	F-T	B	N5	E	1513.,1514.,1519.6., 1606.1.,1606.2.
Vinyl neodecanoate*		B	S/P	3	2G	Open	No			Yes	O	No	A.B		No	1513.,1516.1.,1519.6., 1606.1.,1606.2.
Vinyltoluene	2618	A	S/P	3	2G	Cont.	No		IIA	No	R	F	A,B	N1	No	1513.,1519.6., 1606.1.,1606.2.
White spirit,low(15-20%) aromatic	1300	(B)	P	2	2G	Cont.	No			No	R	F	A		No	1519.6.
Xylenes (bb)	1307	C	P	3	2G	Cont.	No			No	R	F	A		No	1519.6.,1602.9.(w)
Xylenol	2261	B	S/P	3	2G	Open	No		IIA	Yes	O	No	A,B		No	1519.6.,1602.9.,1608.2.(2)
Zinc alkaryl dithiophosphate (C_7-C_{16})		(C)	P	3	2G	Open	No			Yes	O	No	A,B		No	1602.7.,1602.8.
Zinc alkyl dithiophosphate (C_3-C_{14})		B	P	3	2G	Open	No			Yes	O	No	A,B		No	1519.6.,1602.6.

NOTE:

(a) Applies to ammonia aqueous (28% or less), but not below 10%.
Ammonia aqueous(28% or less)

(b) If the product to be carried contains flammable solvents such that the flashpoint does not exceed 60°C c. c., then special electrical systems and a flammable vapour detector should be provided.
Diphenylmethane diisocyanate
Polymethylene polyphenyl isocyanate

(c) Although water is suitable for extinguishing open-air fires involving chemicals to which this footnote applies, water should not be allowed to contaminate closed tanks containing these chemicals because of the risk of hazardous gas generation.
Diphenylmethane diisocyanate
Toluene diisocyanate

Trimethylhexamethylene diisocyanate(2,2,4- and 2,4,4-isomers)

(d) UN No. 1198 only applies if flashpoint is below 60°C c.c.

Formaldehyde solutions(45% or less)

(e) Applies to formaldehyde solutions(45% or less), but not below 5%.

Formaldehyde solutions (45% or less)

(f) Applies to hydrochloric acid not below 10%.

Aluminium chloride (30% or less)/Hydrochloric acid (20% or less) solution

Hydrochloric acid

(g) Dry chemical cannot be used because of the possibility of an explosion.

Maleic anhydride

(h) UN No. 2032 assigned to red fuming nitric acid.

Nitric acid (70% and over)

(i) Deleted.

(j) UN number assigned to this substance containing more than 3% of ortho-isomer.

Tricresyl phosphate (conatining 1% or more ortho-isomer)

(k) Phosphorus (yellow or white) is carried above its autoignition temperature and therefore flashpoint is not appropriate. Electrical equipment requirements may be similar to those for substances with a flashpoint above 60°C c. c.

Phosphorus, yellow or white

(l) Sulphur (molten) has a flashpoint above 60°C c.c.; however, electrical equipment should be certified safe for gases evolved.

Sulphur (molten)

(m) UN No. 2672 refers to 10-35% ammonia solutions.

Ammonia aqueous (28% or less)

(n) UN No. 2511 applies to 2-chloropropionic acid only.

2- or 3-Chloropropionic acid

(o) Dinitrotoluene should not be carried in deck tanks.

Dinitrotoluene (molten)

(p) Deleted.

(q) Requirements are based on those isomers having a flashpoint of 60°C c. c., or less; some isomers have a flashpoint greater than 60°C c. c., and therefore the requirements based on flammability would not apply to such isomers.

Heptanol (all isomers)

(r) Reference **1608. 2** (2) applies to 1-undecyl alcohol only.

Undecyl alcohol

(s) Applies to n-decyl alcohol only.

Decyl alcohol (all isomers)

(t) UN No. 1114 applies to benzene.

Benzene and mixtures having 10% benzene or more

(u) Dry chemical should not be used as fire-extinguishing media.

Nitropropane (60%)/Nitroethane (40%) mixture

(v) Confined spaces should be tested for both formic acid vapours and carbon monoxide gas, a decomposition product.

Formic acid

(w) Applies to p-xylene only.

Xylenes

(x) Applies to p-isomer and mixtures containing p-isomer viscosity of which is 23$mPa.s$ at 20°C.

Dichlorobenzene (all isomers)

(y) Applies to p-isomer and mixtures containing p-isomer the melting point of which is 0°C and above.

Dichlorobenzene (all isomers)

(z) Applies to p-isomer and mixtures containing p-isomer the melting point of which is 15°C and above.

Dichlorobenzene (all isomers)

(aa) Applies only to products with the melting point of 15°C and above.

Nonylphenol poly(4-12)ethoxylates

(bb) Applies to oil-like substances identified in accordance with the provisions of the unified interpretations of regulation 14 of Annex II of MARPOL 73/78 agreed by the MEPC.

① For mixtures containing no other components with safety hazards and where the pollution category is C or less.

② Deleted.

③ In case of specific n.o.s. cargo assessed as falling within this n. o.s. group that is carried on a ship, this entry, including the cargo's trade name and one or two principal components, should be provided in the shipping document. Abbreviations used mean:

N. F.: Flashpoint exceeding 60°C (closed cup test)
F: Flashpoint not exceeding 60°C (closed cup test)
n.o.s.: Not otherwise specified
S. T.: Ship type
Cat.: Pollution category
m. p.: Melting point

④ Only certain alcohol- resistant foams are effective.

⑤ For high viscosity or high melting point cargoes.

SECTION 18

List of Chemicals to which this Chapter does not apply

1. The following are chemicals which have been reviewed for their safety and pollution hazards and determined not to present hazards to such an extent as to warrant application of this Chapter. This may be used as a guide in considering bulk carriage of chemicals whose hazards have not yet been evaluated.
2. Although the products listed in this Section fall outside the scope of this Chapter, the attention of the Society is drawn to the fact that some safety precautions may be needed for their safe transportation. Accordingly, the Society should prescribe appropriate safety requirements.
3. Some chemicals are identified as falling into pollution category D and, therefore, subject to certain operational requirements of Annex II of MARPOL 73/78.
4. Liquid mixtures which are provisionally assessed under regulation 3(4) of Annex II of MARPOL 73/78 as falling into pollution category D, and which do not present safety hazards, may be carried under the entry for noxious liquids not otherwise specified in this Section. Similarly, those mixtures provisionally assessed as falling outside pollution category A, B, C, or D and which do not present safety hazards, may be carried under the entry for non-noxious liquids, not otherwise specified in this Section.

EXPLANATORY NOTES

Product name (column a)

In some cases, the product names may not be identical with the names given in previous issues of the Rules, the IBC Code or the BCH Code (for explanation, see index of chemicals).

UN number (column b)

The number relating to each product shown in the recommendations proposed by the United Nations Committee of Experts on the Transport of Dangerous Goods. UN numbers, where available, are given for information only.

Pollution category (column c)

The letter D means the pollution category assigned to each product under Annex II of MARPOL 73/78. "III" means the product was evaluated and found to fall outside the categories A, B, C or D.

Pollution category in brackets indicates that the product is provisionally categorized and that further data are necessary to complete the evaluation of their pollution hazards. Until the hazard evaluation is completed, the pollution category assigned is used.

Table 7.6.2(1) Chemicals to which the Rules do not apply

a	b	c
Product name	UN number	Pollution category for operational discharge (regulation 3 of Annex II)
Acetone	1090	III
Acrylonitrile-Styrene copolymer dispersion in polyether polyol	–	D
Alcoholic beverages, n.o.s.	3065	III
Alcohols (C_{13} and above)	–	III
n-Alkanes (C_{10}^{+})	–	III
Alkenyl(C_{11}^{+})amide	–	D
Alkyl (C_8^{+}) amine, Alkenyl (C_{12}^{+}) acid ester mixture	–	D
Alkyl (C_9^{+}) benzenes	–	III
Alkyldithiothiadiazole (C_6-C_{24})	–	D
Aluminium sulphate solution	–	D
Aminoethyldiethanolamine/Aminoethylethanolamine solution	–	III
2-Amino-2-hydroxymethyl-1, 3-propanediol solution (40% or less)	–	III
Ammonium hydrogen phosphate solution	–	D
Ammonium lignosulphonate solutions	–	III
Ammonium polyphosphate solution	–	D
Ammonium sulphate solution	–	D
n-Amyl alcohol	1105	D
sec-Amyl alcohol	1105	D
tert-Amyl alcohol	1105	III
Amyl alcohol, primary	1105	D
Animal and fish oils, n.o.s., including: Cod liver oil, Lanolin, Neatsfoot oil, Pilchard oil, Sperm oil	–	D
Animal and fish acid oils and distillates, n.o.s., including: Animal acid oil, Fish acid oil, Lard acid oil, Mixed acid oil, Mixed general acid oil, Mixed harc acid oil, Mixed soft acid oil	–	D
Apple juice	–	III
Aryl polyolefin (C_{11}-C_{50})	–	D
Benzenetricarboxylic acid, trioctyl ester	–	III
Brake fluid base mix: (Poly(2-8)alkylene (C_2-C_3) glycols/Polyalkylene (C_2-C_{10}) glycols monoalkyl (C_1-C_4) ethers and their borate esters)①	–	D
n-Butyl alcohol	1120	III
sec-Butyl alcohol	1120	III
tert-Butyl alcohol	1120	III
Butylene glycol	–	D
Butyl stearate	–	III
gamma -Butyrolactone	–	D
Calcium carbonate slurry	–	III
Calcium hydroxide slurry	–	D
Calcium lignosulphonate solutions	–	III
Calcium long-chain alkaryl sulphonate(C_{11}-C_{50})	–	D
Calcium long-chain alkyl phenate sulphide(C_8-C_{40})	–	D
Calcium long-chain alkyl phenolic amine (C_8-C_{40})	–	III
Calcium nitrate/Magnesium nitrate/Potassium chloride solution	–	III
Caramel solutions	–	III
epsilon-Caprolactam (molten or aqueous solutions)	–	D
Chlorinated paraffins(C_{14}-C_{17}) (with 52% chlorine)	–	III
Choline chloride solutions	–	D
Citric acid (70% or less)	–	D
Clay slurry	–	III
Coal slurry	–	III
Coconut oil fatty acid methyl ester	–	D

Table 7.6.2(2) Chemicals to which the Rules do not apply

a	b	c
Product name	UN number	Pollution category for operational discharge (regulation 3 of Annex II)
Cyclohexanol	–	D
Decahydronaphthalene	1147	(D)
Dextrose solution	–	III
Diacetone alcohol	1148	D
Dialkyl (C_7-C_{13}) phthalates	–	D
Diethylene glycol	–	D
Diethylene glycol dibutyl ether	–	D
Diethylene glycol diethyl ether	–	III
Diethylene glycol phthalate	–	D
Diethylenetriamine pentaacetic acid, pentasodium salt solution	–	III
Di- (2-ethylhexyl) adipate	–	D
Diheptyl phthalate	–	III
Dihexyl phthalate	–	III
1, 4-Dihydro-9, 10-dihydroxy anthracene, disodium salt solution	–	D
Diisobutyl ketone	1157	D
Diisononyl adipate	–	D
Diisooctyl phthalate	–	III
Diisopropyl naphthalene (bb)	–	D
2, 2-Dimethylpropane-1, 3-diol	–	(D)
Dimethyl polysiloxane	–	III
Dinonyl phthalate	–	D
Dioctyl phthalate	–	III
Dipropylene glycol	–	III
Ditridecyl Adipate	–	III
Ditridecyl phthalate	–	D
Diundecyl phthalate	–	D
Dodecane (all isomers)	–	III
Dodecenyl succinic acid, dipotassium salt solution	–	(D)
Dodecyl benzene	–	III
Dodecyl xylene	–	III
Drilling brines including: Calcium bromide solution, Calcium chloride solution, Sodium chloride solution	–	III
2-Ethoxyethanol	1171	D
Ethyl acetate	1173	D
Ethyl acetoacetate	–	(D)
Ethyl alcohol	1170	III
Ethylene carbonate	–	III
Ethylenediamine tetraacetic acid, tetrasodium salt solution	–	D
Ethylene glycol	–	D
Ethylene glycol acetate	–	(D)
Ethylene glycol methyl butyl ether	–	D
Ethylene glycol phenyl ether	–	D
Ethylene glycol phenyl ether/Diethylene glycol phenyl ether mixture	–	D
Ethylene-vinyl acetate copolymer (emulsion)	–	III
2-Ethylhexanoic acid	–	D
2-Ethyl-2-(hydroxymethyl) propane-1,3-diol,C8-C10 ester	–	D
Ethyl propionate	1195	D
Fatty acid (saturated C_{13} and above)	–	III
Ferric hydroxyethylethylene diamine triacetic acid, trisodium salt solution	–	D
Fish solubles ②	–	III
Formamide	–	D

Table 7.6.2(3) Chemicals to which the Rules do not apply

a	b	c
Product name	UN number	Pollution category for operational discharge (regulation 3 of Annex II)
Glucose solution	–	III
Glycerine	–	III
Glycerine (83%), Dioxanedimethanol (17%) mixture	–	D
Glycerol monooleate	–	D
Glycerol polyalkoxylate	–	III
Glyceryl triacetate	–	(III)
Glycine, soidum salt solution	–	III
Glyoxal solution (40% or less)	–	D
n-Heptanoic acid	–	D
Hexamethylenediamine adipate (50% in water)	–	D
Hexamethylene glycol	–	III
Hexamethylenetetramine solutions	–	D
Hexanoic acid	–	D
Hexanol	2282	D
Hexylene glycol	–	III
N-(Hydroxyethyl) ethylenediamine triacetic acid, trisodium salt solution	–	D
Isoamyl alcohol	1105	D
Isobutyl alcohol	1212	III
Isobutyl formate	2393	D
Iso-& cyclo-Alkanes (C_{10}-C_{11})	–	D
Iso-& cyclo-Alkanes (C_{12}^{+})	–	III
Isophorone	–	D
Isopropyl acetate	1220	III
Isopropyl alcohol	1219	III
Kaolin slurry	–	III
Lactic acid	–	D
Lard	–	III
Latex: Carboxylated styrene-butadiene copolymer	–	III
Styrene-butadiene rubber	–	III
Latex, ammonia (1% or less)-inhibited	–	D
Lignin sulphonic acid, sodium salt solution	–	III
Long-chain alkaryl sulphonic acid (C_{16}-C_{60})	–	D
Long-chain alkylphenate/Phenol sulphide mixture	–	III
Magnesium chloride solution	–	III
Magnesium hydroxide slurry	–	III
Magnesium long-chain alkaryl sulphonate (C_{11}-C_{50})	–	D
3-Methoxy-1-butanol	–	III
3-Methoxybutyl acetate	–	D
Methyl acetate	1231	III
Methyl acetoacetate	–	D
Methyl alcohol	1230	D
Methyl amyl ketone	1110	D
Methyl propyl ketone	1249	D
N -Methyl-2-pyrrolidone	–	D
Methyl butenol	–	(D)
Methyl tert-butyl ether	2398	D
Methyl butyl ketone	–	D
Methyl butynol	–	D
Methyl ethyl ketone	1193	III
N-Methylglucamine solution(70% or less)	–	III

Table 7 6 2(4) Chemicals to which the Rules do not apply

a	b	c
Product name	UN number	Pollution category for operational discharge (regulation 3 of Annex II)
Methyl isobutyl ketone	1245	D
3-Methyl-3-methoxy butanol	–	III
3-Methyl-3-methoxy butyl acetate	–	III
Molasses	–	III
Myrcene	–	D
Naphthalene sulphonic acid-Formaldehyde copolymer, sodium salt solution	–	D
Nitrilotriacetic acid, trisodium salt solution	–	D
Nonanoic acid (all isomers)	–	D
Nonyl methacrylate monomer	–	(D)
Noxious liquid, n.o.s. (17) (trade name ..., contains...) Cat. D ③	–	D
Non-noxious liquid, n.o.s. (18) (trade name ..., contains...) Appendix III ③	–	III
Octanoic acid (all isomers)	–	D
Octyl decyl adipate	–	III
Olefins (C_{13} and above, all isomers)	–	III
Olefin-Alkyl ester copolymer (molecular weight 2000+)	–	D
Oleic acid	–	D
Palm oil fatty acid methyl ester	–	D
Palm stearin	–	D
Paraffin wax	–	III
Pentaethylenehexamine	–	D
Pentanoic acid	–	D
Petrolatum	–	(III)
Poly (2-8) alkylene glycol monoalkyl (C_1-C_6) ether	–	D
Poly (2-8) alkylene glycol monoalkyl (C_1-C_6) ether acetate	–	D
Polyaluminium chloride solution	–	III
Polybutene	–	III
Polybutenyl succinimide	–	D
Polyether (molecular weight 2000+)	–	D
Polyethylene glycol	–	III
Polyethylene glycol dimethyl ether	–	III
Polyglycerin, sodium salt solution (containing less than 3% sodium hydroxide)	–	III
Polyglycerol	–	III
Poly (4+) isobutylene	–	III
Polyolefin (molecular weight 300+)	–	III
Polyolefin amide alkeneamine (C_{28}^+)	–	D
Polyolefin amide alkeneamine borate (C_{28}-C_{250})	–	D
Polyolefin amide alkeneamine/molybdenum oxysulphide mixture	–	III
Polyolefin amide alkeneamine polyol	–	D
Polyolefin anhydride	–	D
Polyolefin ester (C_{28}-C_{250})	–	D
Polyolefin phenolic amine (C_{28}-C_{250})	–	D
Poly(20)oxyethylene sorbitan monooleate	–	III
Poly (5+) propylene	–	III
Polypropylene glycol	–	D
Polysiloxane	–	III
n-Propyl acetate	1276	D
n-Propyl alcohol	1274	III
Propylene-Butylene copolymer	–	III
Propylene glycol	–	III

Table 7.6.2(5) Chemicals to which the Rules do not apply

a	b	c
Product name	UN number	Pollution category for operational discharge (regulation 3 of Annex II)
Propylene glycol monoalkyl ether	–	(D)
Propylene glycol methyl ether acetate	–	D
Sodium acetate solutions	–	(D)
Sodium aluminosilicate slurry	–	III
Sodium benzoate	–	D
Sodium carbonate solution	–	D
Sodium poly(4+)acrylate solutions	–	III
Sodium sulphate solutions	–	III
Sorbitol solution	–	III
Sulphohydrocarbon (C_3-C_{88})	–	D
Sulpholane	–	D
Tallow	–	D
Tallow fatty acid	–	(D)
Tetraethylene glycol	–	III
Tridecane	–	III
Tridecyl acetate	–	III
Triethyl phosphate	–	D
Triethylene glycol	–	III
Triisopropanolamine	–	III
Trimethylol propane polyethoxylate	–	D
2, 2, 4-Trimethyl-1, 3-pentanediol diisobutyrate	–	III
Tripropylene glycol	–	III
Urea/Ammonium mono- and di-hydrogen phosphate/Potassium chloride solution	–	(D)
Urea/Ammonium nitrate solution	–	D
Urea/Ammonium phosphate solution	–	D
Urea formaldehyde resin solution	–	III
Urea solution	–	III
Vegetable oils, n.o.s., Including: babbasu oil, beech nut oil, castor oil, cocoa butter, coconut oil, corn oil, cotton seed oil, groundnut oil, hazelnut oil, linseed oil, nutmeg butter, oiticica oil, olive oil, palm nut oil, palm oil, peel oil (oranges and lemons), perilla oil, poppy oil, raisin seed oil, rape seed oil, rice bran oil, safflower oil, salad oil, sesame oil, soya bean oil, sunflower oil, tucum oil, tung oil, walnut oil	–	D
Vegetable acid oils and distillates, n.o. s., Including: corn acid oil, cotton seed acid oil, dark mixed acid oil, groundnut acid oil, mixed acid oil, mixed general acid oil, mixed hard acid oil, mixed soft acid oil, rape seed acid oil, safflower acid oil, soya acid oil, sunflower seed acid oil	–	D
Vegetable protein solution (hydrolysed)	–	III
Water	–	III
Waxes	–	D
Zinc alkenyl carboxamide	–	D

NOTE:
① Use "Brake fluid base mix" as a proper name on the shipping document.
② Water-based fish meal extract.
③ In case of a specific n. o. s. (not otherwise specified) cargo assessed as falling within this n. o. s. group that is carried on a ship, this entry, including the cargo's trade name and one or two principal components, should be provided in the shipping document.

SECTION 19
Requirements for Ships engaged in the Incineration at Sea of Liquid Chemical Waste

1901. General (IBC Code 19.1)

1. **Secs 1** to **16** apply to incinerator ships, as relevant, and as supplemented or modified by the provisions of this Section.

2. Information on the composition and the hazards of the waste to be incinerated should be made available to the Society or port Administration, or both, as appropriate, which may prohibit carriage of those wastes deemed to be too hazardous to be carried in bulk.

3. The following additional definitions apply:

(1) **"Incinerator space"** is a gastight space containing solely the incinerator and its associated auxiliaries.
(2) **"Incinerator blower space"** is a space containing the blowers which supply combustion air to the incinerator burners.
(3) **"Dumping Convention"** means the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter at Sea, 1972.
(4) **"Cargo area"** is that part of the ship defined in **106. 5,** excluding incinerators and chemical waste piping leading to the incinerators.

4. During the periodical and intermediate surveys, all cargo tanks and the cargo piping system should be inspected for corrosion and the remaining thickness of material should be determined. Where severely corrosive wastes have been carried, inspections of cargo tanks and the cargo piping system for corrosion should be held annually and the remaining thickness of materials determined during those inspections.

1902. Ship survival capability and location of cargo tanks (IBC Code 19.2)

1. Ships subject to this Section should comply with type 2 ship standards and with the requirements for location of cargo tanks in type 2 ships.

2. Waste mixtures containing substances which would require a type 1 ship standard may be carried in type 2 ships if solely for the purpose of incineration.

1903. Ship arrangements (IBC Code 19.3)

1. Liquid chemical wastes should not be stowed adjacent to oil fuel tanks except those tanks containing oil fuel to be used exclusively for incineration.

2. Tanks and pumps, other than those described in **Par 3,** which may contain liquids and which are to be used for the incineration process or for washing cargo pipes and cargo tanks may be located adjacent to cargo tanks and should be located within the cargo area. The provisions of **301.** should apply to such tanks and equipment to the same extent as they apply to cargo tanks.

3. Where necessary, oil fuel tanks and fuel pumps directly feeding the incinerator burners during the process of pre-heating or supporting incineration may be located outside the cargo area provided the oil fuel used has a flashpoint above 60°C (closed cup test). (see also **1905. 3**)

4. Liquids which have been used for cleaning cargo pipes and cargo tanks as well as for pump-room drainage should be stored in a slop tank in the cargo area, for disposal in conformity with the technical guidelines annexed to the Dumping Convention. A cargo tank may be used as a slop tank. Pumps used for handling contaminated cleaning fluids should be located in the cargo area.

5. Where necessary, compliance with **302. 1** need not be required in so far as accommodation spaces, service spaces, control stations and machinery spaces other than those of category A may be permitted forward of the cargo area, subject to an equivalent standard of safety and appropriate fire-extinguishing arrangements being provided to the satisfaction of the Society.

6. If accommodation spaces, service spaces, control stations or machinery spaces other than those of category A are located forward of the cargo area in accordance with **1903. 5,** the requirements of **302. 3** should be applied by analogy; i.e. the specified distances should be measured from the after end of a house located forward of the cargo area.

7. The incinerator should be located outside the external perimeter of the cargo area. Alternative arrangements may, however, be considered by the Society, provided an equivalent degree of safety is achieved.

8. The effect which combustion gases may have on adequate vision from the navigating bridge, on air intakes and openings into accommodation, service and machinery spaces, and on deck working areas and passageways should be considered.

9. Access to the incinerator space should be from the open deck. However, the incinerator control room and incinerator blower space may have direct access to the incinerator space provided that these spaces have an additional access from the open deck. Access openings of the incinerator space should be fitted with self-closing gastight doors.

1904. Cargo containment and incinerator standards (IBC Code 19.4)

1. Integral gravity tanks may be used for hazardous wastes.

2. The incinerator, including burners, should be designed and constructed to safety standards acceptable to the Society. For materials of construction the provisions of **601.** apply.

3. The steel structure of the incinerator, including supports and other fixtures, should be designed for the most unfavourable static angle of heel within the range of 0° to 30°, taking into account the dynamic loads due to the ship's motion.

4. Suitable brick lining and insulation should be provided to ensure that any temperature rise will not impair the strength of the incinerator structure or the functioning of the associated auxiliaries and instruments and will not adversely affect personnel safety.

5. Means should be provided for measuring the temperature on the outside furnace surfaces. Means for alarms should be provided to indicate when the temperature approved by the Society is exceeded and the process of incineration has to be stopped.

1905. Cargo transfer (IBC Code 19.5)

1. The requirements of **501.** apply except that cargo piping should, as far as practicable, be fitted in the cargo area and that cargo piping leading to the incinerator should:

(1) be fitted at least 760 *mm* inboard;
(2) if outside the cargo area, be on the open deck;
(3) be clearly marked; and
(4) be so designed as to allow draining and purging.

2. Arrangements of the cargo piping and controls should be such as to preclude the discharge overboard of wastes intended to be incinerated during normal cargo-handling operations.

3. Oil fuel and cargo piping systems may be connected in front of the burners, provided that three-way cocks are installed and the oil fuel pipes are fitted with two screw-down nonreturn valves inside the incinerator space.

4. Remote shutdown devices to cut off the supply of waste and fuel for incineration should be fitted at the control station and on the navigating bridge. Shutoff valves should be located in the cargo area. Where shutoff valves are remotely controlled, provision for local manual operation should be made, or a separate manually operated valve should be fitted.

5. Flanges of the loading manifold connections should be provided with shields, which may be portable, to guard against the danger of the cargo being sprayed. Drip trays should also be provided.

1906. Materials of construction (IBC Code 19.6)

1. 602. - special requirements for materials - is replaced by the following:

(1) Aluminium, copper, copper alloys, zinc, galvanized steel or mercury should not be used for cargo tanks, pipelines, valves, fittings and other equipment which may come into contact with the liquid wastes or their vapour.
(2) Materials of construction having a melting point below 925°C, e.g. aluminium and its alloys, should not be used for external piping involved in cargo handling operations on ships intended for the carriage of wastes with a flashpoint not exceeding 60°C (closed cup test). Short lengths of external pipes connected to cargo tanks may be permitted by the Society if they are provided with fire-resistant insulation.
(3) In determining the scantlings of the cargo system, the corrosivity of the waste should be taken into account.

1907. Tank vent systems (IBC Code 19.7)

1. The provisions for controlled venting systems - **Sec 8** and **1512.** - apply, except **802. 1** and **1512. 3.**

1908. Cargo tank environmental control (IBC Code 19.8)

1. When the recirculating drop line does not terminate near the bottom of the cargo tank, the tank should be inerted whenever wastes having a flashpoint not exceeding 60°C (closed cup test) are being recirculated to it.

2. When washing machines using liquids having a flashpoint not exceeding 60°C (closed cup test) are employed, the cargo tank should be inerted.

3. The oxygen content of the atmosphere in an inerted tank should not exceed 8% by volume in any part of the tank.

4. An audible and visual alarm should be provided to indicate when the pressure in the vapour space of an inerted cargo tanks is less than 0.07 bar gauge.

1909. Electrical installation (IBC Code 19.9)

1. In incinerator spaces, incinerator blower spaces, and adjacent spaces having direct access thereto, the lighting systems, telephone and public address systems and general alarm systems should be of the certified safe type.

2. All other electrical installations which are fitted in the spaces referred to in **Par 1** should be of the certified safe type unless the following conditions are complied with:

(1) It is assured that the spaces are adequate-

ly ventilated prior to activating installations not of a certified safe type. Interlocks should be provided between fans and the switch gear of such installations to ensure compliance with this requirement.

(2) Installations not of a certified safe type should be automatically switched off in case of loss of the pressure required by **1911. 2** (1) and **1911. 3** (1). A reasonable time delay may be permitted by the Society before these installations are switched off.

(3) Installations not of a certified safe type should comply as a minimum with IP 55 or equivalent protection.

1910. Fire protection and fire-extinguishing (IBC Code 19.10)

1. The incinerator space should be provided with a fixed foam fire-extinguishing system complying with regulation II-2/8 or II-2/9 of the 1983 SOLAS amendments. This system may be connected to the deck foam fire-extinguishing system.

1911. Mechanical ventilation in the cargo area and in the incinerator location (IBC Code 19.11)

1. For cargo pump rooms the provisions of 1517. - increased ventilation requirements - apply.

2. The ventilation system of the incinerator space should be permanent, normally of the positive pressure type and independent of all other air supply systems.

(1) The air pressure should always be positive to the pressure within the furnace (see also **1909. 2** (2))

(2) A minimum capacity of 45 changes of air per hour should be provided, based upon the total volume of the incinerator space.

Consideration should be given to venting requirements during maintenance of burners.

3. The ventilation system of the incinerator blower space should be permanent, normally of the positive pressure type and independent of other air supply systems.

(1) The air pressure should always be positive to the pressure within the furnace (see also **1909. 2** (2)).

(2) A minimum capacity of 20 changes of air per hour should be provided based upon the total volume of the incinerator blower space.

1912. Instrumentation and overflow control (IBC Code 19.12)

1. Closed gauging devices described in **1301. 1** (3) should be fitted and overflow control systems required in **1519.** should be provided.

2. Vapour detection instruments for toxic and flammable products described in **1302.** should be fitted.

1913. Personnel protection (IBC Code 19.13)

1. The safety equipment described in **1402.**, including respiratory and eye protection for every person on board described in **1402. 8,** should be provided.

SECTION 20
Transport of Liquid Chemical Wastes

2001. General (IBC Code 20.1)

1. Maritime transport of liquid chemical wastes could present a threat to human health and to the environment.

2. Liquid chemical wastes should, therefore, be transported in accordance with relevant international conventions and recommendations and, in particular, where it concerns maritime transport in bulk, with the requirements of this Chapter.

2002. Definitions (IBC Code 20.2)

For the purpose of this Section:

(1) **"Liquid chemical wastes"** are substances, solutions or mixtures, offered for shipment, containing or contaminated with one or more constituents which are subject to the requirements of this Chapter and for which no direct use is envisaged but which are carried for dumping, incineration or other methods of disposal other than at sea.

(2) **"Transboundary movement"** means maritime transport of wastes from an area under the national jurisdiction of one country to or through an area under the national jurisdiction of another country, or to or through an area not under the national jurisdiction of any country, provided at least two countries are concerned by the movement.

2003. Applicability (IBC Code 20.3)

1. The requirements of this Section are applicable to the transboundary movement of liquid chemical wastes in bulk by seagoing ships and should be considered in conjunction with all other requirements of this Chapter.

2. The requirements of this Section do not apply to:

(1) wastes derived from shipboard operations which are covered by the requirements of MARPOL 73/78;

(2) liquid chemical wastes carried by ships engaged in the incineration of such wastes at sea which are covered by **Sec 19**; and

(3) substances, solutions or mixtures containing or contaminated with radioactive materials which are subject to the applicable requirements for radioactive materials.

2004. Permitted shipments (IBC Code 20.4)

Transboundary movement of wastes is permitted to commence only when:

(1) notification has been sent by the competent authority of the country of origin, or by the generator or exporter through the channel of the competent authority of the country of origin, to the country of final destination; and
(2) the competent authority of the country of origin, having received the written consent of the country of final destination stating that the wastes will be safely incinerated or treated by other methods of disposal, has given authorization to the movement.

2005. Documentation (IBC Code 20.5)

In addition to the documentation specified in **1602.,** ships engaged in transboundary movement of liquid chemical wastes transported in bulk should carry on board a waste movement document issued by the competent authority of the country of origin.

2006. Classification of liquid chemical wastes (IBC Code 20.6)

For the purpose of the protection of the marine environment all liquid chemical wastes transported in bulk should be treated as Category A noxious liquid substances, irrespective of the actual evaluated category.

2007. Carriage and handling of liquid chemical wastes (IBC Code 20.7)

Liquid chemical wastes are to be carried in ships and cargo tanks in accordance with the minimum requirements for liquid chemical wastes specified in **Sec 17,** unless there are clear grounds indicating that the hazards of the wastes would warrant:

(1) carriage in accordance with the ship type 1 requirements; or
(2) any additional requirements of this Chapter applicable to the substance or, in case of a mixture, its constituent presenting the predominant hazard.

CHAPTER 7
FERRIES AND ROLL-ON/ROLL-OFF SHIPS

Section

SECTION 1
General

101. Application

1. This Chapter applies to seagoing roll-on/roll-off cargo ships specially designed and constructed for the carriage of vehicles, and cargo in pallet form or in containers, and loaded and unloaded by wheeled vehicles.

2. The hull structures and equipments of ships that are intended for restricted sevice and carriage of vehicles through the bow door, inner door, side door or ramp formed the hull structures (hereinafter fefered to as vehicle doors) is to in accordance with the discretion of the Society.

3. The scantlings and arrangements are to be as required by **Pt 3** except as otherwise specified in this Chapter.

102. Construction and arrangement

1. The requirements provide for a basic structural configuration of a multideck hull which includes a double bottom, and in some cases wing tanks up to the lowest deck. Special consideration is to be given to roll on-roll off cargo ships and ferries intended to be operated only in certain areas or conditions which have been agreed by the Society.

2. Where bulkheads are omitted in accordance with **Pt 3, Ch 9,** a system of partial bulkheads, web frames and deck transverses should be fitted to provide equivalent transverse strength.

3. Longitudinal framing is to be adopted at the strength deck and at the bottom, but special consideration will be given to proposals for transverse framing in these regions.

103. Submission of plans and documentations

In addition to plans and documentations required by **Pt 3, Ch 1, Sec 3,** the following details are to be submitted:

(1) The intended service areas required for ships designed to operate within specified geographical limits.
(2) Bow or stern ramps
(3) Bow, stern and side doors
(4) Movable decks, if fitted, including stowing arrangements for portable components.

SECTION 2
Longitudinal Strength

201. General

Longitudinal strength calculations are to be made in accordance with the requirements given in **Pt 3, Ch 3.**

SECTION 3
Deck Structure

301. Application

The arrangements and scantlings of vehicle decks for the carriage of cars, trucks, etc., are be in accordance with the discretion of the Society.

302. Securing arrangements

Details of the connections to the hull of vehicle securing arrangements are to be submitted for approval.

SECTION 4
Electrical Equipment of Automobile Carriers

401. General

The requirements in tnis Section apply to the electrical equipment installed in the cargo holds and the compartments adjacent thereto of automobile carriers.

402. Electrical equipment

1. Electrical equipment in cargo hold

(1) In principle, no electrical equipment is to be installed within a height 450mm above each vehicle deck. Where it is inevitable to fit electrical equipment in this zone, the equipment is to be of explosion protected type with explosion group **IIA** and temperature class **T3** as specified in **IEC** publication **60079.**

(2) All electrical equipment situated at more than 450mm above the vehicle decks, electrical equipment is to be of explosion protected type accepted by this Society or having enclosure of at least **IP55.** In this case, ventilation system is so designed and operated as to provide continuous ventilation of the cargo space at the rate of at least 10 air changes per hour when vehicles are on board.

(3) Electrical equipment and wiring, if installed in an exhaust ventilation duct, is to be of a type approved for use in explosive petrol and air mixtures and the outlet from any exhaust duct is to be sited in a safe position, having regard to other possible sources of ignition.

2. Electrical equipment in the compartment adjacent to cargo holds

For the electrical equipment in the compartments adjacent to the cargo holds and having an opening such as nongastight door, hatch, scuttle and the like in their bulkheads and decks, the requirements in **Par 1** are generally to be applied. ⚓

CHAPTER 8
OFFSHORE SUPPLY SHIPS

Section

SECTION 1
General

101. Application

1. The construction and equipment of ships intended to be registered and classed as "Offshore Supply Ship" are to be in accordance with the requirements in this Chapter, where "Offshore Supply Ship" means a ship designed and constructed for the carriage of specialized stores and cargoes to mobile offshore units and other offshore installations, and also to “Offshore Tug and Supply Ship” which in addition to the above perform the duties of a tug.

2. The scantlings and arrangements are to be as required by **Pt 3,** except as otherwise specified in this Chapter.

3. Attention is drawn to the need for masters to be able to assess the stability of their ships quickly and accurately in all service conditions.

102. Submission of plans and documentations

In addition to plans and documentations required by **Pt 3, Ch 1, Sec 3,** the followings are to be submitted.

(1) Separate or independent cargo tanks
(2) Cargo tank foundations and securing arrangements
(3) Towing arrangements, including supports and foundations of towing winches
(4) Supports and foundations for anchor handling and laying arrangements for anchors carried as cargo.
(5) Arrangements for the stowage of deck cargoes (cargo containment) and details of any associated racks or other similar structures and their supports and foundations.
(6) Movable decks including the stowing arrangements for portable components
(7) Freeing arrangements

SECTION 2
Longitudinal Strength

201. General

Longitudinal strength calculations for an offshore supply ship or an offshore tug/supply ship are to comply with the relevant requirements of **Pt 3, Ch 3.**

SECTION 3
Shell Plating

301. Shell plating

1. The thickness of side shell is to be that required by **Pt 3, Ch 4,** but is in no case to be less than 9 mm.

2. Efficient fenders are to be fitted, with adequate support behind them, in exposed areas.

3. Shell in way of stern rollers immediately adjacent to high duty bollards and in other high load areas is to be suitably reinforced.

SECTION 4
Deck Plating

401. Weather decks

1. Where cargo is to be carried on weather decks, the scantlings are to be suitable for the specified loadings, but in no case is a head less than 3.5 m to be used. Additional local increases in scantlings may be required where specialized cargoes

Table 7.8.1 Thickness of Plating and Section Modulus of Bulkhead Stiffeners etc.

Position	Thickness of plating t (mm)	Modulus of stiffeners Z (cm^3)	Depth of stiffeners d (mm)
Fronts	The greater of $t = 0.012S$ or 8.0	$Z = 0.034\ Sl^2$	$d \geq 100$
Sides	The greater of $t = 0.01S$ or 6.5	$Z = 0.027\ Sl^2$	$d \geq 75$
Aft ends	The greater of $t = 0.008S$ or 6.5	$Z = 0.021\ Sl^2$	$d \geq 65$

S = stiffener spacing (mm)
l = effective length of stiffeners (m)

NOTE :
The ends of stiffeners are to be connected on all tiers.

are likely to induce concentrated loads.

2. The thickness of deck plating is to be not less than that obtained from the following formula.

$$t = 0.025L + 6 \quad (mm)$$

402. Cargo containment

1. Means are to be provided to enable deck cargoes to be adequately secured and protected. In general, suitable inner bulwarks, rails, bins or storage racks of substantial construction are to be provided and properly secured to adequately strengthened parts of the hull structure .
2. Properly designed locking equipment or efficient means of lashing containers are to be fitted where appropriate.
3. Small hatches (including escape hatches), valve controls, ventilators, air pipes, etc., are to be situated clear of the cargo containment areas.

SECTION 5 Framing

501. Transverse framing

The section moduli of the main and tween deck frames are to be 25 *percent* greater than those required by **Pt 3, Ch 8, Sec 4.** Frames are not to be scalloped.

SECTION 6 Superstructures and Deckhouses

601. Scantlings

The scantlings of deckhouses situated on the forecastle deck and above are to comply with the requirements of **Table 7.8.1.**

SECTION 7 Watertight Bulkhead Doors

701. Watertight doors

Watertight doors are to be efficiently constructed anc fitted in accordance with **Pt 3, Ch 14, Sec 4.**

SECTION 8 Engine Exhaust Outlets

801. Location

Engine exhaust outlets are to be located as high as is practicable above the deck and are to be fitted with spark arresters. ⚓

CHAPTER 9
TUGS

Section

SECTION 1
General

101. Application

1. The construction and equipment of ships intended to be registered as “Tug” are to be in accordance with the requirements in this Chapter. The construction and equipment of ships intended to be registered as “Offshore Tug/Supply Ships” are to be in accordance with the requirements of **Ch 8.**

2. The scantlings and arrangements are to be as required by **Pt 3** except as otherwise specified. The draught d used for the determination of scantlings is to be not less than $0.85D$.

SECTION 2
Longitudinal Strength

201. General

Longitudinal strength calculations are to be made in accordance with the requirements given in **Pt 3, Ch 3.**

SECTION 3
Single Bottoms

301. Floors

Single bottom floors are to be in accordance with the requirements of **Pt 3, Ch 6.**

SECTION 4
Panting and Strengthening of Bottom Forward

401. Panting region reinforcement

The arrangements to resist panting required by **Pt 3, Ch 9**, do not apply to tugs less than $46\,m$ in length. In tugs $46\,m$ or more in length, addition stiffening is also to be fitted in the tween decks throughout the panting region.

402. Strengthening of bottom forward

The requirements for strengthening of bottom forward detailed in **Pt 3, Ch 7, Sec 8,** do not apply to tugs.

SECTION 5
Machinery Casings

501. Escape Hatches

Any emergency exit from the machinery room to the deck is to be capable of being used at extreme angles of heel, and should be positioned as high as possible above the waterline and on or near the ship’s centerline. Covers to escape hatches are to have hinges arranged athwartships. Coaming heights are to be at least $600\,mm$ above the upper surface of the deck.

502. Exposed casings

Exposed machinery casings are to be not less in height than $900\,mm$ above the upper surface of the deck. Stiffeners to exposed casings are to be connected to the deck or carried through.

SECTION 6
Towing Arrangements

601. Towing hooks

1. Towing hooks or equivalent should normally be 5 to 10 *percent* of the ship’s length abaft amidships, but in no circumstances should they be sited forward of the longitudinal center of gravity of the tug in any anticipated condition of loading. In addition, the towing hook should be located as low as practicable in order to minimize heeling moments arising in normal working conditions.

2. TTowing hooks are to have reliable release slip arrangement which facilitate towline release regardless of the angle of heel. It is recommended that release units should also be operable from the bridge. The arrangements should be tested to the surveyor's satisfaction. The breaking strength of the hook or its equivalent should generally be 50 percent in excess of that of the towline.

SECTION 7
Fenders

701. Ship's side fenders

An efficient fender is to be fitted to the ship's side at deck level extending all fore and aft. ⚓

CHAPTER 10
DOUBLE HULL TANKERS

Section

SECTION 1
General

101. Application

1. The constructions and equipments of ships of 90 m and above in length which are framed for tankers with machinery aft having one or more longitudinal bulkheads and single decks with double bottom or with double hull structures, intended to be registered and classed as “tanker” and intended to carry crude oil, petroleum products having a vapour pressure (absolute pressure) less than 0.28 MPa at 37.8 °C or other similar liquid cargoes in bulk are to be in accordance with the requirements in this Chapter.

2. In tankers intended to carry liquid cargoes other than crude oil and petroleum products, having the vapour pressure (absolute pressure) less than 0.28 MPa at 37.8 °C and having no hazard as poisonous, corrosive, etc. and moreover less inflammablity than that of crude oil and petroleum products, the structural arrangements and scantlings are to be to the satisfaction of the Society, having regared to the properties of the cargoes to be carried.

3. In case where the construction differs from that specified in **Par 1** and the requirements in this Chapter are considered to be not applicable, matters are to be determined as deemed appropriate by the Society.

4. As regards matters not specifically provided for in this Chapter, the general requirements for the construction and equipment of steel ships given in the relevant **Pts** are to be applied.

5. In addition to the requirements specified in **Par 4,** the relevant requirements in **Ch 1, Secs l0** to **12** and **Pt 8, Ch 1, Sec 4** are to be applied to ships specified in **Par 1**.

102. Location and Separation of Spaces

1. In cargo oil spaces, the standard arrangement of bulkheads is to be such that the interval between longitudinal bulkheads or transverse bulkheads does not exceed $1.2\sqrt{L}$ (m).

2. Cofferdams are to be provided in accordance with the following (1) to (3) :

(1) Cofferdams of air-tight construction and not to be less than 600 mm in width access are to be provided at fore and aft terminations of cargo oil spaces and the space between cargo space and accommodation space. Where, however, for oil tankers intended to carry cargo oil having a flash point above 60°C this requirements may be suitablly modified.

(2) Cofferdams specified in (1) may be used as pump rooms.

(3) Fuel oil or ballast water tanks may be concurrently used as the cofferdams to be provided between cargo oil tanks and fuel oil or ballast tanks, subject to the approval by the Society.

3. Passageways leading to cargo areas are to be provided in accordance with the following (1) to (4):

(1) Access to cofferdams, ballast tanks, cargo oil tanks and any other spaces in the cargo area are to be direct from the open deck and such as to ensure their complete inspection. Access to double bottom spaces may be through a cargo pump room, pump room, deep cofferdam, pipe tunnel or similar compartments, subject to consideration of ventilation aspects.

(2) For access through horizontal openings, hatches or manholes, the dimensions are to be suf-

ficient to allow a person wearing a selfcontained air breathing apparatus and protective equipment to ascend or descend any ladder without obstruction and also to provide a clear opening to facilitate the hoisting of an injured person from the bottom of the spaces. The minimum clear opening is not to be less than 600 *mm* x 600 *mm*.

(3) For Access through vertical openings, or manholes providing passage through the length and breadth of the space, the minimum clear opening should be not less than 600 *mm* x 800 *mm* at a height of not more than 600 *mm* from the bottom shell plating unless grating or other footholds are provided.

(4) For tankers with a deadweight tonnage of less than 5000 *tons*, smaller dimension of minimum clear opening specified in (2) and (3) may be approved by the Society in special circumstances, if the ability to traverse such openings or to remove an injured person can be proved to the satisfation of the Society.

4. Air-tight bulkheads

All areas, where cargo oil pumps and cargo oil piping are provided, are to be segregated by an air-tight bulkhead from areas where stoves, boilers, propelling machinery, electric installations other than those of explosion-proof type in accordance with the requirements in **Pt 6, Ch 1, Sec 9** where source of ignition is normally present. Where, however, for oil tankers carrying cargo oil having a flash point above 60°C, the requirements may be suitably modified.

5. Ventilations

Ventilation inlets and outlets are to be arranged so as to minimize the possibilities of vapours of cargoes being admitted to an enclosed space containing a source of ignition, or collecting in the vicinity of deck machinery and equipment which may constitute an ignition hazard. Especially, opening of ventilation for machinery spaces are to be situated as far afterwards apart from the cargo spaces as practicable.

6. Ullage openings, sighting ports and tank cleaning opening are not to be arranged in enclosed spaces.

7. Openings in superstructure and deckhouse

The arrangement of openings on the boundaries of superstructures and deckhouse are to be such as to minimize the possibility of accumulation of vapours of cargoes. Due considerartion in this regard is to be given for the openings in superstructures and deckhouse when the ship is equipped with cargo piping to load or unload at the stern. The scuttles to the poop front or other similar walls are to be of fixed type.

8. Pipe duct in double bottom

Pipe ducts in the double bottom shall comply with the following requirements :

(1) They should not communicate with the engine room.

(2) Provision shall be made for at least two exits to the open deck arranged at a maximum distance from each other. One of these exits fitted with a watertight closure may lead to the cargo pump room.

(3) In the duct, provision shall be made for adequate mechanical ventilation.

(4) For ships to which the convention applies, refer to **SOLAS 1974**(as amended) **Regulation II-2/56.9.**

103. Minimum thickness

1. The thickness of structural members in cargo oil tanks and deep tanks such as bulkhead plating, floors, transverse girders including struts and their end brackets is not to be less than the value determined from **Table 7.10.1** according to the Length of Ship.

2. The thickness of structural members other than **Par 1** in cargo oil tanks and deep tanks is not to be less than 7 *mm*.

104. Direct strength calculation

Where approved by the Society, the scantlings of structural members may be determined basing upon direct calculation defined in **Pt 3, Ch 1, 206.** Notwithstanding the results of direct calculation, where, however, this is not to be applied to the minimum thickness specified in **103.** and the special requirements for corrosion specified in **605.** to **607.**

105. Symbols

The definition of symbols used in this Chapter otherwise specified, are to be in accordance with following:

L' = length of ship (m). Where, however, L exceeds 230 m, L' is to be taken as 230 m.

l = span of stiffeners, longitudinals, frames, transverses or girders (m).

S = spacing of stiffeners, longitudinals, frames,

Table 7.10.1 Minimum thickness

L (m)												
	and over		105	120	135	150	165	180	195	225	275	325	375
	and under	105	120	135	150	165	180	195	225	275	325	375	
Thickness(mm)		8.0	8.5	9.0	9.5	10.0	10.5	11.0	11.5	12.0	12.5	13.0	13.5

transverses or girders (m).

C_1 = coefficients determined according to values of L as specified below:

C_1 = 1.0 where L is 230 m and under,
= 1.07 where L is 400 m and above.

For intermediate values of L, C_1 are to be obtained by linear interpolation.

C'_1 = coefficients determined according to values of L as specified below:

C'_1 = 1.0 where L is 230 m and under,
= 1.2 where L is 400 m and above.

For intermediate values of L, C'_1 are to be obtained by linear interpolation .

f_D and f_B = section modulus ratios are as following formulae, f_B, however, is not to be less than 0.85 or 0.0015L + 0.5, whichever is the lesser.

$$f_D = \frac{Z_{DM\,req}}{Z_{D\,act}} \qquad f_B = \frac{Z_{BM\,req}}{Z_{B\,act}}$$

Z_{DMreq} and Z_{BMreq} = section modulus at the deck and bottom of transverse sections of the hull determined to the requirements in **Ch 3, 201.** respectively, when mild steel material symbol RA, RB, RD and RE specified in **Pt 2, Ch 1, 301. Par 1** is used (cm^3).

Z_{Dact} and Z_{Bact} = actual section modulus at the deck and bottom of transverse sections of the hull respectively. (cm^3)

α = either α_1 or α_2 according to value of y. However, value of α is not to be less than α_3.

$$\alpha_1 = 15.0\, f_D \left(\frac{y - y_B}{Y©} \right) \quad \text{for} \quad y \geq y_B$$

$$\alpha_2 = 15.0\, f_B \left(\frac{y_B - y}{y_B} \right) \quad \text{for} \quad y < y_B$$

$$\alpha_3 = \beta \left(\frac{B - 2\,b}{B} \right)$$

y = distance from the top of keel to the lower edge of plating when the platings under consideration are under y_B, to the upper edge of plating when the platings under consideration are above y_B and to the longitudinals stiffener under consideration for longitudinal stiffener, respectively (m).

y_B = distance from the top of keel to the horizontal neutral axis of transverse section amidship (m).

Y' = the greater of the value specified in **Pt 3, Ch 3, 203.,** (5), (a) or (b).

β = coefficient determined according to the values of L as specified below: For intermediate values of L, the value of β is to be determined by linear interpolation:

β = 6.0 when L is 230 m and under,
β = 10.5 when L is 400 m and above.

a = $\sqrt{K}$ when high tensile steels are used for not less than 80% of side shell platings at the transverse section amidship and 1.0 for other parts.

b = horizontal distance from the side shell plating to the longitudinal bulkhead plating under consideration (m).

SECTION 2
Bulkhead Plating

201. Bulkhead plating in cargo oil tanks and deep tanks

1. The thickness of bulkhead plating is not to be less than the greatest of the values obtained from the following formula when h is substituted with h_1, h_2 and h_3.

$$t = C_1 C_2 S \sqrt{h} + 2.5 \quad (mm)$$

where:

h = water head of h_1, h_2 or h_3 is obtained from **Table 7.10.2.**

C_2 = coefficients is obtained from **Table 7.10.3.**

C_1 and S = as specified in **105.**

2. In determining the thickness of longitudinal bulkhead plating, coefficient C_2 for h_1 may be gradually reduced for the parts forward and aftward the midship part, and it may be taken as $3.6\sqrt{K}$ in calculations at 0.1 L from fore end and aft end.

202. Swash bulkhead

1. Stiffeners and girders of swash bulkhead are to be of sufficient strength considering the size of tanks and opening ratios.

2. The thickness of swash bulkhead plating is not to be less than that obtained from the following formula:

$$t = 0.3\, S \sqrt{K(L + 150)} + 2.5 \quad (mm)$$

where:

S = as specified in **105.**

3. In determining the thickness of swash bulkhead plating, sufficient consideration is to be given for buckling.

203. Trunks

The thickness of trunk top and side plating are to be determined applying the requirements in **201.** in addition to the requirements in **Pt 3, Ch 5.**

Table 7.10.2 Water head h_1, h_2, and h_3

<table>
<tr><td></td><td>Cargo oil tanks</td><td>Deep tanks</td></tr>
<tr><td>h_1</td><td>Vertical distance from the lower edge of the bulkhead plating under consideration to the top of hatchway. For side shell plating, a water head corresponding to the minimum draught amidship d_{min} (m) under all operating conditions of the ship may be deducted therefrom. The deductible water head at the top of keel is to be d_{min}, value at point d_{min} above the top of keel, 0, and value at an intermediate point is to be obtained by linear interpolation.</td><td>Vertical distance from the lower edge of the bulkhead plating under consideration to the mid-point between the point on tank top and the upper end of the overflow pipe. For side shell plating, a water head corresponding to the minimum draught amidship d_{min} (m) under all operating conditions of the ship may be deducted therefrom. The deductible water head at the top of keel is to be d_{min}, value at point d_{min} above the top of keel, 0, and value at an intermediate point is to be obtained by linear interpolation</td></tr>
<tr><td>h_2</td><td colspan="2">As obtained from the following formula :
$$h_2 = 0.85\left(h_1 + \Delta h\right)$$
where:
Δh = additional water head given by the following formula; For L-type, U-type etc. of tanks, Δh is to be determined as deemed appropriate by the Society.
$$\Delta h = \frac{16}{L}\left(l_t - 10\right) + 0.25\left(b_t - 10\right)$$
lt = tank length (m), 10, when less than 10 m.
bt = tank breadth (m), 10, when less than 10 m</td></tr>
<tr><td>h_3</td><td>$h_3 = 0.3\sqrt{L} \quad (m)$</td><td>Value (m) obtained by multiplying 0.7 by vertical distance from the lower edge of the bulkhead plating under consideration to the point 2.0 m above the top of overflow pipe.</td></tr>
</table>

Table 7.10.3 Coefficient C_2

<table>
<tr><td rowspan="3">For h_1</td><td>longitudinal bulkhead of longitudinal framing</td><td>longitudinal bulkhead of transverse framing</td></tr>
<tr><td>$C_2 = 13.4\sqrt{\dfrac{K}{27.7 - \alpha K}}$</td><td>$C_2 = 100\sqrt{\dfrac{K}{767 - \alpha^2 K^2}}$</td></tr>
<tr><td colspan="2">minimum: $3.6\sqrt{K}$</td></tr>
<tr><td>For h_2 or h_3 and for transverse bulkhead</td><td colspan="2">$C_2 = 3.6\sqrt{K}$</td></tr>
</table>

Table 7.10.4 Section modulus of bottom and side longitudinal

<table>
<tr><td>longitudinals</td><td>section modulus (cm^3)</td></tr>
<tr><td>Bottom longitudinals</td><td rowspan="2">$Z = 100\, C_1 C_2 S h l^2$</td></tr>
<tr><td>Side longitudinals including bilge longitudinals</td></tr>
<tr><td colspan="2">h = distance from the longitudinals under consideration to the h' (m).
C_2 and h' = as given in following table

<table>
<tr><td></td><td>h'</td><td>C_2</td></tr>
<tr><td>Bottom longitudinals</td><td>$h' = d + 0.026\, L'$</td><td>$C_2 = \dfrac{K}{24 - 15.0\, f_B K}$</td></tr>
<tr><td>Side longitudinals including bilge longitudinals</td><td>$h' = d + 0.038\, L'$</td><td>$C_2 = \dfrac{K}{24 - \alpha K}$</td></tr>
</table>

C_1, S, l, L', α and f_B = as specified in **105.**</td></tr>
</table>

SECTION 3
Longitudinals and Stiffeners

301. Longitudinals

1. The section modulus of bottom longitudinals is not to be less than the value obtained from the formula in **Table 7.10.4.**

2. The section modulus of side longitudinals including bilge longitudinals is not to be less than the value obtained from the formula in **Table 7.10.4.** The section modulus, however, need not exceed that of bottom longitudinals specified in **Table 7.10.4,** but is not to be less than that obtained from the following formula:

$$Z = 2.9K\sqrt{L}Sl^2 \quad (cm^3)$$

where:

S and l = as specified in **105.**

3. For the parts forward and aftward of midship part, the scantlings of longitudinals may be gradually reduced and at 0.1L from fore end and aft end they may be reduced by 15% of the value obtained from the requirements in **Pars 1** and **2.** In no case, however, are the scantlings of longitudinals to be less than those required in **Pars 1** and **2** for the part between a point 0.15L from the fore end and the collision bulkhead.

4. For side longitudinals, sufficient consideration is to be given for fatigue strength.

5. In addition to the requirements in **Pars 1** to **4,** the beams or longitudinals on deck or side shell consisiting of deep tanks should comply with the requirements in **302.**

302. Bulkhead stiffeners in cargo oil tanks and deep tanks

1. Section modulus of stiffeners is not to be less than that obtained from the following formula:

Table 7.10.5 Coefficient C_2

Bulkhead and framing systems	C_2
Longitudinal bulkhead of longitudinal framing system	$C_2 = \dfrac{K}{24 - \alpha K}$ minimum $C_2 = \dfrac{K}{18}$
Longitudinal bulkhead of transverse framing system, transverse bulkhead	$C_2 = \dfrac{K}{18}$
α = as specified in **105.**	

$$Z = 125\,C_1C_2C_3Shl^2 \quad (cm^3)$$

Where:

h = water head h_1, h_2 or h_3 as specified in **Table 7.10.2**. Where, however, "the lower edge of the bulkhead plating under consideration" is to be construed as "the midpoint of the stiffener under consideration" for vertical stiffeners and as "the stiffener under consideration" for horizontal stiffeners. And "side shell plating" is to be construed as "stiffener attached to side shell plating".

C_2 = value obtained from following formula. The value C_2 for h_1, however, is to be as obtained from the formula in **Table 7.10.5.**

$C_2 = K/18$

C_3 = as determined from **Table 7.10.6** according to the fixity condition of stiffener ends;

C_1, S and l = as specified in **105.**

4. For the parts forward and aftward of midship part in determining the section modulus of stiffeners attached to longitudinal bulkhead of longitudinal framing systems, coefficient C_2 for h_1 may be gradually reduced, and at the end parts C_2 may be as $K/18$.

303. Buckling strength

1. Buckling strength of longitudinal frames, beams

Table 7.10.6 Coefficient C_3

One end of stiffener / The other end of stiffener	Connection be hard bracket	Connection be soft bracket	Supported by Rule girder or lug connetion	Snip
Connection be hard bracket	0.70	1.15	0.85	1.30
Connection be soft bracket	1.15	0.85	1.30	1.15
Supported by Rule girder or lug connetion	0.85	1.30	1.00	1.50
Snip	1.30	1.15	1.50	1.50

1. Connection by hard bracket is a connection by bracket to the double bottoms or to the adjacent members, such as longitudinals or stiffeners in line, of the same or larger sections, or a connection by bracket to the equivalent memebers mentioned above. (See **Fig 3.14.2** (a))
2. Connection by soft brackets is a connection by bracket to the transverse members such as beams or equivalent thereto. (See **Fig 3.14.2** (b))

and stiffeners is to be in accordance with the requirements (1) to (3) below. In case where the Society specially considers necessary according to the materials, scantling, geometries and the point of arrangement of these structural members, detailed assessment may be required.

(1) Longitudinals beams, side longitudinals attached to sheer strakes and longitudinal stiffeners attached to the longitudinal bulkhead within 0.1 D from the strength deck are to have a slenderness ratio not exceeding 60 at the mid-ship part as far as practicable.
(2) As for flat bars used for longitudinal beams, frames and stiffeners, the ratio of depth to thickness is not to exceed 15.
(3) The full width of face plate of longitudinal beams, frames and stiffeners is not to be less than that obtained from the following formula:

$$b = 2.2\sqrt{d_0 l} \quad (mm)$$

where:
d_0 = depth of web of longitudinal beam, frame or stiffener (m).
l = as specified in **105.**

2. In case where assembled memebers, special shape steels or flanged plates are used for frames, beams or stiffeners in cargo oil tanks and deep tanks whose scantlings are specified only in terms of section modulus, the thickness of web is intended to be greater than the reqiured level due to reasons other than strength, it may be suitably modified.

$$t = 0.015\, k_0 d_0 + 2.5 \quad (mm)$$

where:
d_0 = depth of web (m).
k_0 = coefficient according to the location of stiffeners as given **Table 7.10.7.**

Table 7.10.7 Coefficient k_0

Locations	k_0
Bottom longitudinals located not more than 0.25 D above top of keel	$k_0 = \sqrt{0.25\left(3 f_B + \frac{1}{K}\right)}$
Deck longitudinals located not less than 0.25 D below deck	$k_0 = \sqrt{0.25\left(3 f_D + \frac{1}{K}\right)}$
Other structural members	$k_0 = \sqrt{0.25\left(3 + \frac{1}{K}\right)}$

SECTION 4 Girders

401. General

1. The double bottom and double side hull structures and arrangements and scantlings of girders in cargo oil spaces are to be determined based upon direct strength calculations.

2. Notwithstanding the requirement in **Par 1,** when approved by the Society, the scantlings of these girdsers may be determined in accordance with the requirements in **403.** to **407.** provided that the arrangements of girders in the double bottom, double side hull and cargo oil tank at cargo oil spaces are determined referring to the structural types shown in following (1) to (5) as the standard:

(1) The height of double bottom at cargo oil spaces is not to be less than $B/20$ (m).
(2) The width of double side hull is not to be less than $D/9$ (m).
(3) In double bottoms at cargo oil spaces, girders are to be provided at a spacing not exceeding $0.9\sqrt{l_t}$ (m) and floors are to be provided at a spacing not exceeding $0.55\sqrt{B}$ (m) or $0.75\sqrt{D}$ (m) , whichever is smaller. l_T is the length of a cargo hold (m).
(4) In double side hull, stringer are to be provided at a spacing not exceeding $1.1\sqrt{l_t}$ (m) .
(5) Transverse in double side hull and girders in cargo oil tanks and deep tanks are to be provided at positions on floors in double bottoms.

402. Direct strength calculation of girders

The structural models, loads, allowable stress levels, etc. for determining the arrangement of girders and scantling based upon direct strength calculation are to as deemed appropriate by the Society.

403. Scantlings of girders and floors in double bottom

The scantling of girders and floors in double bottom are to be as deemed appropriate by the Society.

404. Scantlings of stringers and transverse in double side hull

The scantling of stringers and transverse in double side hull are to be as deemed appropriate by the Society.

405. Girders and transverse in cargo oil tanks and deep tanks

1. The section modulus of girders is not to be less than that obtained from the following formula:

$Z = 7.13\, C_1' k^2 KShl^2 \quad (cm^3)$

Where:

h = waterhead h_1, h_2 or h_3 as specified in **Table 7.10.2.** whichever is the greatest. Where, however, "from the lower edge of the bulkhead plating under consideration" is to be construed as "from the mid-point of S" for horizontal girders, and as "from the mid-point of l" for vertivcal girders in applying the value of h.

k = correction factor for brackets, and to as obtained from the following formula:

$$k = 1 - \frac{0.65\left(b_1 + b_2\right)}{l}$$

b_1 and b_2 = arm length of brackets at respective ends to be girders and transverses (m).

C_1, S and l = as specified in **105.**

2. The moment of inertia of girders is not to be less than that obtained from the following formula. However, in no case is the depth of girders to be less than 2.5 times the depth of slots.

$$I = 30\, hl^4 \quad (cm^4)$$

Where:

h and l = as specified in **Par 1.**

3. The thickness of girders is not to be less than the greatest of the follwing t_1, t_2 or t_3 :

$$t_1 = 41.7 \frac{C_1' C_2 KShl}{d_1} + 2.5 \quad (mm)$$

$$t_2 = 0.174 \sqrt[3]{\frac{C_1' C_2 ShlS_1^2}{d_1}} + 2.5 \quad (mm)$$

$$t_3 = 0.01\, S_1 + 2.5 \quad (mm)$$

Where:

h = as specified in **Par 1.**

S_1 = spacing of stiffeners of girders or the depth of girders, whichever is the smaller (mm).

d_1 = depth of the girder under consideration (mm) subtracting the depth of openings.

C_2 = coefficient as obtained from the following formula. In no case is it to be less than 0.5:

Vertical girder:

$$C_2 = \left| 1 - \frac{2x}{l} \right|$$

Horizontal girder:

$$C_2 = \left| 1 + \frac{0.2\, l}{h} - \left(2 + \frac{l}{h}\right) \cdot \frac{x}{l} + \frac{l}{h}\left(\frac{x}{l}\right)^2 \right|$$

Where:

x = distance from the end of l to the sectional area under consideration(m), and from the lower end for vertical girders.

C'_1, S and l = as specified in **105.**

4. Where, the stiffeners are provided within the effective width, they may be included in the effective steel plates for calculating actual moment of inertia of girders and section modulus.

5. The thickness of webs at the root of struts for girders and transverse in case where struts are provided, is not to be less than that obtained from following formula. Where slots are provided in b_s at the root of struts, they are to be covered effectively with collar plates.

$$t = 16\, S_1 \sqrt{\frac{C_1' Sb_s h_s}{A}} \quad (mm)$$

Where:

b_s = width supported by struts (m).

h_s = distance from mid-point of b to the point of $d + 0.038\, L'$ above top of keel (m).

S_1 = spacing of stiffeners provided depthwise on the web plates of transverses at the portion where cross ties are connected (m).

C'_1 and S = as specified in **105.**

A = as specfied in **Pt 7, Ch 1, 403.** (1).

6. The thickness of face plates forming a girder is to be greater than the thickness of web, and the total width is not to be less than that obtained from the following formula:

$$b = 2.7 \sqrt{d_0 l'} \quad (mm)$$

where:

d_0 = depth of girder (mm)

l' = distance between supporting points of girders (m). Where, however, if effective tripping brackets are provided, they may be regarded as supporting points.

406. Girders of ships without double side hull

1. In addition to the requirements in **405.**, depth of side transverse d_0 and section modulus of transverse Z are not to be less than those obtained from the following formula:

$$d_0 = 150\, l \quad (mm)$$

$$Z = 8.7 k^2 KShl^2 \quad (cm^3)$$

Where:

h = distance from mid-point of l to the point $d + 0.038L'$ above top of keel (m)
k, l and S = as specitied in **405.1.**

2. The scantlings of deck transverses are to as given in (1) and (2) below:

(1) Section modulus of deck transverse of a ship without trunks is not to be less than that obtained from the following formula:

$$Z = 3k^2KS\sqrt{L}l^2 \quad (cm^3)$$

Where:
k, l and S = as specitied in **405.1.**

(2) For ships with trunks, the construction of providing continuous deck transverses across the trunk is to be considered as the standard. In this case, the depth of deck transverses that can be regarded as those supported by trunks may be $0.03B$.

3. For transverses provided on the centreline bulkhead, the section modulus Z and depth d_0 of deck transverses are to be less than those obtained from the following formula:

$$d_0 = 120l \quad (mm)$$
$$Z = 7.0k^2KShl^2 \quad (cm^3)$$

Where:
k, l, S and h = as specified in **Par 1.**

407. Stiffeners attached to girders in cargo oil tanks and deep tanks

The thickness of flat bar stiffeners and tripping brackets provided on girders and transverses is not to be less than that obtained from the following formula. However, it needs not exceed the thickness of webs of the girder to which they are provided.

$$t = 0.5\sqrt{L} + 2.5 \quad (mm)$$

408. Cross ties

1. Cross ties in ships having two or more rows of longitudinal bulkheads, where they are effectively connected with longitudinal bulkhead transverses in cargo oil tanks are to be in accordance with this requirements.

2. The sectional area of cross ties interconnecting longituduinal bulkhead transverses in cargo oil tanks is not to be less than that obtained from the following formula:

$$A = C_1'C_2KSb_sh \quad (cm^2)$$

Where:

b_s = as specified in **405. 5.**

h = h_s where cross ties are provided in wing cargo oil tanks, vertical distance from mid-point of b_s to top of hatchways of adjacent cargo oil tanks where struts are provided in centre cargo oil tanks (m).

C_2 = coefficient obtained from the following formula, in no case, however,is to be less than 1.1:

$$C_2 = \frac{0.77}{1 - 0.5\dfrac{l}{k}}$$

l = length of cross ties between the inner surface of longitudinal bulkhead transverses (m).

k = as given below:

$$k = \sqrt{\frac{I}{A}}$$

I = moment of inertia of cross ties (cm^4).
A = sectional area of cross ties (cm^2)
S and C_1' = as specified in **105.**

SECTION 5
Structural Details

501. General

1. The principal structural members are to be arranged so that continuity of strength can be secured throughout the cargo area. In forward and afterward parts of the cargo area, the structures are to be effectively strengthened so that continuity of strength is not impaired sharply.

2. For the principal structural members, sufficient consideration is to be given for fixity at ends, supporting and stiffening systems against out-of-plane deflections and the construction is to minimize local stress concentration .

502. Frames and stiffeners

Longitudinal beams, frames and stiffeners are to be of continuous structures, or to be connected securely so that their sectional area at ends can be properly maintained providing sufficient resistance against bending moments.

503. Girders and Cross ties

1. Girders provided within the same are to be arranged to avoid sharp changes in strength and rigidity, and brackets in suitable size are to be provided at the ends of girders, and bracket toes are to be sufficiently rounded.

2. In case where the depth of longitudinal girders is large, stiffeners are to be arranged in parallel with face plates.

3. Brackets are to be provided at the ends of cross ties to connect to transverses or girders.

4. Transverses and vertical webs are to be provided with tripping at the junctions with cross ties.

5. Where breadth of face plates forming cross ties exceeds 150 mm on one side of the web, stiffeners are to be provided at proper interval to support the face plates as well.

6. Tripping brackets are to be provided on the web plate transverses at the inner edge of end brackets and at the connecting part of cross ties, etc. and also at the proper interval in order to support transverses effectively. In case where the width of face plates of each girder exceeds 180 mm on one side, the tripping brackets shown above are to support face plates as well.

7. Webs for the upper and lower end brackets of side transverses and longitudinal bulkhead transverses and areas in the vicinity of their inner ends and those in the vicinity of the roots of cross ties are to be stiffened specially with closer spacing.

SECTION 6
Special Requirements for Corrosion

601. Thickness of shell plating

1. The thickness of shell plating forming casing cargo oil tanks planned to carry ballast water in ships without double side hull is not to be less than a thickness added with 0.5 mm to that obtained from the formula given in **Pt 3, Ch 4.**

2. The thickness of shell plating when applying the requirements of this Chapter may be reduced with 0.5 mm from the thickness obtained from the formula given in **201.**

602. Thickness of deck plating

1. The thickness of freeboard deck plating when applying the requirements of this Chapter may be reduced with 0.5 mm from the thickness obtained from the formula given in **201.**

2. The thickness of the freeboard deck plating in spaces carrying cargo oil when applying the requirements in **Pt 3, Ch 5,** is not to be less than a thickness added with 0.5 mm to that obtained from the formula given in **Pt 3, Ch 5.**

603. Thickness of tank top plating

The thickness of tank top plating in cargo oil tanks and deep tanks is not to be less than the thickness corresponding to that obtained from the formula given in **201.** added by 1.0 mm. Such an addition, however, is not required for the thickness of inner bottom plating.

604. Section moduli of longitudinal beams, frames and stiffeners

1. The section modulus of longitudinal beams provided on deck plating forming casing cargo oil tanks is not to be less than 1.1 times that calculated according to the reqiurements of **Pt 3, Ch 10.**

2. The section modulus of frames and stiffeners provided on shell plating and bulkheads forming cargo oil tanks planned to carry also ballast water, except the tank to carry ballast water only in heavy weather conditions, is not to be less than 1.1 times that calculated in accordance with the requirements **301.** and **302.**

605. Thickness of plate members in ballast tanks adjacent to cargo oil tanks

1. The thickness of bulkhead plating at the boundaries between ballast tanks and cargo oil tanks is not to be less than the thickness specified in **103.** added by 1.0 mm.

2. In case where the adjacent cargo oil tanks are equipped with heating systems, the thickness of bulkhead plating at the boundaries between ballast tanks and cargo oil tanks is not to be less than the thickness determined from **Par 1** added by 1.0 mm.

606. Thickness of deck plating in cargo oil tanks

The thickness of deck plating in cargo oil tanks is not to be less than the thickness specified in **103.** added by 1.0 mm.

607. Thickness of inner bottom plating in cargo oil tanks.

1. The thickness of inner bottom plating of cargo oil tanks is to be sufficient considering the effects of pitting corrosion.

2. The thickness of inner bottom plating in the vicinity of suction bell mouths in cargo oil tanks, and the thickness of suction well, when provide, are not to be less than the thickness obtained by the requirements in **201.** for the appropriate area of application added by 2.0 mm.

SECTION 7
Special Requirements for Forward Wing Tanks

701. Application

For tankers of not less than 200 m, in length, the structural members in wing tanks which become empty in full loaded condition for spaces from a point 0.15 L from the fore end to the collision bulkhead are to comply with the requirements in this Section as well as the requirements in each previous Articles concerned.

702. Side longitudinal

1. The section modulus of side longitudinals is not to be less than that obtained from the following formula:

$$Z = 9C_1KShl^2 \quad (cm^3)$$

Where:

h = distance (m) from the longitudinals under consideration to the point $0.7d + 0.05L$ above top of keel.
Where, however, in no case is h to be less than obtained from the following formuia (m);

$$h_{\min} = 0.2\sqrt{L} + 0.03L$$

C_1, S and l = as specified in **105.**

2. In case where side longitudinals are conneted to transverses by brackets, the section modulus may be determined by multiplying the value obtained from the following formula by the value obtained from the formula specified in **Par 1**:

$$(1 - C)^2$$

Where:

C = as obtained from the following formulae:
where brackets are provided at both ends

$$C = \frac{b_1 + b_2 - 0.3}{l}$$

where a bracket is provided at one end

$$C = \frac{b - 0.15}{l}$$

b_1, b_2 and b = length of bracket arms along longitudinals (m). Where, however, in case where the value of C is negative, $C = 0$ (See **Fig 7.10.1**)

703. Reinforcement of bottom forward

The reqiurements of bottom forward are to comply with the requirements in **Pt 3, Ch 4, 404.** and **Pt 3, Ch 7, Sec 8.**

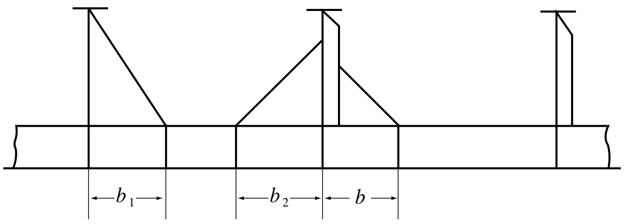


Fig 7.10.1 Measurement of b, b_1 and b_2

SECTION 8
Special Requirements for Tankers with Mid-deck

801. Application

1. The structural members of tankers having mid-deck penetrating longitudinally through the cargo areas are to comply with the requirements in **Sec 1** to **Sec 7.**

2. The scantling of structural members in cargo oil tanks below mid-deck are be as deemed appropriate by the Society.

SECTION 9
Special Requirements for Hatchways and Permanent Gangway

901. Ships having unusally large freeboard

Relaxation from the requirements specified hereunder will be considered to ships having an unusally large freeboard.

902. Hatchways to cargo oil tanks

1. The thickness of coaming plates is not to be less than 10 mm. Where the length and coaming height of a hatchway exceed 1.25 m and 760 mm respectively, vertical stiffeners are to be provided to the side or end coamings and the upper edge of coamings is to be suitably stiffened.

2. Hatchway covers are to be steel or other approved materials. The construction of steel hatchway covers is to comply with the following requirements. The construction of hatchway covers of materials other than steel is to be in accordance with the discretion of the Society.

(1) The thickness of cover plates is not to be less than 12 mm.

(2) Where the area of a hatchway exceeds 1 m^2 but dose not exceed 2.5 m^2, cover plates are to be stiffened by flat bars of 100 mm in depth spaced not more than 610 mm apart. Where, however, the cover plates are 15 mm or more in thickness, the stiffeners may be dispensed with.

(3) Where the area of a hatchway exceeds 2.5 m^2, cover plates are to be stiffened by flat bars of 125 mm in depth spaced not more than 610 mm apart.

(4) Covers are to be secured oiltight by fastenings spaced not more than 457 mm apart in circular hatchways or 380 mm apart and not more than 230 mm far from the corners in rectangular hatchways.

3. The cover is to be provided with an opening at least 150 mm in diameter which is to be so constructed as to be capable of being closed oiltight by means of a screw plug or a cover of peep hole.

4. Hatchway coamings are to be provided with gas cocks or other suitable exhausting devices.

903. Hatchway to spaces other than for cargo oil tanks

In exposed positions on the freeboard and forecastle decks or on the tops of expansion trunks, hatchways serving spaces other than cargo oil tanks are to be provided with steel watertight covers having scantlings complying with the requirements in **Pt 4, Ch 2, Sec 2.**

904. Permanent gangway and passageway

1. A fore and aft permanent gangway complying with the requirements of **Pt 4, Ch 5, 503.** is to be provided at the level of the superstructure deck between the midship bridge or deckhouse and poop or aft deckhouse, or equivalent means of access is to be provided to carry out the purpose of gangway, such as passage below deck. Elsewhere and in ships without midship bridge or deckhouse, arrangements to the satisfaction of Society are to be provided to safeguard the crew in reaching all parts used in the necessary work of the ship.

2. Safe and satisfactory access from the gangway level is to be available between crew accommodations and machinery space or between separated crew accommodations.

3. Where superstructures are connected by trunks, open rails are to be provided for the whole length of the exposed parts of the freeboard deck.

SECTION 10
Welding

1001. Application

The welding in tankers is to be accordance with the requirements given in **1002.** in addition to **Pt 3, Ch 1, Sec 5.**

1002. Fillet welding

1. The application of fillet welding to structural members within the cargo area is to as given in **Table 7.10.9.**

2. The leg length of fillet welds in areas given in (1) and (2) below is to be at least 0.7 times the plate thickness as specified in the requirements in this Chapter.

Table 7.10.9 Application of Fillet Welding

Column	Item		Application	kind of weld
1	Girders and Trans-verese	Web plates	Shell, deck, longitudinal bulkhead or inner bottom plating	F1
2			Web plates	F1
3			Face plates	F2
4		Slots in web plates	Web plates of longitudinal frames, beams and horizontal stiffeners on longitudinal bulkheads	F2
5		Tripping brackets and stiffeners provided on web plates	Web plates	F2
6			longitudinal frames, beams and horizontal stiffeners on longitudinal bulkheads	F1
7	longitudinal frames, beams and horizontal stiffeners on longitudinal bulkheads		Shell, deck or longitudinal bulkhead plating	F2
8	Cross ties		Members forming cross ties (web plates to face plates)	F2
9			Face plates of transverses or girders	F1

Note:
Where the radius at the toe of end brackets is small, it is recommended that F1 be used for appropriate length at the toe of bracket.

(1) Fillet welding at the connected parts between the outermost girders in the double bottom and floors.
(2) Fillet welding at the connected parts between the lowermost stringers in the double side hull and transverses. ⚓

PART G

HULL STRUCTURES

CHAPTER 1
GENERAL

Section

SECTION 1
Definitions

101. Application

The definitions of symbols and terms used in the Rules, except otherwise specified, are to be in accordance with this Section.

102. Length

The length of ship (L) is the distance in *metres* on the load line defined in **110.**, from the fore side of stem to the after side of rudder post in case of a ship with rudder post, or to the axis of rudder stock in case of a ship without rudder post or stern post. L is not to be less than 96 % and need not be greater than 97 % of the extreme length on the load line.

103. Length for freeboard

The length of ship for freeboard (L_f) is 96 % of the length in *metres* measured from the fore side of stem to the aft side of aft end shell plate on the waterline at 85 % of the least moulded depth measured from the top of keel, or the length in metres measured from the fore side of stem to the axis of rudder stock on that waterlines, whichever is the greater. However, where the stem contour is concave above the waterline at 85 % of the least moulded depth, the forward terminal of this length is to be taken at the vertical projection to this waterline of the aftermost point of the stem contour. The waterline on which this length is measured is taken to be parallel to the load line defined in **110.**

104. Breadth

The breadth of ship (B) is the horizontal distance in *metres* from the outside of frame to the outside of frame measured at the broadest part of the hull.

105. Breadth for freeboard

The breadth of ship for freeboard (B_f) is the maximum horizontal distance in *metres* from the outside of frame to the outside of frame measured at the middle of L_f.

106. Depth

The depth of ship (D) is the vertical distance in *metres* at the middle of L measured from the top of keel to the top of the freeboard deck beam at side, Where watertight bulkheads extend to a deck above the freeboard deck and are to be registered as effective to that deck, D is the vertical distance to that bulkhead deck.

107. Depth for strength computation

The depth of ship for strength computation (D_s) is the vertical distance in *metres* from the top of keel to the top of beam at side of the superstructure deck at the middle of L, for the part where the superstructure deck is strength deck, or the freeboard deck for other parts. Where the deck does not cover midship, the depth is to be measured at the imaginary deck line which is extended to the middle of L along the strength deck line.

108. Midship

The midship means the part covering 0.4 L amidships.

109. Fore and aft end part

The fore and aft end part means the part covering 0.1 L from the fore and aft end of the ship.

110. Load line

The load line is the waterline corresponding to the designed summer load draught in case of a ship which is required to be marked with load lines and the waterline corresponding to the designed maximum draught in case of a ship which is not required to be marked with load lines.

111. Load draught

The load draught (d) is the vertical distance in *metres* from the top of keel to the load line measured at the middle of L_f in case of a ship which is required to be marked with load lines and at the middle of L in case of a ship which is not required to be marked with load lines.

112. Full load displacement

The full load displacement (Δ) is the displacement(including shell plating and appendages, etc.) in *tons* at the summer load line.

113. Block coefficient

The block coefficient (C_b) is the coefficient obtained by dividing the moulded volume corresponding to Δ by $L \times B \times d$.

114. Freeboard deck

1. The freeboard deck is normally the uppermost continuous deck. However, in cases where openings without permanent closing means exist on the exposed part of the uppermost continuous deck or where openings without permanent watertight closing means exist on the side of the ship below that deck, the freeboard deck is the continuous deck below that deck.

2. In a ship having a discontinuous freeboard deck, the lowest line of the exposed deck and the continuation of that line parallel to the upper part of the deck is taken as the freeboard deck.

3. Where the designed load draught is less than the draught determined assuming the existing deck below the freeboard deck as the freeboard deck in accordance with the provision in **Pt 1, Ch 1, 1202.** the existing lower deck is taken as the freeboard deck in the application of the Rules. In this case, the lower deck is to be continuous at least between the machinery space and peak bulkheads and continuous athwartships. Where a lower deck in stepped, the lowest line of the deck and the continuation of that line parallel to the upper part of the deck is taken as the freeboard deck.

115. Bulkhead deck

The bulkhead deck is the highest deck to which the watertight transverse bulkheads except both peak bulkheads extend and are made effective.

116. Strength deck

The strength deck at a part of ship's length is the uppermost deck at that part to which the shell plates extend. However, in way of superstructures, except sunken superstructures, not exceeding $0.15L$ in length, the strength deck is the deck just below the superstructure deck. The deck just below the superstructure deck may be taken as the strength deck even in way of the superstructure exceeding $0.15L$ in length at the option of the designer.

117. Raised deck

The raised deck is the sunken superstructure deck below which no deck, is provided.

118. Superstructure

The superstructure is a decked structure on the freeboard deck, extending from side to side of the ship or having its side walls at the position not farther than $0.04B_f$ from the side of ship. Raised quarter deck is to be considered as a superstructure.

119. Enclosed superstructure

An enclosed superstructure is a superstructure complying with the following conditions:

(1) Enclosed by bulkheads of efficient construction.
(2) Access openings in these bulkheads are fitted with doors complying with the requirements of **Ch 16, 301.** or equivalent.
(3) All other openings in sides or ends of the superstructure are fitted with efficient weathertight means of closing.
(4) Access means, which are available at all times when bulkhead openings are closed, are provided for the crew to reach machinery and other working spaces within a bridge or poop.

120. Speed of ship

The speed of ship (V) is the designed speed in *knots* obtainable with clean bottom at calm sea and at the designed summer load line with the engine running at maximum continuous rating.

121. Light weight

The Light Weight (LW) is the displacement in *tons* excluding cargoes, fuel oil, lubricating oil, ballast and fresh water in tanks, stored goods, crew and their properties.

122. Deadweight tonnage

The dead Weight (DW) is the difference in *tons* between Full Load Displacement and Light Weight.

123. Fore end and aft end

The fore end is the start point of forward side, where measuring the length of ship L in **102.**, and after end is the end point of afterward side of L.

124. Section modulus ratio

The section modulus ratios (f_D and f_B) are as following formulae, However f_B is not to be less than 0.85 or $0.0015L + 0.5$, whichever is the lesser.

$$f_D = \frac{Z_{DMreq}}{Z_{Dact}}, \quad f_B = \frac{Z_{BMreq}}{Z_{Bact}}$$

where:

Z_{DMreq} and Z_{BMreq} = required section moduli at the deck and bottom of transverse sections of the hull determined according to the requirements in **Ch 3, 201.** respectively when mild steel material symbol RA, RB, RD and RE specified in **Pt 2, Ch 1, 301. Par 3** is used (cm^3).

Z_{Dact} and Z_{Bact} = actual section moduli at the deck and bottom of transverse sections of the hull respectively (cm^3).

SECTION 2
General

201. Application

1. The requirements in this Part unless otherwise specified elsewhere, are framed for hull structural arrangement and scantlings of ships not less than 90 *metres* in length, of normal form and proportion, and intended for unrestricted service.
2. Hull construction, equipment and scantlings of ships to be classed for restricted service may be appropriately modified according to the condition of service.
3. In the application of relevant provisions in this Rule to ships which are not required to be marked with load lines, L_f is to be read as L and B_f as B.

202. Exception in application

In ships of which length is specially long or in ships to which requirements in this Rule for some special reasons, are not directly applicable, hull construction, equipment, arrangement and scantlings are to be in accordance with the discretion of the Society, notwithstanding the provisions in **201.**

203. Ships of unusual form or proportion, or intended for carriage of special cargoes

In ships of unusual form or proportion, or intended for carriage of special cargoes, the requirements concerning hull construction, equipment, arrangement and scantlings will be decided individually basing upon the general principle of the Rules instead of the requirements in this Rules.

204. Passenger ships

Hull construction, equipment, arrangement and scantlings of passenger ships are to be specially considered with respect to the design features in addition to the requirements in **201.** to **203.**

205. Equivalency

Alternative hull construction, equipment, arrangement and scantlings will be accepted by the Society, provided that the Society is satisfied that such construction, equipment, arrangement and scantlings are equivalent to those required in this Rule.

206. Direct calculation

1. Where approved by the Society, scantlings of structural members may be determined basing upon direct calculation. Where the calculated scantlings based on direct calculation exceed the scantlings required in this Part, the former is to be adopted.
2. Where the direct calculation specified in the preceding **Par 1** is carried out, the data necessary for the calculation are to be submitted to the Society.

207. Stability of ship

The requirements in the Rules are framed for ships having appropriate stability in all conceivable conditions. The Society emphasizes that the special attention be paid to the stability by the builders in design and construction stage and by the masters while in service.

208. Carriage of oil

1. The requirements for construction and arrangement for carriage of fuel oils specified in **Pts 3, 4** and **7** are to be applied to the case intended to carry fuel oils having a flash point 60°C or above at a closed cup test.
2. The construction and arrangement for carriage of fuel oils having a flash point below 60°C at a closed cup test, are to be in accordance with the requirements provided in **Pts 3, 4** and **7** or the special requirements are to be applied.
3. The construction and arrangement of deep oil tanks intended to carry cargo oils are to be correspondingly in accordance with the requirements in **Pt 7, Ch 1.**

209. Structural testing, leak testing and hose testing

In the Classification Survey during construction, structural testing, leak testing and hose testing are to be carried out in accordance with the following:

1. General

(1) Application
The following requirements determine the testing conditions for :
- gravity tanks, excluding independent tanks of less than $5m^3$ capacity.
- watertight or weathertight structures.

(A) The purpose of these tests is to check the tightness and/or the strength of structural elements at time of ships construction and on the occasion of major repairs.
(B) Tests are to be carried out in the presence of the Surveyor at a stage sufficiently close to completion so that any subsequent work would not impair the strength and tightness of the structure.
(C) For the general testing requirements, see items **Par 3** and **4.**

(2) Definitions
(A) Shop primer is a thin coating applied after surface preparation and prior to fabrication as a protection against corrosion during fabrication.
(B) Protective coating is a final coating protecting the structure from corrosion.
(C) Structural testing is a hydrostatic test carried out to demonstrate the tightness of the tanks and the structural adequacy of the design. Where practical limitations prevail and hydrostatic testing is not feasible(for example when it is difficult, in practice, to apply the required head at the top of the tank), hydropneumatic testing may be carried out instead. When a hydropneumatic testing is performed, the conditions should simulate, as far as parcticable, the actual loading of the tank.
(D) Hydropneumatic testing is a combination of hydrostatic and air testing, consisting in filling the tank with water up to its top and applying an additional air pressure. The value of the additional air pressure is to be at least as defined in **2.** (2).
(E) Leak testing is an air or other medium test carried out to demonstrate the tightness of the structure.
(F) Hose testing is carried out to demonstrate the tightness of structural items not subjected to hydrostatic or leak testing and to other components which contribute to the watertight or weathertight integrity of the hull.

2. Testing methods

(1) Structural testing
(A) Structural testing may be carried out after application of the shop primer. Structural testing may be carried out after the protective coating has been applied, provided that one of the following two conditions is satisfied:
(a) all the welds are completed and carefully inspected visually to the satisfaction of the Suyrveyor prior to the application of the protective coating.
(b) leak testing is carried out prior to the application of the protective coating.
(B) Regardless the previous (A), the protective coating may be applied prier to the structural testing of the following (a), (b) and (c), provided that the tightness of them are confirmed with the next (E) and (F) of (2).
(a) all erection welds, both manual and automatic
(b) all manual fillet weld connections on tank boundaries
(c) manual penetration welds

(2) Leak testing
(A) Where leak testing is carried out, in accordance with **Table 3.1.1**, an air pressure of $0.15 \times 10^5 Pa (0.15 kg/cm^2)$ is to be applied during the test. Prior to inspection, it is recommened that the air pressure in the tank is raised to $0.20 \times 10^5 Pa (0.2 kg/cm^2)$ and kept at this level for about 1 hour to reach a stabilized state, with a minimum number of personnel in the vicinity of the tank, and then lowered to the test pressure.
(B) The test may be conducted after the pressure has reached a stabilized state at $0.20 \times 10^5 Pa (0.2 kg/cm^2)$, without lowering the pressure, provided they are satisfied of the safety of the personnel involved in the test.
(C) Welds are to be coated with an efficient indicating liquid.
(D) A U-tube filled with water up to a height corresponding to the test pressure is to be fitted to avoid overpressure of the compartment tested and verify the test pressure. The U-tube should have a cross section larger than that of the pipe supplying air. In addition, the test pressure is also to be verified by means of one master pressure gauge. The Society may accept alternative means which are considered to be equivalently reliable.
(E) Leak testing is to be carried out, prior to the application of a protective coating, on all fillet weld connections on tank boundaries, penetrations and erection welds on tank boundaries excepting welds made by automatic processes.
(F) Selected locations of automatic erection welds and pre-erection manual or automatic welds may be required to be similary tested at the discretion of the Surveyor taking

account of the quality control procedures operating in the shipyard. For other welds, leak testing may be carried out, after the protective coating has been applied, provided that these welds were carefully inspected visually to the satisfaction of the Surveyor.

(G) Any other recognized method may be accepted to the satisfaction of the Surveyor.

(3) Hose testing
When hose testing is required to verify the tightness of the structures, as defined in **Table 3.1.1,** the minimum pressure in the hose, at least equal to $2 \times 10^5 Pa (2.0 kg/cm^2)$, is to be applied at a maximum distance of $1.5 m$. The nozzle diameter is not to be less than $12 mm$.

(4) Hydropneumatic testing
When hydropneumatic testing is performed, the same safety precautions as for leak testing(see previous (2)) are to be adopted.

(5) Other testing methods
Other testing methods may be accepted, at the discretion of the Society, based upon equivalency considerations.

3. General testing requirements

General requirements for testing are given in **Table 3.1.1.**

4. Additional requirements for special type vessels/tanks

In addition to the requirements of **Table 3.1.1,** particular requirements for testing of certain spaces within the cargo area of;
- liquefied gas carriers,
- edible liquid carriers,
- chemical carriers,
are given in **Table 3.1.2.** These requirements intend generally to verify the adequacy of the structural desigh of the tank, based on the loading conditions which prevailed when determing the tank structure scantlings.

SECTION 3
Approval of Plans and Documents

301. Plans and documents for approval

When it is intended to build a ship for Classification, the following plans and documents are to be submitted for the approval of the Society before the work is commenced.

(1) Midship section
(2) Construction profile
(3) Shell expansion
(4) Watertight and oiltight bulkheads
(5) Deck plans
(6) Stem, sternframe and rudder
(7) Single bottoms and double bottoms
(8) Superstructure end bulkheads
(9) Fore and aft bodies
(10) Pillars and deck girders
(11) Shaft tunnels
(12) Foundations and the relevant structure plan of boilers, main engines, thrust and plummer blocks, generators, and other heavy weight auxilary machinery.
(13) Machinery casings
(14) Deckhouses
(15) Masts, derrick posts and derrick booms and the relevant stucture plans
(16) Final stability data
(17) Loading manual
(18) Other plans and documents deemed necessary by the Society

302. Plans and documents for reference

1. When it is intended to build a ship for Classification, the following plans and documents for reference are to be submitted in addition to the plans and documents for approval in **301.**

(1) General arrangement
(2) Specification
(3) Calculation sheets for midship section modulus
(4) Where special cargoes are to be loaded, the plans showing their distribution and loading arrangements.
(5) Calculation sheets for masts, derrick booms, boat davits, and similar structures requiring strength.
(6) Preliminary stability data.
(7) Other plans and documents deemed necessary by the Society.

2. Lines, hydrostatic curves, capacity plans, records of sea trials and various tests are to be submitted before the delivery of the ship.

303. Plans and documents for assignment of load lines

Where load lines are to be assigned the following plans and documents are to be submitted. But submission of plans and documents already submitted for the Classification Survey during construction may be dispensed with.

(1) General arrangement
(2) Midship section
(3) Construction profile
(4) Superstructures and superstructure end bulkheads
(5) Lines
(6) Hydrostatic curves
(7) If the timber load lines are to be assigned, the plans showing the height of timber deck cargo and the arrangements of lashing and fixing
(8) Other plans and documents deemed necessary by the Society.

Table 3.1.1 General testing requirements

Item number	Structure to be tested	Type of testing	Test pressure	Remarks
1	Double bottom tanks	Structural testing (1)	The greater of the followings : - head of water up to the top of overflow - head of water up to the margin line	Tank boundaries tested from at least one side
2	Double side tanks	Structural testing (1)	The greater of the followings : - head of water up to the top of overflow - 2.4m head of water above highest point of tank	Tank boundaries tested from at least one side
3	Tank bulkheads, deep tanks	Structural testing (1)	The greater of the followings : (2) - head of water up to the top of overfolw - 0.9m head of water above top of hatch	Tank boundaries tested from at least one side
	Fuel oil bunkers	Structural testing		
4	Ballast holds in bulk carriers	Structural testing (1)	The greater of the followings : - head of water up to the top of overflow - 0.9m head of water above top of hatch	-
5	Fore peak and after peak used as tank	Structural testing	The greater of the followings : - head of water up to the top of overflow - 2.4m head of water above highest point of tank	Test of the after peak carried out after the stern tube has been fitted
	Fore peak not used as tank	Refer to **SOLAS Ch.II-1 Reg.14**	-	-
	After peak not used as tank	Leak testing	-	-
6	Cofferdams	Structural testing (3)	The greater of the followings : - head of water up to the top of overfolw - 2.4m head of water above highest point of tank	-
7	Watertight bulkheads	Refer to **SOLAS Ch.II-1 Reg.14** (4)	-	-
8	Watertight doors below freeboard or bulkhead deck	Refer to **SOLAS Ch.II-1 Reg.18**	-	-
9	Double plate Rudders	Leak Testing	-	-
10	Shaft Tunnel clear of deep tanks	Hose testing	-	-
11	Shell doors	Hose testing	-	-
12	Watertight hatchcovers of tanks in bulk carriers	Hose testing	-	-
	Watertight hatchcovers of tanks in combination carriers	Structural testing (1)	The greater of the followings : - 2.4m head of water above the top of hatch cover - setting pressure of safety relief valves, where relevant	At least every 2nd hatch cover is to be tested
13	Weathertight hatchcovers and closing appliances	Hose testing	-	-
14	Chain locker(if aft of collision bulkhead)	Structural testing	Head of water up to the top	-
15	Independent tanks	Structural testing	Head of water up to the top of overflow, but not less than 0.9m	-
16	Ballast ducts	Structural testing	Ballast pump maximum pressure	-

Table 3.1.1 General testing requirements (continued)

Notes :
1. (1) Leak or hydropneumatic testing may be accepted under the conditions specified in **Par 2** (2), provided that at least one tank for each type is structurally tested, to be selected in connection with the approval of the design. In general, structural testing need not be repeated for subsequent vessels of a series of identical newbuildings. However, the following spaces are to be structurally tested.
   (a) cargo space boundaries in tankers and combination carriers
   (b) tanks for segregated cargoes or pollutants
   If the structural test reveals weakness or severe faults not detected by the leak test, all tanks are to be structurally tested.
   (2) Where applicable, the highest point of tank is to be measured to the deck and excluding hatches. In holds for liquid cargo or ballast with large hatch covers, the highest point of tank is to be taken at the top of the hatch.
   (3) Leak testing may be accepted under the conditions specified in **Par 2** (2) except that structural testing or hydropneumatic testing may be required at the Society discretion.
   (4) When hose test cannot be performed without damaging possible outfitting (machinery, cables, switchboards, insulation, etc.) already installed, it may be replaced, at the Society discretion, by a careful visual inspection of all the crossings and welded joints; where necessary, dye penetrant test or ultrasonic leak test may be required.
2. Tests on hull piping will be as specified in **Pt 5, Ch 6.**

Table 3.1.2 Additional testing requirements for spaces within the cargo area of certain types of ships

Item number	Types of ships	Structure to be tested	Testing requirements	Structural test pressure	Remarks
1	Liquefied gas carriers	Integral tanks	Refer to **Pt 7, Ch 5, 410. 6**	-	-
		Hull structure supporting membrane or semi-membrane tanks	Refer to **Pt 7, Ch 5, 410. 7**	-	-
		Independent tanks type A	Refer to **Pt 7, Ch 5, 410. 10**, (1)	-	-
		Independent tanks type B	Refer to **Pt 7, Ch 5, 410. 10**, (2)	-	-
		Independent tanks type C	Refer to **Pt 7, Ch 5, 410. 10**, (3)	-	-
2	Edible liquid carriers	Independent tanks	Structural testing	Head of water up to the top of overflow without being less than 0.9m	-
3	Chemical tankers	Integral or independent tanks	Structural testing of cargo tanks boundaries from at least one side	The greater of the following : - 2.4m head of water above highest point of tank - setting pressure of safety relief valves, where relevant	-

SECTION 4
Materials

401. Standard of materials

The materials used for hull construction and equipment are to be those complying with the requirements in **Pt 2, Ch 1,** unless otherwise specified.

402. Materials outside the rules

Where meterials other than those specified in the Rules are used, the use of such materials and corresponding, scantlings are to be specially approved by the Society.

403. High tensile steels

1. Where high tensile steels are to be used for hull construction, the drawings showing the scope and locations of the used place together with the type and scantlings are to be submitted for the approval of the Society.

2. Where high tensile steels are used for hull construction, material factor K (hereinafter refer to as K in this Part and **Pt 7**) according to steels being used is as specified in **Table 3.1.3.**

404. Ships of restricted service area

Materials for hull construction and equipment for ships intended for Classification with the condition of restricted service areas are to be in accordance with the discretion of the Society.

Table 3.1.3 Material Factor K

Steel grades	K
RA, RB, RD and RE	1.0
$RA32$, $RD32$ and $RE32$	0.78
$RA36$, $RD36$ and $RE36$	0.72

405. Application of steels

1. The steels used for hull structures are to be of the grades provided in **Pt 2, Ch 1** in accordance with the requirements given in **Tables 3.1.4** and **3.1.5.** In applying these requirements, RB, RD or RE may be substituted for RA; RD or RE for RB; RE for RD; $RD32$ or $RE32$ for $RA32$; $RE32$ for $RD32$; $RD36$ or $RE36$ for $RA36$; and $RE36$ for $RD36$, respectively.

2. For strength members not mentioned in **Table 3.1.4,** grade RA, $RA32$ and $RA36$ may generally be used. Single strakes required to be of class Ⅲ or of Grade RE, $RE32$ and $RE36$ are within 0.4L amidships to have breadths not less than the value given by the following formula, need not be greater than 1800 mm. As for rounded gunwale, the single strake is to have breadth to the satisfaction of the Society.

$$b = 5L + 800 \ (mm)$$

The steel grade is to correspond to the as-built plate thickness when this is greater than the rule requirement.

3. Plating materials for sternframes, rudder horns, rudders and shaft brackets are not to be of lower grades than corresponding to class II. However, for rudder and rudder body plates subjected to stress concentrations(e.g. in way of lower support of semi-spade rudder(D and E in **Fig. 4.1.1** of **Pt 4, Ch 1**) or at upper part of space rudder(C in **Fig. 4.1.1** of **Pt 4, Ch 1**)) class III is to be applied.

4. The grades of steel to be used in the hull construction are to be clearly indicated on the hull structural plans.

406. Special requirements for application of steels

For vessels intended to operate for longer period in areas with low temperatures or to carry refrigerated cargoes, and for the cases where deemed necessary, the Society may require the grade of heigher toughness, regardless of the requirements in **405.**

Table 3.1.4 Material Classes

Structural member category	Material classes	
	Within 0.4L amidships	Outside 0.4L amidships
○ Secondary : - Lower strake in longitudinal bulkhead - Deck plating exposed to weather, in general - Side plating	I	A/AH
○ Primary : - Bottom plating including keel plate - Strength deck plating(2) - Continuous longitudinal members above strength deck, excluding longitudinal hatch coamings - Upper strake in longitudinal bulkhead - Vertical strake(hatch side girder) and upper sloped strake in top wing tank	II	A/AH
○ Special : - Sheer strake at strength deck(4) - Stringer plate in strength deck(4) - Deck strake at longitudinal bulkhead(1) - Bilge strake(3), (5) - Continuous longitudinal hatch coamings(6)	III	II (I outside 0.6L)

Notes:
(1) In ships with breadth exceeding 70m at least three deck strakes to be class III.
(2) Plating at corners of large hatch openings to be specially considered. Class III or grade E/EH to be applied in positions where high local stress may occur.
(3) May be of class II in ships with a double bottom over the full breadth and with length less than 150 $metres$.
(4) Not to be less than grade E/EH within 0.4L amidships in ships with length exceeding 250 $metres$.
(5) Not to be less than grade D/DH in ships with length exceeding 250 $metres$.
(6) Not to be less than grade D/DH
(7) The symbols in the table mean the grades of steel as follows :
A : RA, AH : $RA32$ and $RA36$
D : RD, DH : $RD32$ and $RD36$
E : RE, EH : $RE32$ and $RE36$

Table 3.1.5 Steel Grades

Class / Thickness (mm)	I		II		III	
	MS	HT	MS	HT	MS	HT
$t \leq 15$	A	AH	A	AH	A	AH
$15 < t \leq 20$	A	AH	A	AH	B	AH
$20 < t \leq 25$	A	AH	B	AH	D	DH
$25 < t \leq 30$	A	AH	D	DH	D	DH
$30 < t \leq 35$	B	AH	D	DH	E	EH
$35 < t \leq 40$	B	AH	D	DH	E	EH
$40 < t \leq 50$	D	DH	E	EH	E	EH

Note:
The symbols in the table mean the grades of steel as follows:
A : RA AH : $RA32$ and $RA36$ MS : Mild steels
B : RB DH : $RD32$ and $RD36$ HT : High tensile steels
D : RD EH : $RE32$ and $RE36$
E : RE

SECTION 5 Weldings

501. General

1. Arrangements

Special attention is to be paid to the arrangements of hull structural members so that welding may be carried out without much difficulty.

2. Structural details

(1) Structural discontinuities and the abrupt changes of cross sections are to be avoided as far as practicable, and welded joints are to be properly shifted from places where the stresses are highly concentrated.
(2) Corners of all openings are to be well rounded.
(3) Where rigid structural members with small sectional area, such as brackets, are welded on relatively thin plate, at least the toes of members are to be welded just on other rigid members.
(4) Upper ends of sheer strakes for midship part are to be finished smoothly, and bulwark or equipment is not to be directly welded to the sheer strakes.

3. Tee joints

The kinds and sizes of fillet welds are to be in accordance with **Table 3.1.6** and their application to the hull construction parts is to be as required by **Table 3.1.7.**

4. Slot weld

(1) The slot weld is to have adequate shape to permit a thoroughly fused bead to be applied all around the bottom edge of the opening.
(2) The fillet sizes of slot welds are to be F1 and the spacing of slots is to be as determined by the Society.

SECTION 6 Scantlings

601. General

1. The midship scantlings and scantlings specified in the Rules are to be applied for the parts which specified in **108.** and **109.**

2. The reduction from the midship scantlings to the end scantlings is to be applied for the parts within $0.1L$ from the fore and aft ends.

602. Section modulus

Unless otherwise specially specified, the section moduli of members required by the Rules are those including the steel plates with the effective breadth of $0.1l$ on either plate side of the members. However, the breadth of $0.1l$ is not to exceed one-half of the spacing of member, l is the length specified in the relevant Chapter.

603. Built-up sections

Where flat bars, bulb plates, inverted angles or flanged plates are welded to form beams, frames or stiffeners for which section moduli are specified, they are to be of suitable depth and thickness in proprotion to the section modulus.

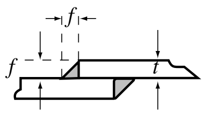
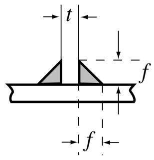
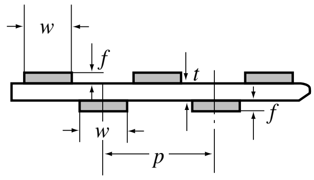
604. Scantlings of end brackets

1. Secondary members, such as longitudinals, beams, frames and stiffeners forming part of the hull structure, are generally to be connected at their ends by the brackets of thckiness not to be less than that obtained from the following formula, Where it is desired to adopt bracketless connections, the proposed arrangements will be individually considered.

$$t_b = C_1\sqrt{Z} + 4.5 \quad (mm)$$

where:
Z = section modulus in cm^3 specified in the following (a) to (c):
(a) Bracket connecting stiffener to primary member, section modulus of the stiffener.
(b) Bracket at the head of main transverse frame where frame terminated, section modulus of frame
(c) Elsewhere the lesser section modulus of the members being connected by the bracket.

Table 3.1.6 Kinds and Sizes of Fillet Weld (Unit : *mm*)

<table>
<tr><td rowspan="4">Kind of fillet weld
Thickness of members</td><td colspan="6">Lap joint  Tee joint  Measurement of weld length and pitch </td></tr>
<tr><td colspan="2">continuous fillet weld</td><td colspan="4">Intermittent fillet weld</td></tr>
<tr><td colspan="2">size of fillet f</td><td rowspan="2">Size of fillet f</td><td rowspan="2">Length of fillet w</td><td colspan="2">Pitch p</td></tr>
<tr><td>F 1</td><td>F 2</td><td>F 3</td><td>F 4</td></tr>
<tr><td>Up to 5</td><td>3</td><td>3</td><td>3</td><td>60</td><td>150</td><td>250</td></tr>
<tr><td>6</td><td>4</td><td>3</td><td>4</td><td rowspan="21">75</td><td rowspan="21">200</td><td rowspan="21">350</td></tr>
<tr><td>7</td><td rowspan="2">5</td><td rowspan="5">4</td><td rowspan="2">5</td></tr>
<tr><td>8</td></tr>
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<tr><td>from 26 to 40</td><td>11</td><td>8</td><td>11</td></tr>
</table>

NOTE:

1. The size of fillet "f" for tee joints is in general to be determined according to the thickness of webs in case of connections of beams, frames, stiffeners and girders to deck plating, inner bottom plates, bulkhead plates, shell plating or face plates, and the thickness of the thinner plate in case of connections of other members.
2. Lap joints are to have the fillet size of F1 determined according to the thickness of thinner plate
3. The throat thickness of fillet is to be $0.7f$
4. In general F2 is to be minimum fillet size.
5. Intermittent fillet welds are to be staggered and w at the ends is to be welded on both sides.
6. The minus tolerance of fillet size is to be 10 % of the nominal size.

Table 3.1.7 Application of Fillet Weld

Line No.	Item			Application		Kind of weld
1	Rudders	Rudder frames		Rudder plates		F3
2				Vertical frames forming main pieces		F1
3				Rudder frames (except above)		F2
4	Single bottoms	Floors plates		Shell plates	In strengthened bottom forward, aft peaks and deep tanks	F2
5					Elsewhere	F4
6				Face plates of floor polates	In strengthened bottom forward and main engine rooms	F2
7					Elsewhere	F4
8				Through plates and rider plates of centre keelsons		F1
9		Centre keelson	Girders	Flat plate keels	In strengthened bottom forward	F2
10					Elsewhere	F3
11				Rider plates		F3
12				Floor plates		F2
13		Side keelson	Girders	Shell plates	In strengthened bottom forward	F2
14					Elsewhere	F4
15				Rider plates	In main engine rooms	F2
16					Elsewhere	F4
17				Floor plates		F3
18	Double bottoms with transverse framing	Solid floors		Shell plates	In strengthened bottom forward	F2
19					Elsewhere	F4
20				Inner bottom plates	Bed plates of main engine and thrust bearings	F2
21					In strengthened bottom forward and engine rooms (except above)	F2
22					Elsewhere	F4
23				Girders under inner bottom below main engine seatings		F1
24				Centre girders	In strengthened bottom forward and main engine rooms (except above)	F2
25					Elsewhere	F3
26				Margin plates		F2
27		Oiltight or watertight floors		Boundaries		F1
28		Stiffeners on floor plates		Oiltight and watertight floors		F3
29				Elsewhere		F4
30		open floors	Frames	Shell plates		F4
31			Reverse frames	Inner bottom plates		F4
32			Brackets	Centre girders		F3
33				Margin plates		F2
34			Vertical struts	Side girders		F4
35		Centre girders		Flat plate keels	Where oiltight or watertight	F1
36					Elsewhere	F3
37				Inner bottom plates	Where oiltight or watertight	F1
38					Lower portion of girders for main engine seatings or thrust bearings	F2
39					Elsewhere	F3
40		Side girders (intercostal plates)		Shell plates	In strengthened bottom forward	F2
41					Elsewhere	F4
42				Inner bottom plates	In engine rooms	F2
43					Else where	F4
44				Solid floors	In strengthened bottom forward and main engine rooms	F2
45					Elsewhere	F4
46		Main engine girders		Inner bottom plates		F2
47				Shell plates		F2
48		Margin plates		Shell or gusset plates		F1

Table 3.1.7 Application of Fillet Weld (continued)

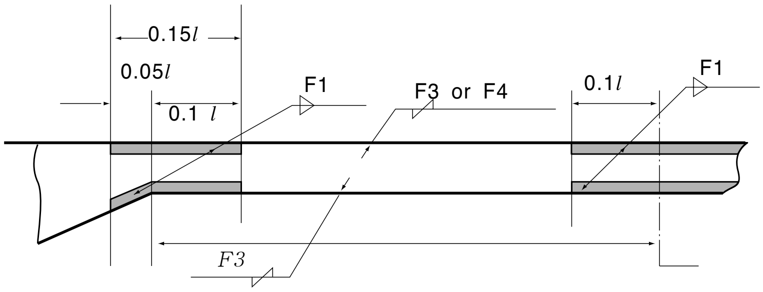
Line No.	Item		Application			Kind of weld
49		Hold frame brackets	Margin plates			F1
50		Hold frame brackets	Gusset plates			F2
51		Shell stiffeners	Connections to shell plates are as required for longitudinal frames			
52		Half height girders	Connections to shell plates and solid floors are as required for side girders			
53	Double bottoms with longitudinal framing	Longitudinal frames	Shell plates in strengthened bottom forward			F2
54	Double bottoms with longitudinal framing	Longitudinal frames	Shell plates(except above) or inner bottom plates			F4
55	Double bottoms with longitudinal framing	Solid floors	Shell plates and inner bottom plates	For two frame spaces at the end of floors		F2
56	Double bottoms with longitudinal framing	Solid floors	Shell plates and inner bottom plates	Elsewhere		F3
57	Double bottoms with longitudinal framing	Solid floors	Centre girders			F2
58	Double bottoms with longitudinal framing	Brackets on centre girders	Centre girders, shell plates and inner bottom plates			F3
59	Double bottoms with longitudinal framing	Brackets on margin plates in double bottoms	Margin plates			F2
60	Double bottoms with longitudinal framing	Brackets on margin plates in double bottoms	Shell plates and inner bottom plates			F3
61	Double bottoms with longitudinal framing	Stiffeners on side girders	Side girders			F4
62	Frames	Shell plates	In aft peak tanks, for 0.125L from fore end, and in deep tanks			F3
63	Frames	Shell plates	Elsewhere			F4
64	Built-up frames	Webs	Shell plates or face plates	0.125L from fore end, and in deep tanks		F2
65	Built-up frames	Webs	Shell plates or face plates	Elsewhere		F3
66	Decks	Stringer plates	Shell plates	In strength decks		F1
67	Decks	Stringer plates	Shell plates	Elsewhere		F2
68	Decks	Beams	Decks	In tanks		F3
69	Decks	Beams	Decks	Elsewhere		F4
70	Built-up beams	Webs	Decks or face plates	In tanks		F2
71	Built-up beams	Webs	Decks or face plates	Elsewhere		F3
72	Pillars	Pillars	Heels and heads			F1
73	Pillars	Pillars	Connections of built-up pillar members			F3
74	Hatch-ways	Coamings	Decks(except below)			F2
75	Hatch-ways	Coamings	Hatchway corners on strength decks			F1
76	Hatch-ways	Portable beams	Connections of members			F3
77	Bulkheads	Stiffeners	Bulkhead plates	Above the lower ends of brackets connecting stiffeners to deck girders		F1
78	Bulkheads	Stiffeners	Bulkhead plates	In deep tank bulkheads		F3
79	Bulkheads	Stiffeners	Bulkhead plates	Elsewhere		F4
80	Bulkheads	Bulkhead plates	Boundaries	In oiltight and watertight bulkheads		F1
81	Bulkheads	Bulkhead plates	Boundaries	Elsewhere		F3
82	Seatings	Girders or brackets	Bed plates	In seatings for main engines, thrust bearings, boiler bearers and main dynamo engines		F1
83	Seatings	Girders or brackets	Inner bottom plates or shell	In seatings for main engine or thrust bearings		F2
84	Seatings	Girders or brackets	Girder plates	In seatings for main engine or thrust bearings		F1
85	Web beams, web frames, side stringers, deck girders and girders on bulkheads	Web plates or girder plates	Shell, decks or bulkhead	In tanks, web frames for 0.125L from fore end and side stringers		F2
86	Web beams, web frames, side stringers, deck girders and girders on bulkheads	Web plates or girder plates	Shell, decks or bulkhead	Elsewhere		F3
87	Web beams, web frames, side stringers, deck girders and girders on bulkheads	Web plates or girder plates	End connections of web or girder plates to shell, decks, inner bottom plates or bulkheads			F1
88	Web beams, web frames, side stringers, deck girders and girders on bulkheads	Web plates or girder plates	Webs or face plates of webs	In tanks, web frames for 0.125L from fore end and side stringers		F2
89	Web beams, web frames, side stringers, deck girders and girders on bulkheads	Web plates or girder plates	Webs or face plates of webs	Elsewhere	Where face area exceeds 65cm^2	F2
90	Web beams, web frames, side stringers, deck girders and girders on bulkheads	Web plates or girder plates	Webs or face plates of webs	Elsewhere	Where face area does not exceed 65cm^2	F3
91	Web beams, web frames, side stringers, deck girders and girders on bulkheads	Tripping brackets on webs or girder plates	Boundaries			F2
92	Web beams, web frames, side stringers, deck girders and girders on bulkheads	Serrations of webs or girder plates	Webs of frames, beams or stiffeners			F2
93	Brackets at ends of members		Connections of members to brackets(except otherwise specified)			F1

Table 3.1.7 Application of Fillet Weld (continued)

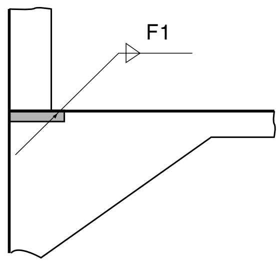
NOTES:

1. Where longitudinal strength members are mutually, connected by fillet weld, the fillet sizes are to be in accordance with **Table 3.1.6** and this **Table**, except that the total throat areas of fillet joints are not to be less than the minimum sectional area of the members.
2. Where the ends of frames, beams and stiffeners are directly fillet welded to decks, shell, inner bottom plates or bulkhead plates, the fillet sizes are not to be less than 0.7 times the web thickness of members.
3 Where beams, frames, stiffeners and girders are intermittently welded to decks, shell, inner bottom plates and bulkhead plates, the fillet welds are to be partly continuous as shown in **Fig. (a).** Where members are fitted at the opposite side of brackets as shown in **Fig. (b)** or **(c),** the fillet welds are to be continuous for proper length at the ends of members or at the toe of brackets of members. The fillet weld may be as shown in **Fig. (d),** where the whole lengths of the joints are light continuously welded with the fillet size not less effective than F2
4. Where the rider plates or inner bottom plates consist of bed plates of main engine seating or important seatings, the kind of fillet is to in accordance with the requirements for the seatings.
5. As to the connections not specified in double bottoms with longjtudinal framing, the requirements for transverse framing are to be applied.

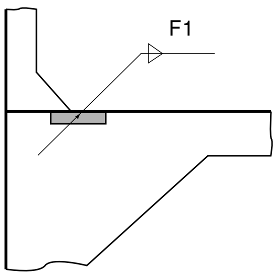
(a)



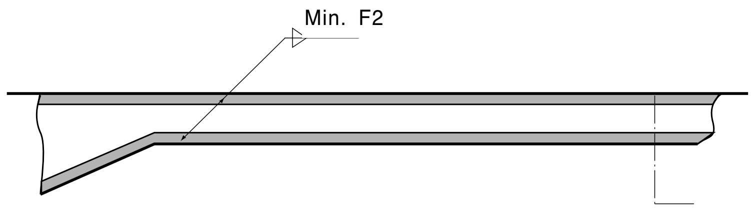
(b)



(c)



(d)



C_1 = factor depending on the flange of bracket is as following:

$C_1 = 0.27$: without flange

$C_1 = 0.23$: with flange

2. Where a flanged is fitted, its breadth is not to be less than that obtained from following formula. Where the length of longer arm exceeds 800 mm, the free edge of brackets are to be stiffened by flange or other means, except where tripping brackets or the like are provided.

$$w_f = \frac{Z}{33} + 45 \quad (mm)$$

where:

Z = as sepeified in **Par 1.**

3. The length of bracket arm measured from shown in **Fig. 3.1.1** is not to be less than that obtained from the following formula. The lengths of bracket arms of tank side and hopper side are to be 20 percent greater than that required above.

$$a + b \geq 2.0\,l$$

$$a \text{ and } b \geq 0.8\,l$$

where:

l = as given by the following formula, but in no case is to be taken as less than twice the web depth of the stiffener on which the bracket scantlings are to be based.

$$l = 180\sqrt{\frac{Z}{14+\sqrt{Z}}} - 90 \quad (mm)$$

Z = as specified in **Par 1.**

605. Modification of l

Where brackets of not less thickness than that of the girder plates, the value of l specified in **Chs 9, 11, 12, 14** and **15** may be modified in accordance with the following:

(1) Where the face area of the bracket is not less than one-half that of the girder and the face plates or flange on the girder is carried to the bulkhead, deck, tank top, etc., the length l may

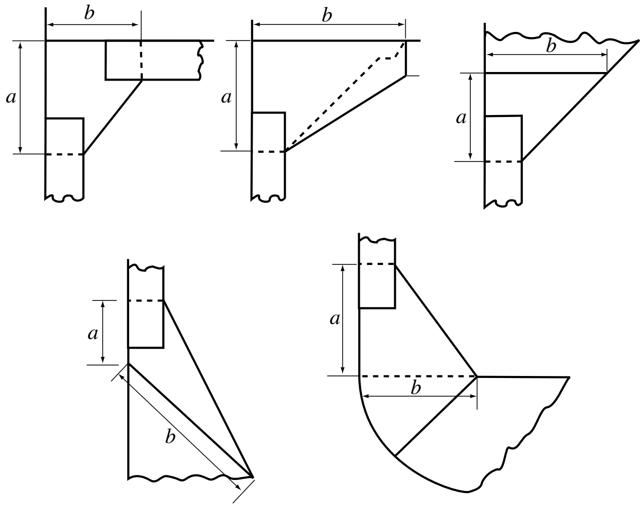


Fig. 3.1.1 Measurement of a and b for Arms

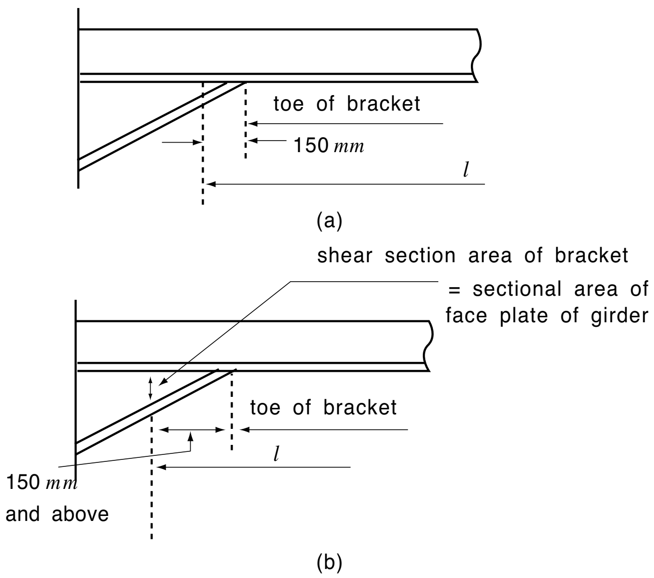


Fig 3.1.2 Modification of l

be measured to a point 0.15 m inside the toe of bracket.(See **Fig 3.1.2**(a))

(2) Where the face sectional area of the bracket is less than one-half that of the girder and the face plate or flange on the girder is carried to the bulkhead, deck, tank top, etc., l may be measured to a point where the sum of sectional area of the bracket outside the line of girder and its free flanges equal to the sectional area of free flanges of girder, or to a point 0.15 m inside the toe of bracket, whichever is the greater.(**See Fig 3.1.2**(b))

(3) Where brackets are provided and the face plate or flange on the girder are extended along the brackets to the bulkhead, deck, tank top, etc., the face plate or flange of bracket may be curved, but l is to be measured to the toe of bracket.

(4) Brackets are not to be considered effective beyond the point where the arm on the girder is 1.5 times the length of arm on the bulkhead, deck, tank top, etc.

(5) In no case is the allowance in l at either end to exceed one-quarter of the overall length of the girder.

SECTION 7
Workmanship

701. General

1. The workmanship is to be of the best quality.

2. During the construction, the builder is to supervise and inspect in detail every job performed in shed or yard and prepare the necessary records.

702. Caulking

Caulking edges are to be finished by edge planing, gas cutting, chipping or other appropriate methods.

703. Penetrating parts

Where frames or beams pass through watertight deck or bulkhead, the deck or bulkhead is to be constructed watertight without the use of wooden materials or cement.

704. Welding

The welding is to be applied in **Pt 2, Ch 2.**

705. Heating

1. In the hot work of steel, the steel is not to be overheated and it is to be hammered or bent in the proper heated condition.

2. Steel which is burnt is not to be used.

SECTION 8
Corrosion Control

801. Reduction of scantlings due to corrosion control

1. Where an approved measure of corrosion control is applied to deep tanks, double bottom tanks, peak tanks or fuel oil tanks, the required scantlings of structural members in the tanks may be reduced at the discretion of the Society.

2. Where it is intended to apply a system of corrosion control to tanks the plans showing the description and scope of such control, the required scantlings in the Rules and the scantlings intended to be reduced are to be submitted to the Society for approval.

802. Notation for corrosion control

Where an approved measure of corrosion control is applied to a ship, the notation *"CoC"* will be added and entered in the Record.

803. Corrosion protection coating for sea water ballast spaces

1. For ships not intended to receive a corrosion control notation specified in **801.** and **802.,** all sea water ballast spaces having boundaries formed by the hull envelope are to have an effective corrosion protection coating in accordance with the manufacturer's requirements.

2. The corrosion prevention system in seawater ballast tanks for oil tankers and bulk carriers is to be in accordance with the requirements as specially prepared by the Society. ⚓

CHAPTER 2
STEMS AND STERN FRAMES

Section

SECTION 1
Stems

101. Plate stems

1. The thickness of steel plate stems at the load waterline is not to be less than that obtained from the following formula. Above and below the load waterline, the thickness may be gradually tapered toward the stem head and the keel. And at the upper end of stem it may be equal to the thickness of the side shell plating (at the fore end part) of the ship, and at the lower end of stem, it is to be equal to the thickness of plate keel.

$$t = 1.5\sqrt{L'-50} + 2.0 \qquad (mm)$$

where:

L' = length of ship(m), where, however, L exceeds 230 m, L' is to be taken as 230 m

2. Horizontal ribs are to be provided on the stem plates at an interval preferably not exceeding 1 *metre*, and where the radius of curvature at the fore end of stem is large, proper reinforcement is to be made by providing with a centre line stiffener or by other means.

SECTION 2
Stern Frames

201. Application

The requirements in this Section apply only to stern frames without rudder post.

202. General

1. Stern frames may be cast, forged, or fabricated of plates and are to be of the shape suitable for the stream line of the stern part of the hull.

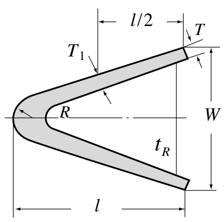
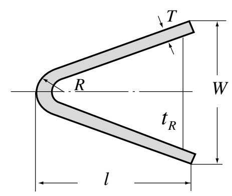
2. Cast or plate stern frames are to be fitted with transverse ribs of suitable spacing and where the curvature is large a centre line stiffener is to be fitted.

3. Care is to be taken to avoid any sudden change in thickness or sectional area along the frame.

203. Propeller post

1. The scantlings of propeller post are not to be less than those obtained from the formulae given in **Table 3.2.1.**

Table 3.2.1 Standards of Propeller Posts

Cast steel	Steel plate
$W = 30\sqrt{L}$ $l = 40\sqrt{L}$ (mm) $T = \dfrac{3\sqrt{L}}{\sqrt{K^{(1)}}}$ (mm) $T_1 = \dfrac{3.7\sqrt{L}}{\sqrt{K^{(1)}}}$ (mm) $t_R = 0.6T$ (mm) $R_{min} = 40$ (mm)	$W = 37\sqrt{L}$ $l = 53\sqrt{L}$ (mm) $T = \dfrac{2.4\sqrt{L}}{\sqrt{K^{(2)}}}$ (mm) $t_R = 0.55T$ (mm) $R_{min} = 40$ (mm)
	
Note : (1) Material facter K for the Propeller post of cast steel is to be as **Pt 4, Ch 1, Table 4.1.1.** (2) Material facter K for the Propeller post of steel plate is to be as **Pt 4, Ch 1, Table 4.1.2.**	

2. The propeller post may be built up of plates welded to a suitable bar steel of circular or rectangular cross section at the after end.

3. The scantlings of propeller post below the propeller boss are to be gradually increased to suit the strength of the shoe piece.

4. In ships with relatively high speed for their length, and in ships exclusively engaged in towing purposes, the scantlings of various parts of propeller posts are to be suitably increased.

204. Propeller boss

The thickness of propeller boss is not to be less than that obtained from the following formula:

$$t = 0.23\, d_p + 30 \quad (mm)$$

where:

d_p : diameter(mm) of propeller shaft specified in **Pt 5, Ch 3, 204.**

205. Shoe piece

1. The scantlings of each cross section of the shoe piece are to be determined by the following formula (1) to (4) considering the bending moment and shear force acting on shoe piece when the rudder force specified in **Pt 4, Ch 1, 201.** is applied to the rudder.

(1) The section modulus Z_z around Z–axis(axis of depthwise) is not to be less than that obtained from the following formula:

$$Z_z = \frac{MK_{sp}}{80} \quad (cm^3)$$

where:

M = bending moment at the section considered, which is obtained from the following formula.($N \cdot m$):

$$M = Bx \quad (N \cdot m)$$
$$M_{max} = Bl \quad (N \cdot m)$$

B = supporting force in the pintle bearing as given in **Pt 4, Ch 1, 401.**(N).

x = distance from mid-point of the length of pintle bearing to section considered(m).(See **Fig 3.2.1**).

l = distance from mid-point of the length of pintle bearing to fixed point of the shoe piece(m).(See **Fig 3.2.1**).

K_{sp} = material factor for the shoe piece as given in **Pt 4, Ch 1, 102.**

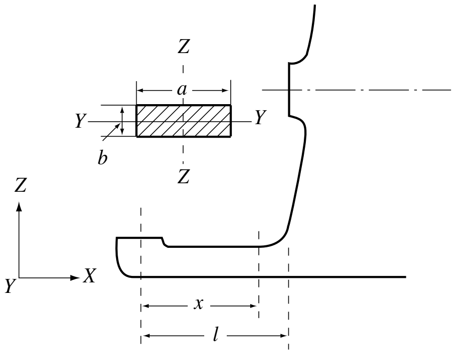


Fig. 3.2.1 Shoe Piece

(2) The section modulus Z_y around Y-axis(axis of breadthwise) is not to be less than that obtained from the following formula:

$$Z_y = 0.5\, Z_z \quad (cm^3)$$

where:

Z_z = as specified in (1)

(3) The total section area A_s in Y-axis is not to be less than that obtained from the following formula:

$$A_s = \frac{BK_{sp}}{48} \quad (mm^2)$$

where:

B and K_{sp} = as specified in (1).

(4) At no section within the length of shoe piece, the equivalent stress σ_e is to be exceed $115/K_{sp}$ (N/mm^2). The equivalent stress σ_e is to be determined by the following formula:

$$\sigma_e = \sqrt{\sigma_b^2 + 3\tau^2} \quad (N/mm^2)$$

where:

σ_b = bending stress acting on shoe piece is to be determined by the following formula (N/mm^2):

$$\sigma_b = \frac{M}{Z_z(x)} \quad (N/mm^2)$$

τ = shear stress acting on shoe piece is to be determined by the following formula (N/mm^2):

$$\tau = \frac{B}{A_s\,(x)} \quad (N/\,mm^2)$$

$Z_z(X)$ = actual section modulus of shoe piece around Z-axis at the section considered.(cm^3)

$A_s(X)$ = actual section area of shoe piece in Y-axis at the section considered.(mm^2)

M and B = as specified in (1).

2. The thickness of steel plates forming the main part of shoe piece of steel plate stern frame is not to be less than that of steel plates forming the main part of propeller post. Ribs are to be arranged in the shoe piece below the propeller post, under brackets and at other suitable positions.

206. Heel piece

Heel piece of stern frame is to be of length at least 3 times the frame space at that part and is to be strongly connected to the keel.

207. Rudder horn

1. The scantlings of each cross section of the rudder horn are to be determined by the formulae in (1) to (3) considering the bending moment, shear force and torsional moment acting on rudder horn when the rudder force as given in **Pt 4, Ch 1, 201.** is applied to the rudder.

(1) Section modulus Z_x around X-axis(axis of lengthwise) is not to be less than that obtained from the following formula:

$$Z_x = \frac{MK_{rh}}{67} \quad (cm^3)$$

where:

M = bending moment at the section considered, which is obtained from the following formula ($N{\cdot}m$) (See **Fig 3.2.2**):

$$M = Bz \quad (N \cdot m)$$
$$M_{\max} = Bd \quad (N \cdot m)$$

B = supporting force in the pintle bearing (N) as given in **Pt 4, Ch 1, 401.**

z = distance(m) from mid-point of length of the pintle bearing to the section considered (see **Fig 3.2.2**).

d = distance(m) from mid-point of length of pintle bearing to the supporting point of rudder horn (See **Fig 3.2.2**).

K_{rh} = material factor for rudder horn as given in **Pt 4, Ch 1, 102.**

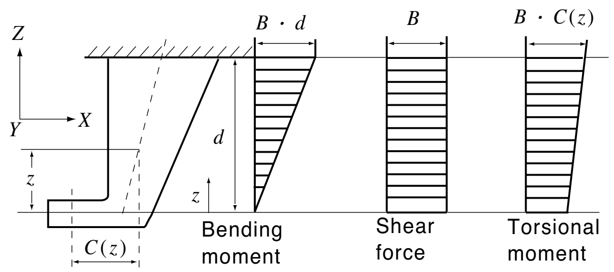


Fig. 3.2.2 Rudder Horn

(2) The total section area A_h in Y-axis is not to be less than that obtained from following formula:

$$A_h = \frac{BK_{rh}}{48} \quad (mm^2)$$

where:

B and K_{rh} = as specified in (1).

(3) At no section within the total height of rudder horn d, the equivalent stress σ_e is to exceed $120/K_{rh}$ (N/mm^2). The equivalent stress σ_e is determined by following formula:

$$\sigma_e = \sqrt{\sigma_b^2 + 3(\tau^2 + \tau_t^2)} \quad (N/mm^2)$$

where:

σ_b = bending stress acting on rudder horn is determined by the following formula:

$$\sigma_b = \frac{M}{Z_{xa}} \quad (N/mm^2)$$

τ = shear stress acting on rudder horn is determined by the following formula:

$$\tau = \frac{B}{A_h(z)} \quad (N/mm^2)$$

τ_t = torsional stress acting on rudder horn is determined by the following formula:

$$\tau_t = \frac{1000\, T_h}{2\, A_t t_h} \quad (N/mm^2)$$

T_h = torsional moment at the section considered is determined by the following formula:

$$T_h = B \cdot C(z) \quad (N \cdot m)$$

A_t = area in horizontal section enclosed by the mean thickness of rudder horn (mm^2)

t_h = thickness of rudder horn plate (mm)

M, B and K_{rh} = as specified in (1).

$A_h(z)$ = actual section area (mm^2) in Y-axis at the section considered.

Z_{xa} = actual section modulus (cm^3) around X-axis at the section considered.

$C(z)$ = distance(m) from section considered to the centre of rudder stock.

2. At the connection between the rudder horn and the hull structure, special consideration is to given to structural continuity.

208. Attachment to floor plates

The stern frame is to be extended upward at the part of the propeller post and to be connected strongly to the transom floor of thickness not less than that obtained from the following formula:

$$t = 0.035\,L + 7.5 \quad (mm)$$

209. Gudgeon

1. The bearing length of pintle, l_p, is to be such that

$$d_p \leq l_p \leq 1.2\, d_p \qquad (mm)$$

where:
d_p = diameter of pintle (mm)

2. The length of the pintle housing in the gudgeon is not to be less than the pintle diameter d_p.

3. The thickness of the pintle housing is not to be less than 0.25 d_p. For ships specified in **Pt 4, Ch 1, 103.,** however, the thickness of the pintle housing is to be appropriately increased. ⚓

CHAPTER 3
LONGITUDINAL STRENGTH

SECTION 1
General

101. Application

1. The requirements in this Chapter apply to ships of 90 m in length and above in unrestricted service. For ships having one or more of the following characteristics, special additional considerations will be given by the Society.

(1) Proportion $L/B \leq 5$, $B/D_s \geq 2.5$
(2) Length $L \geq 500\,m$
(3) Block coefficient $C_b < 0.6$
(4) Large deck opening
(5) Ships with large flare or high speed ships
(6) Carriage of heated cargoes
(7) Unusual type or design

2. Notwithstanding the requirements in **Par 1**, the requirements specified in **103.** and **104.** are applied to the ships of 65 m and above in L_f.

102. Continuity of strength

Longitudinal members are to be so arranged as to maintain as good continuity of strength as practicable.

103. Loading manual

1. For ships of 65m in length and above in L_f, in order to enable the ship master to adjust the loading of cargo and ballast to avoid the occurrence of unacceptable stress in the ship's structure, the ship is to be provided with a loading manual approved by the Society. However, a ship may not be provided with a loading manual where deemed unnecessary by the Society.

2. In the loading manual, as required in the preceding paragraph, at least the following items are to be included.

(1) Loading conditions on the basis of which the ship is designed, and the allowable limits of longitudinal still water bending moment and still water shear force.
(2) Results of calculation longitudinal still water bending moment and still water shear force corresponding to the standard loading conditions.
(3) Data and calculation examples to calculate the still water bending moment and the still water shear force for the loading conditions other than standard loading conditions. This requirement, however, may be dispense with to the ships with which the loading instruments specified in **104.** is provided.
(4) Allowable limits of local loads applied to hatch covers, deck, double bottom construction, etc., where deemed necessary by the Society.

104. Longitudinal strength loading instrument

1. In addition to loading manual as specified in **103.,** the following ships of 100m in length and above in L_f are to be provided with loading instrument(Longitudinal strength loading instrument), together with its operating manual, by means of which the still water bending moments, still water shear forces and still water torsional moments, etc. where applicable, in any loading or ballast condition can be easily and quickly ascertained. However, a ship may not be provided with a loading instrument where deemed unnecessary by the Society.

(1) Ships with large deck openings where combined stresses due to vertical and horizontal hull girder bending and torsional and lateral loads have to be considered.
(2) Ships liable to carry non-homogeneous loadings, where the cargo and/or ballast may be unevenly distributed. Ships less than 120m in length, when their design takes into account uneven distribution of cargo or ballast, are deemed unnecessary.
(3) Chemical tankers and gas carriers.

2. The loading instrument specified in **Par 1** is to be approved by the Society and tested at the presence of the surveyor in accordance with the approved test reports after installation on board.

SECTION 2
Bending Strength

201. Bending strength at amidships

1. The section moduli of the transverse sections of the hull calculated in accordance with the requirements in **203.,** at the midship part are not to be less than the values of Z_1 obtained from the formulae given in **Table 3.3.1** at the transverse sections under consideration along the length of hull for all conceivable loading and ballast conditions.

2. Notwithstanding the requirements of **Par 1**, the section modulus of the transverse section of hull at $0.4L$ part is not to be less than the value of Z_{min} obtained from formula given in **Table 3.3.1.**

3. Moment of inertia of the transverse section of hull at the middle point of L is not to be less than the value of I_{min} obtained from the formula given in **Table 3.3.1.** and the calculation method for moment of inertia of the actual transverse section is to be correspondingly in accordance with the requirements in **203.**

4. Scantlings of all continuous longitudinal members of hull girder based on the section modulus requirement in **Pars 2** and **3** are to be maintained within $0.4L$ amidships. However, in special cases, based on consideration of type of ship, hull form and loading conditions, the scantlings may be gradually reduced towards the end of the $0.4L$ part, where deemed necessary by the Society.

202. Bending strength at sections other than amidships

1. The bending strength of hull at sections other than $0.4L$ amidships is to be determined according to the requirements of **Ch 5, Sec 2.**

2. Where the Society considers that the application of requirements of the preceding paragraph is inappropriate, the bending strength at sections other than $0.4L$ amidships is to be determined according to **201. 1.** with necessary modifications.

203. Calculation of hull section modulus

As for calculation of the hull section modulus, the following (1) through (6) are to be applied:

(1) All longitudinal members which are considered effective to the longitudinal strength of the ship may be included in the calculation.

(2) Deck openings on the strength deck are to be deducted from the sectional area used in the section modulus calculation. However, small openings not exceeding 2.5 *metres* in length or 1.2 *metres* in breadth need not be deducted, provided that the sum of their breadths in one transverse section is not more than $0.06(B-\Sigma b)$. Where, Σb is the sum of breadths of large openings (m).(See **Fig 3.3.3**)

(3) Notwithstanding the requirement in (2), deck openings on the strength deck need not be deducted, provided that the sum of their breadths in one transverse section is not reducing the section modulus at deck or bottom by more than 3%.

(4) Deck openings prescribed in (2) and (3) include

Table 3.3.1 Section Modulus of Transverse Sections of Hull, etc.

Item	Requirement
Section modulus	$Z_1 = \dfrac{\lvert M_S + M_W(+)\rvert}{\sigma} \times 10^3\ (cm^3)$ $Z_1 = \dfrac{\lvert M_S + M_W(-)\rvert}{\sigma} \times 10^3\ (cm^3)$
Minimum section modulus	$Z_{min} = C_1 L^2 B(C_b + 0.7)K\ \ (cm^3)$
Minimum moment of inertia	$I_{min} = 3C_1 L^3 B(C_b + 0.7)\ \ (cm^4)$

M_s = longitudinal bending moment in still water ($kN{\cdot}m$) at the transverse section under consideration along the length of hull, which is calculated by the method deemed appropriate by the Society. The value of M_S is defined as positive which is obtained assuming that downward loads are taken as positive and are integrated in the forwared direction from the aft end of the ship. Sign of positive M_S is shown in **Fig. 3.3.1.**

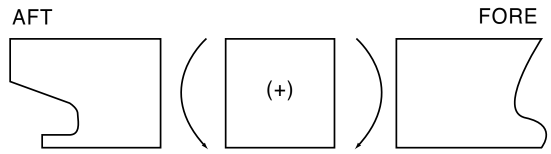


Fig. 3.3.1 Sign Convention of Bending Moment

$M_W(+)$ and $M_W(-)$ = wave induced longitudinal bending moments (kN-m) at the transverse section under consideration along the length of hull, which are obtained from the following formulae,

$$M_W(+) = +0.19C_1C_2L^2BC_b \qquad (kN \cdot m)$$
$$M_W(-) = -0.11C_1C_2L^2B(C_b + 0.7) \qquad (kN \cdot m)$$

σ = allowable bending stress obtained from the following formula.

$\sigma = 175/K$

C_1 = coefficient given by the following table.

$L(m)$	C_1
$90 \le L \le 300$	$10.75 - \left(\dfrac{300 - L}{100}\right)^{1.5}$
$300 < L \le 350$	10.75
$350 < L \le 500$	$10.75 - \left(\dfrac{L - 350}{150}\right)^{1.5}$

C_2 = distribution factor specified along the length of L at positions where the transverse section of the hull is under consideration, as given in **Fig. 3.3.2.**

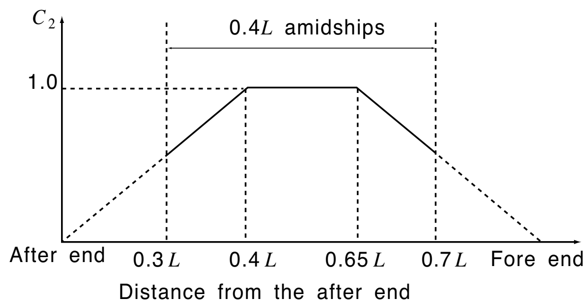
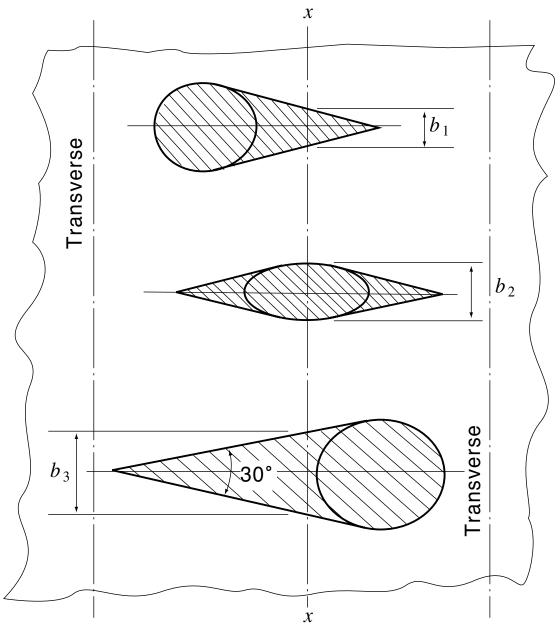


Fig. 3.3.2 Value of Coefficient C_2

C_b = block coefficient, however, to be taken as 0.6, where it is less than 0.6.



$$\Sigma b_i = b_1 + b_2 + b_3$$

Fig. 3.3.3 Deck openings on the strength deck

shadow area which is obtained by drawing two tangential lines with an opening angle of 30 *degrees* having the focus on the longitudinal line of the ship. (See **Fig. 3.3.3**)

(5) Continuous trunks and longitudinal hatch coamings are to be included in the longitudinal sectional area provided they are effectively supported by longitudinal bulkheads or deep girders. And the section modulus at the strength deck is to be calculated by dividing the moment of inertia of the athwartship section about its horizontal neutral axis by the following distance (a) or (b), whichever is the greater.

(a) Vertical distance from the neutral axis to the top of the strength deck beam at side.

(b) Distance obtained from the following formula:

$$Y\left(0.9 + 0.2\frac{X}{B}\right)$$

where:

X = horizontal distance from the top of continuous strength member to the centre line of the ship (m).

Y = vertical distance from the neutral axis to the top of continuous strength member (m).

X and Y are to be measured to the point giving the largest value of the above formula.

(6) The section modulus at the bottom is to be calculated by dividing the moment of inertia of the athwartship section about its horizontal neutral axis by the vertlcal distance from the neutral axis to the top of keel.

SECTION 3 Shear Strength

301. Thickness of side shell of ships without the effective longitudinal bulkhead

1. Thickness of side shell plating of ships without the effective longitudinal bulkhead is not to be less than the values obtained from the following formulae the transverse section under consideration along the length of hull for all conceivable loading and ballasting conditions.

$$t = \frac{0.5\left|F_s + F_w(+)\right|}{\tau}\cdot\frac{Q}{I}\times 10^2\ (mm)$$

$$t = \frac{0.5\left|F_s + F_w(-)\right|}{\tau}\cdot\frac{Q}{I}\times 10^2\ (mm)$$

I = moment of inertia (cm^4) of the transverse section under consideration about its horizontal neutral axis, where the requirements in **203.** are to be applied to the calculation method.

Q = at the transverse section under consideration, moment of area about the horizontal neutral axis (cm^3) for the longitudinal members above the horizontal line passing through the considered position of side shell plating in case the considered position is above the horizontal axis, or for the longitudinal members under the horizontal line in case the considered position is under the horizontal neutral axis, where the requirements in **203.** are to be applied to the calculation method.

τ = allowable shear stress obtained from the following formula.

$$\tau = 110/K\quad (N/mm^2)$$

F_S = shear force in still water (kN) at the transverse section under consideration which is calculated by the method deemed appropriate by the Society. The value of F_S, is defined as positive which is obtained assuming that downward loads are taken as positive and are integrated in the forward direction from the aft end of the ship. Sign of F_S shown in **Fig. 3.3.4** is taken as positive.

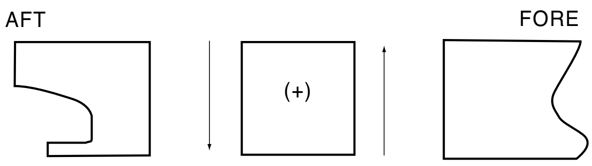


Fig 3.3.4 Sign Covention of Shear Force

$F_w(+)$ and $F(-)$ = wave induced shear forces(kN) at the transverse section under consideration along the length of hull, which are obtained from the following formulae.

$$F_W(+) = +0.30\,C_1C_3LB(C_b + 0.7) \quad (kN)$$
$$F_W(-) = -0.30\,C_1C_4LB(C_b + 0.7) \quad (kN)$$

C_1, C_b = as specified in **Table 3.3.1.**
C_3 and C_4 = distrbution factor to be determined at the position of the transverse section under consideration along the length of the ship, where the value is to be as specified in **Fig. 3.3.5** and **3.3.6.**

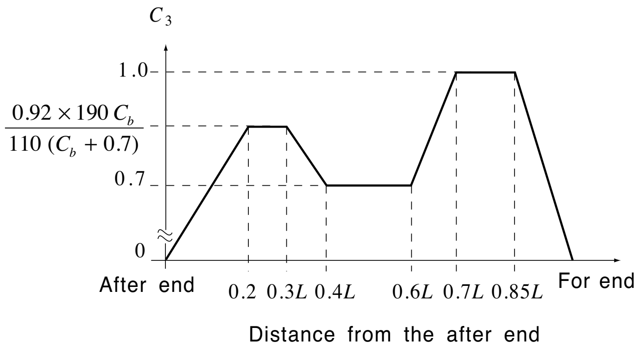


Fig 3.3.5 Value of Coefficient C_3

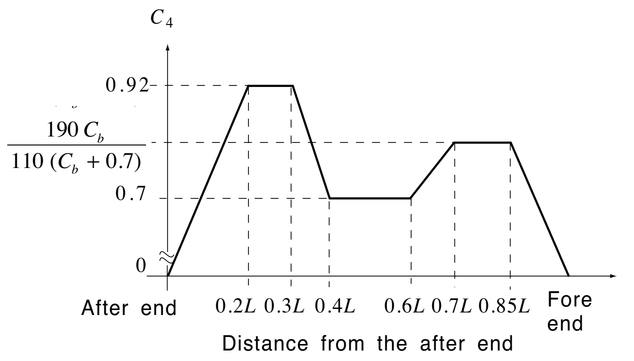


Fig 3.3.6 Value of Coefficient C_4

2. In case of ships which have bilge hopper tanks or top side tanks, or ships of which other longitudinal members below the stregth deck are considered to shar a part of the shear force effectively, the thickness of side shell plate required by **Par 1** may be reduced at the discretion of the Society.

302. Thickness of side shell and longitudinal bulkhead plating of ships having one to four rows of longitudinal bulkheads

Thickness of side shell and longitudinal bulkhead plating of ships specified **Fig 3.3.7** is not to be less than the value obtained from the following formula at the transverse section under consideration along the length of hull for all conceivable loading and ballasting conditions. Where, however, ships with double side hull construction provided with bilge hoppers in double side hull structure are to be as deemed appropriate by the Society.

$$t = \frac{FQ}{\tau I} \times 10^2 \quad (mm)$$

where:

t, I, and Q = as specified in **301.**
F = shear force acting on the side shell plating or longitudinal bulkhead plating, the value of which is to be the following $F(+)$ or $F(-)$, whichever is the greater (kN):

$$F(+) = \left|\alpha(F_s + F_w(+)) + \Delta F\right|$$
$$F(-) = \left|\alpha(F_s + F_w(-)) + \Delta F\right|$$

F_S, $F_w(+)$ and $F_w(-)$ = as specified in **301.**
α = sharing factor of shear force shared by the side shell and longitudinal bulkhead, the value of which is to be deemed appropriate by the Society. However, unless otherwise specially specified, α may be obtained from the formulae in **Table 3.3.2.**
ΔF = shear force acting on side shell and longitudinal bulkhead due to local load (kN) the value of which is to be as deemed appropriate by the Society. However, unless otherwise specially specified, ΔF may be obtained from the formulae in **Table 3.3.2.**

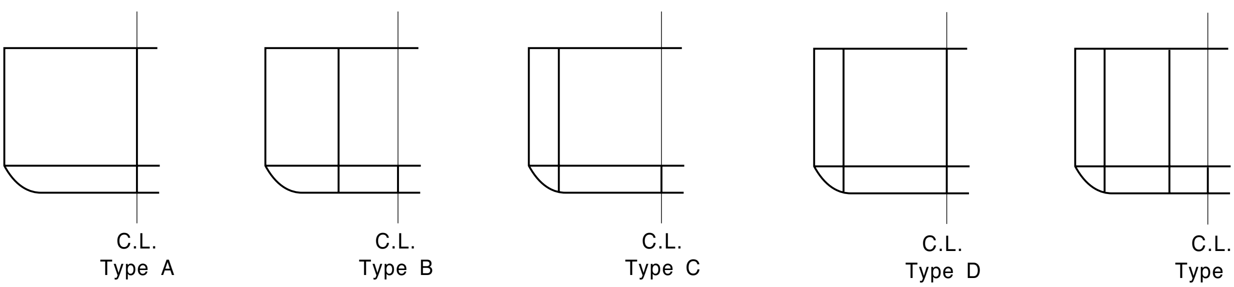


Fig. 3.3.7 Types of A Ship with Longitudinal Bulkheads

Table 3.3.2 Values of α and ΔF

Ship type	Application	$\alpha(=\alpha_1 \times \alpha_2)$		$\Delta F\left(= n_i\left(R - \alpha f\right)\right)$	
		α_1	α_2	R	f
A	Side shell	$0.5 - \dfrac{0.575k_1A_L}{2A_S + A_L}$	1	$4.9W_bbS$	$19.6W_bbS$
	Longitudinal bulkhead	$\dfrac{0.575k_1A_L}{2A_S + A_L}$	2	$9.8W_bbS$	
B	Side shell	$0.5 - \dfrac{0.55k_1A_L}{A_S + A_L}$	1	$4.9W_bbS$	$19.6\left(W_aa + W_bb\right)S$
	Longitudinal bulkhead	$\dfrac{0.55k_1A_L}{A_S + A_L}$		$9.8\left(\beta W_aa + 0.5W_bb\right)S$	
C	Side shell	0.5	$1 - \dfrac{1.06k_2A_{DL}}{A_S + A_{DL}}$	$4.9\left(\beta W_aa + W_cc\right)S$	$19.6\left(W_aa + W_cc\right)S$
	Longitudinal bulkhead		$\dfrac{1.06k_2A_{DL}}{A_S + A_{DL}}$		
D	Side shell	$0.5 - \dfrac{0.675k_1A_L}{2\left(A_S + A_{DL}\right) + A_L}$	$1 - \dfrac{1.05k_2A_{DL}}{A_S + A_{DL}}$	$4.9\left(0.5W_bb + W_cc\right)S$	$19.6\left(W_bb + W_cc\right)S$
	Outer longitudinal bulkhead		$\dfrac{1.05k_2A_{DL}}{A_S + A_{DL}}$		
	Centre longitudinal bulkhead	$\dfrac{0.675k_1A_L}{2\left(A_S + A_{DL}\right) + A_L}$	2	$9.8W_bbS$	
E	Side shell	$0.5 - \dfrac{0.615k_1A_L}{A_S + A_{DL} + A_L}$	$1 - \dfrac{1.04k_2A_{DL}}{A_S + A_{DL}}$	$4.9\left(0.5W_bb + W_cc\right)S$	$19.6\left(W_aa + W_bb + W_cc\right)S$
	Outer longitudinal bulkhead		$\dfrac{1.04k_2A_{DL}}{A_S + A_{DL}}$		
	Inner longitudinal bulkhead	$\dfrac{0.615k_1A_L}{A_S + A_{DL} + A_L}$	1	$9.8\left(\beta W_aa + 0.5W_bb\right)S$	

NOTE:

k_1 = value is to be as specified in (a) to (c) below for longitudinal bulkheads other than those provided in double side hull.

k_2 = value is to be as specified in (a) to (c) below for longitudinal bulkheads provided in double side hull.
Where, however, values of k_1, and k_2 may be suitably modified for cases where members considered to share part of shear force are provided:

(a) 0, for the part not provided with longitudinal bulkhead

(b) 1.0, for the part provided with longitudinal bulkhead excluding the length of $0.5D_s$ respectively from both ends.

(c) Value obtained by linear interpolation for the intermediate parts between those specified in (a) and (b).

A_s, A_L, and A_{DL} = sectional area of side shell plating amidships, longitudinal bulkhead plating provided other than in double side hull, and longitudinal bulkhead plating in double side hull, respectively at midship part(mm^2).

W_a, W_b, and W_c = value obtained from the following formula, respectively:

$$W_a = h_a + h_d - d'$$
$$W_b = h_b + h_d - d'$$
$$W_c = h_c + h_d - d'$$

d' = draught at the part concerned in the loading condition under consideration(m).

h_a, h_b, h_c, and h_d = water head converted from the pressure of cargo or ballast in the centre tanks, wing tanks, double side hull tanks(excluding double bottom parts) and double bottom tank in the loading conditions under consideration, respectively(m). In this connection, even in case where the double hull forms one single tank, the requirements apply separately to a portion of the double side hull tank and portion of double bottom tank. In case where the double bottom tank is divided within either a, b or c, h_d is to be determined for respective ranges of the tank divided.

a, b and c = half breadth of the centre tank, breadth of wing tanks, and breadth of double side hull tanks(m).

S = spacing of floors in double bottom(m).

n_i = number of floors in double bottom from the mid-point of transverse bulkheads to the section under consideration in double bottom. The sign of n_i is negative when counted afterward and positive when counted forward. Where, however, a swash bulkhead with an opening ratio of not less than 20% is not to be considered as a transverse bulkhead. When a floor is proveded at mid-point between transverse bulkheads, n_i in this case, is to be obtained counting the floor as 0.5.

β = as specified by the following table.

Description	β
where effective centre girder is provided	0.7
wnere no effective centre girder is provided	1.0

303. Compensation for opening

Where openings are provided in the shell plating, sufficient consideration is to be paid to the shear strength and suitable compensation is to be made as necessary.

SECTION 4
Buckling Strength

401. Apllication

The requiremints in this section apply to the buckling strength of panels and longitudinal frames subject to hull girder bending stress and shear stress.

402. Working stress

1. Compression stresses

The compression stress $\sigma_{act}(N/mm^2)$ acting on the members under consideration are given in the following formula, however, minimum value is not to be less than $30/K$:

$$\sigma_{act} = \frac{(M_s + M_w)}{I} y \times 10^5 \quad (N/mm^2)$$

where:

M_S = as specified in **Table 3.3.1.** For strength deck, value of M_w is taken 0 in case that M_s is always positive.

M_w = wave bending moment as given in **Table 3.3.1.** For the members above the neutral axis of transverse section of hull, value of M_w is taken $M_w(+)$ and for the members under, value of M_w is taken $M_w(-)$.

y = distance(m) from the neutral axis of transverse section of hull to the considered point.

I = as specified in **301. 1.**

2. Shear stresses

The shear stress $\tau_{act}(N/mm^2)$ acting on the members under consideration are given in the following formula:

(1) For ships not provided the effective longitudinal bulkheads

$$\tau_{act} = \frac{0.5\,|F_s + F_w|}{t} \times \frac{Q}{I} \times 10^2 \ (N/mm^2)$$

where:

F_s, Q and I = as specified in **301. 1.**

F_w = absolute value of $F_w(+)$ or $F_w(-)$ as given in **301. 1.,** whichever is the greater.

t = actual thickness of the considered plate(mm).

(2) For ships having one to four row longitudinal bulkheads.

$$\tau_{act} = \frac{FQ}{tI} \times 10^2 \ (N/mm^2)$$

where:

Q = as specified in **301. 1.**

F = as specified in **302.**

t and I = as specified in (1).

403. Elastic buckling stresses

1. Elastic buckling of plates

(1) Compression

The ideal elastic buckling stress $\sigma_E(N/mm^2)$ is determined by the following formula:

$$\sigma_E = 0.9\,kE\left(\frac{t_b}{1000\,b}\right)^2 \quad (N/mm^2)$$

where:

k = value is determined the following formulae depending on direction of working stress:

(a) longitudinal framing panel:

$$k = \frac{8.4}{\varphi + 1.1}$$

(b) transverse framing panel:

$$k = C\left\{1 + \left(\frac{b}{a}\right)^2\right\}^2 \frac{2.1}{\varphi + 1.1}$$

E = modulus of elasticity of material. For steels, $E = 2.06 \times 10^5$ (N/mm^2)

t_b = net thickness of plate(mm), considering standard deductions equal to the values given in **Table 3.3.3.**

b = length of shorter side of panel(m)

a = length of longer side of panel(m)

C = factor depending on kind of stiffeners on longer side of panel is as following:

When plating stiffened by floors or deep girders: $C = 1.3$

When stiffeners are angles or T-section: $C = 1.21$

When stiffeners are bulb plates: $C = 1.10$

When stiffeners are flat bar : $C = 1.05$

φ = ratio between smallest and largest compression stress σ_{act} when linear variation across panel. $(0 \le \varphi \le 1)$

(2) Shear

The ideal elastic buckling stress τ_E (N/mm^2) is

Table 3.3.3 Standard deduction

Structure	Standard deduction (mm)	Limit values min-max (mm)
- Compartments carrying dry bulk cargoes - One side exposure to ballast and/or liquid cargo Vertical surfaces and surfaces sloped at an angle greater than 25° to the horizontal line	0.05 t	0.5~1 mm
- One side exposure to ballast and/or liquid cargo Horizontal surfaces and surfaces sloped at an angle less than 25° to the horizontal line - Two side exposure to ballast and/or liquid cargo Vertical surfaces and surfaces sloped at an angle greater than 25° to the horizontal line	0.10 t	2~3 mm
- Two side exposure to ballast and/or liquid cargo Horizontal surfaces and surfaces sloped at an angle less than 25° to the horizontal line	0.15 t	2~4 mm

determined by the following formula:

$$\tau_E = 0.9\, k_t E \left(\frac{t_b}{1000\, b} \right)^2 \quad (N / mm^2)$$

where:

k_t = factor depending on aspect ratio of panel is determined by the following formula:

$$k_t = 5.34 + 4 \left(\frac{b}{a} \right)^2$$

E, t_b, b and a = as specified in (1)

2. Ideal elastic buckling of longitudinals

The ideal elastic buckling of longitudinals is calculated by the method deemed appropriate by the Society.

404. Critical buckling Stresses

1. Compression

The critical buckling stresses σ_c in compression is determined as following:

$$\sigma_c = \sigma_E \qquad \text{for} \quad : \sigma_E \le 0.5\,\sigma_y$$

$$\sigma_c = \sigma_y \left(1 - \frac{\sigma_y}{4\,\sigma_E} \right) \qquad \text{for} \quad : \sigma_E > 0.5\,\sigma_y$$

where:

σ_y = yield stress of material of the member considered, which are given as follows (N/mm^2) :

235 = for mild steels as specified in **Pt 2, Ch 1**

315 = for high tensile steels $RA32$, $RD32$, $RE32$ or $RF32$ as specified in **Pt 2, Ch 1**

355 = for high tensile steels $RA36$, $RD36$, $RE36$ or $RF36$ as specified in **Pt 2, Ch 1**

σ_E = ideal elastic buckling stress calculated according to **403., 1** (1)(N/mm^2).

2. Shear

The critical buckling stress τ_c in shear is determined as following:

$$\tau_c = \tau_E \qquad \text{for} \quad : \tau_E \le 0.5\,\tau_y$$

$$\tau_c = \tau_y \left(1 - \frac{\tau_y}{4\,\tau_E} \right) \qquad \text{for} \quad : \tau_E > 0.5\,\tau_y$$

where:

τ_y = shear stress of material, in N/mm^2, τ_y is to be determined as $\sigma_y / \sqrt{3}$

τ_E = ideal elastic buckling stress calculated to **401. 1** (2) (N/mm^2).

σ_y = as specified in **Par 1.**

405. Scantling criteria

1. The critical buckling stress σ_c of panel and longitudinal frames in compression calculated according to **404. 1** is to comply with the following formula:

$$\sigma_c \ge \beta \sigma_{act}$$

where:

β = safety facor is as following:
For plate panel and web plating of stiffeners: $\beta = 1.0$
For stiffeners: $\beta = 1.1$

σ_{act} = working stress as given in **402.**

2. The critical buckling stress τ_y of panel and longitudinal frames in shear calculated according to **404. 2** is to comply with the following formula:

$$\tau_c \ge \tau_{act}$$

where:

τ_{act} = working stress as given in **402.** ⚓

CHAPTER 4
PLATE KEELS AND SHELL PLATINGS

Section

SECTION 1
General

101. Consideration for corrosion

The thickness of shell plating at such parts that the corrosion considered excessive due to the location and/or special service condition of the ship is to be properly increased over that required in this Chapter.

102. Special consideration for contact with the quay, etc.

In cases where the service condition of the ship is considered to be such that there is possibility of indent of shell plating due to contact with the quay, etc., special consideration is to be given to the thickness of shell plating.

103. Consideration for ship with unusually large freeboard

Correction from the requirements in this Chapter will be specially considered where the ship has an unusually large freeboard.

104. Consideration for buckling

With regard to the prevention of buckling of the shell, in addition to complying with the requirements in **Ch 3, Sec 4.** sufficient consideration is to be paid to the prevention of buckling due to compression.

105. Continuity in thickness of the shell plating

Sufficient consideration is to be paid to the continuity in the thickness of shell plating and to the avoidance of remarkable difference between the thickness of the shell plating under consideration and that of the adjacent shell plating.

SECTION 2
Plate Keels

201. Breadth

The breadth of plat keel over whole length of the ship is not to be less than that obtained from the following formula:

$$b = 2L + 1000 \quad (mm)$$

202. Thickness

The thickness of plate keel over whole length of the ship is not to be less than the thickness of the bottom shell for the midship part obtained from the requirements in **304.** increased by 2.0 mm. This thickness, however, is not to be less than that of the adjacent bottom shell plating.

SECTION 3
Shell Plating below Strength Deck

301. Minimum thickness

The thickness of shell plating below the strength deck is not to be less than that obtained from the following formula:

$$t = \sqrt{L} \quad (mm)$$

302. Thickness of side shell plating

The thickness of side shell plating other than the sheer strake of the strength deck of the midship part is to be as required in the following formula, in addition to the requirement specified in **Ch 3, 301.** and **302.**

$$t = C_1 C_2 S \sqrt{d - 0.125D + 0.05L' + h_1} + 1.5 \, (mm)$$

where:

S = spacing of frames (m).

L' = length of ship (m). Where, however, L exceeds 230 m, L is to be taken as 230 m.
h_1 = as given in (a) or (b).
(a) For 0.3 L from the fore end:
$2.25\ (17-20\,C_b')\ (1-x)^2$
(b) For elsewhere except (a) : 0
C_b' = block coefficient. Where, however, C_b exceeds 0.85, C_b' is to be taken as 0.85.
C_1, C_2 and x = coefficient given in **Table 3.4.1.**

Table 3.4.1 Coefficients C_1 and C_2

Framing	C_1	C_2
Transverse	$L \le 230m$: 1.0 $L \ge 400m$: 1.07 For intermediate values of L, C_1 is to be obtained by linear interpolation.	$91\sqrt{\dfrac{K}{576-\alpha^2K^2x^2}}$
Longitudinal		$13\sqrt{\dfrac{K}{24-\alpha Kx}}$ But, in no case is it to be less than $3.78\sqrt{K}$

α = either α_1 or α_2 according to value of y. However, value of α is not to be less than β.

$$\alpha_1 = 15.0 f_D\left(\frac{y-y_B}{Y'}\right) \quad \text{for} \quad y_B \le y$$

$$\alpha_2 = 15.0 f_B\left(\frac{y_B-y}{y_B}\right) \quad \text{for} \quad y_B > y$$

y_B = vertical distance from the top of keel at midship to the horizontal neutral axis of the athwartship section of hull (m).
y = distance(m) from the top of keel to the lower edge of plating when the platings under consideration are under y_B and to the upper edge of plating when the platings under consideration are above y_B, respectively.
Y' = the greater of the value specified in **Pt 3, Ch 3, 203.,** (5) (a) or (b)
β = coefficient determined according to values of L as specified below:

β = $6/a$ when L is 230 m and under
β = $10.5/a$ when L is 400 m and above

For intermediate values of L, β is to be obtained by liner interpolation.
a = $\sqrt{K}$ when high tensile steels are used for not less not less than 80 % of side shell plating at the transverse section amidship and 1.0 for other parts.
x = as given by the following formula.

$$x = \frac{X}{0.3L}$$

X = distance from the fore end to the part under consideration for the side shell plating afore the midship, or from the after end to the part under consideration for the side shell plating after the midship (m). Where, however, X is less than 0.1 L, X is to be taken as 0.1 L and where X exceeds 0.3 L, X is to be taken as 0.3 L.

303. Sheer strakes for midship part

The thickness of sheer strakes at the strength deck for midship part is not to be less than 0.75 times that of the stringer plate of the strength deck. In no case, however, is the thickness to be less than that of the adjacent side shell plating.

304. Thickness of bottom shell plating

The thickness of bottom shell plating for the midship part is not to be less than that obtained from the following formula.

$$t = C_1C_2S\sqrt{d+0.035L'+h_1} + 1.5 \quad (mm)$$

where:

S = spacing of transverse frames or longitudinals (m).
L', C_1, h_1 = as specified in **302.**
C_2 = coefficient given in **Table 3.4.2.**

Table 3.4.2 Coefficient C_2

Framing	C_2
Transverse	$91\sqrt{\dfrac{K}{576-(15.0f_BKx)^2}}$
Longitudinal	$13\sqrt{\dfrac{K}{24-15.0f_BKx}}$ But, in no case is it to be less than 3.78 $\sqrt{K}$
x = as specified in **Table 3.4.1**	

305. Bilge plates

1. The thickness of bilge plates is not to be less than that obtained from the following formula. However, it is not to be less than the thickness of the adjacent bottom plating.

$$t = \left\{5.22(d+0.035L')\left(R+\frac{a+b}{2}\right)^{\frac{3}{2}} l\right\}^{\frac{2}{5}} + 1.5 \quad (mm)$$

where:

R = bilge radius (m). (see **Fig. 3.4.1**)
a, b = distance from the lower and upper turns of bilge to the longitudinal frames nearest to the turns respectively, taking the distance outward from the bilge part as positive (m). Where, however, $(a+b)$ is negative, $(a+b)$ is to be taken as zero. (see **Fig. 3.4.1**)
L' = as specified in **302.**

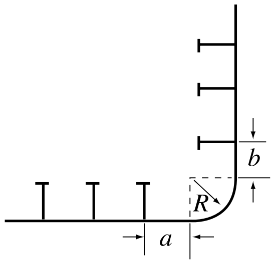


Fig. 3.4.1 Measurement of a and b

l = spacing of solid floors, bottom transverses or bilge brackets (m).

2. Where some of longitudinal frames at bilge part in longitudinal framing system is omitted, longitudinal frames are to be provided as near to the turns of bilge as practicable and suitably constructed to maintain the continuity of strength.

3. Where longitudinal frames are provided at bilge part at nearly the same spacing as that of bottom longitudinals, the bilge plates may be in accordance with the requirements in **304.** irrespective of the requirements in **Par 1.**

Table 3.4.3 Thickness of Shell Plating at the Strengthened Bottom Forward

Bow draft d_F	Thickness (mm)
$d_F \le 0.025L'$	$t = 0.9CS\sqrt{PK} + 1.5$
$d_F \ge 0.037L'$	$t = 1.34S\sqrt{L'K} + 1.5$

L' = as defined in **302.**
S = spacing of frames, girders or longitudinal shell stiffeners, whichever is the smallest (m).
P = slamming impact pressure specified in **Ch 7, 804.**
C = coefficient given in following formula.

$$C = \left(1.1 - 0.25\frac{S}{l}\right)^2$$

Where, however, S/l is less than 0.4, C is to be taken as 1.0 and where S/l is 1.0, C is to be taken as 0.72.
l = spacing of frames, girders or longitudinal shell stiffeners, whichever is greater (m).

NOTES:
In ships having intermediate value of the bow draught at the ballast condition specified in the above Table, the thickness is to be obtained by linear interpolattion.

SECTION 4
Special Requirements for Shell Plating

401. Large flared ship

With regard to the shell plating at a location where flare is specially large, sufficient consideration is to be paid to the reinforcement against panting impact, etc. at bow.

402. Shell plating stiffened in a spacing remarkably different from the frame spacing

Where the stiffener spacing measured along the shell plating supported by frames is remarkably different from the frame spacing, the shell plating is to be reinforced in consideration of the stiffener spacing, for example, by suitably increasing in thickness.

403. Aft part of ships with specially high power engines

With regard to the shell plating at the aft part of ships with specially high power engines compared with the ship length, sufficient consideration is to be paid to the reinforcement against vibration.

404. Strengthened bottom forward

1. The thickness of shell plating at the strengthened bottom forward in ships having the bow draught at the ballast condition is not to be less than that obtained from the formula given in **Table 3.4.3.**

2. Notwithstanding the requirements in **Par 1,** in ships of which L and C_b are not more than 150 m and 0.7 respectively and $V(kt)/\sqrt{L\ (m)}$ is 1.4 and over, the thickness of shell plating at the stregthened bottom forward is to be increased to a value deemed appropriate by the Society.

405. Spectacle bossings and stern frames

The thickness of shell plating fitted up on spectacle bossings and stern frams is not to be less than that obtained from the following formula. Where, however, the spacing of transverse frames in afterpeak exceeds 610 mm or the length of ship exceeds 200 m, the thickness of shell plating concerned is to be in accordance with the satisfaction of the Society.

$$t = 0.09L + 3.5 \quad (mm)$$

SECTION 5
Side Plating in way of Superstructure

501. Superstructure deck not designed as strength deck

Where the superstructure deck is not designed a strength deck, the thickness of superstructure side plating is not to be less than that obtained from the formula given in **Table 3.4.4,** but not less than 5.5 mm. Side plating of superstructures exceeding

Table 3.4.4 Thickness of Superstructure Side Plating

Location	Thickness (mm)
For 0.25L from the fore end	$t = 1.15 S \sqrt{KL} + 1.0$
Elsewhere	$t = 0.94 S \sqrt{KL} + 1.0$
S = spacing of longitudinals or transverse frames (m).	

0.15L in length, except at the end parts, is to be suitably increased in thickness.

SECTION 6
Compensation at ends of Superstructure

601. Strengthening method

Breaks of superstructures are to be strengthened according to the following requirements:

(1) The sheer strakes of the strength deck, clear of the superstructure, are to be extended well into the superstructure and to be increased in thickness by not less than 20% above the normal thickness of sheer strakes, for a distance well inside and outside the superstructure end.
(2) The side plating of the superstructure is to be tapered into upper deck sheer strakes to avoid abrupt change of the form at the breaks. The thickness of side plating at the superstructure end is to be increased approximately by 20% above the normal thickness of superstructure side plating.
(3) For the breaks of superstructures located at fore and after end parts, the requirements in (1) and (2) may be suitably modified.

602. Openings in shell

Gangway ports, large freeing ports and other openings in the shell or bulwarks are to be kept well clear of the break. Where holes are necessarily provided in the plating near breaks, they are to be kept as small as possible and to be circular or oval in form.

SECTION 7
Local Compensation of Shell Plating

701. Openings in shell

All openings in the shell plating are to have well rounded corners and to be compensated as necessary.

702 Thickness of sea chest

In case where a sea chest is provided in the shell plating for sea suction or discharge the thickness of sea chest is not to be less than that obtained from the following formula and to be suitably stiffened so as to provide sufficient rigidity as necessary. The thickness, however, is not to be less than the thickness of shell plating where the sea chest is installed.

$$t = \sqrt{L} + 1.0 \qquad (mm)$$

703. Location of openings

Openings for cargo ports, coaling ports, etc. are to be kept well clear of discontinuous parts in the hull construction, and they are to be locally compensated so as to maintain the longitudinal and transverse strengths of the hull.

704. Hawse pipes and the plating below

The shell plating fitted with hawse pipes and the plating below is to be increased in thickness or to be doubled, and their longitudinal seams are to be protected against damages by anchors or cables. ⚓

CHAPTER 5
DECKS

SECTION 1
General

101. Steel deck plating

Decks are to be plated from side to side of the ship except deck openings, etc. Decks, however, may be provided with only stringer plates and tie plates, subject to the approval by the Society.

102. Watertightness of decks

Weather decks are to be made watertight.

103. Continuity of steps of decks

Where strength deck or effective decks (the decks below the strength deck which are considered as strength members in the longitudinal strength of hull) change in level, the change is to be accomplished by gradually sloping, or each of structural members which form deck is to be extended, and is to be effectively tied together by diaphragms, girders, brackets, etc. and special care is to be taken for the continuity of strength.

104. Compensation for openings

Hatchways or other openings on strength or effective decks are to have well rounded corners, and compensation is to be suitably provided as necessary.

105. Rounded gunwales

Rounded gunwales, where adopted, are to have a sufficient radius for the thickness of plates.

SECTION 2
Effective Sectional Area of Strength Deck

201. Definition

The effective sectional area of strength deck is the sectional area, on each side of the ship's centre line, of steel plating, longitudinal beams, longitudinal girders, etc. extending for $0.5L$ amidships.

202. Effective sectional area of strength deck

1. The effective sectional area for the midship part is to be so determined as not to give less modulus of athwartship section of the hull specified in **Ch 3.**

2. Beyond the midship part, the effective sectional area may be gradually reduced, however, at $0.15L$ from each end it is not to be less than 40% for ships with machinery amidship and 50% for ships with machinery aft, of the area required for the midship part.

3. Where the section modulus of the hull at $0.15L$ from each end is calculated and approved by the Society, the requirements specified in **Par 2** may not be applied.

203. Strength deck beyond 0.15L from each end

Beyond $0.15L$ from each end, the effective sectional area and the thickness of strength deck may be gradually reduced avoiding abrupt change.

204. Long poop

Notwithstanding the requirements of **202.,** the effective sectional area of strength deck within long poop may be properly modified.

205. Superstructure deck designed as strength deck

Where the superstructure deck is designed as strength deck, the strength deck plating clear of the superstructure is to extend into the superstructure for about $0.05L$ without reducing the effective sectional area, and may be gradually reduced within.

SECTION 3
Deck Plating

301. Thickness

1. The thickness of deck plating is to be as specified in **Table 3.5.1,** however, within such enclosed

Table 3.5.1 Thickness of deck plating

Kind of deck	Location	Framing	Thickness (mm)
Strength deck	Outside the line of openings for the midship part	Longitudinal systems	$t = 1.47SC\sqrt{Kh} + 1.5$
		Transverse systems	$t = 1.63SC\sqrt{Kh} + 1.5$
	Elsewhere		$t = 1.25SC\sqrt{Kh} + 1.5$
Other deck			

S = spacing of longitudinal or transverse beams.
C = coefficient obtained from the following formula:

$$C = 0.905 + \frac{L'}{2430}$$

L' = length of ship (m). Where, however, L is 230 m and under, L' is to be taken as 230 m, and where L is 400 m and above, L' is to be taken as 400 m.
h = deck load as specified in **Ch 10, 201.** (kN/m^2)

spaces as superstructures, deckhouses, etc., the thickness may be reduced by 1.0 mm.

2. Where strength deck is transversely framed, or decks inside the line of openings are longitudinally framed, sufficient care is to be taken to prevent buckling of the deck plating.

302. Thickness of the top of tanks

The thickness of deck plating forming the top of tanks is not to be less than that required in **Ch 15, 208.** for deep tank bulkhead plating, taking the beam spacing as the stiffener spacing.

303. Thickness of the bulkhead recesses

The thickness of deck plating forming the top of shaft tunnels, thrust recesses or bulkhead recesses is not to be less than that required in **Ch 14, 309.** for watertight bulkhead plating, taking the beam spacing as the stiffener spacing.

304. Under boilers or refrigerated cargoes

1. The thickness of effective deck plating under boilers is to be increased by 3 mm above the normal thickness.

2. The thickness of deck plating under refrigerated cargoes is to be increased by 1 mm above the normal thickness. Where special means for the protection against the corrosion of the deck is provided, the thickness need not be increased.

305. Loaded by wheeled vehicles

The thickness of deck plating loaded by wheeled vehicles is to be determined by considering the concentrated loads from the wheeled vehicles.

SECTION 4
Wood Decks and Deck Compositions

401. Quality of wood planks

1. Planks of wood decks are to be of good quality, thoroughly seasoned, free from rot, sap and shakes and reasonably free from bad knots.

2. Teaks and similar woods are treated as hard wood, and cedars and similar woods as soft wood.

402. Scantlings of wood planks

Hard wood planks are not to be less than 50 mm in thickness and soft wood planks not less than 63 mm. They are to be effectively arranged and fastened. For decks used for accommodation or navigation spaces, the thickness may be properly reduced.

403. Deck composition

The deck composition is to be non-destructive to steel, or to be effectively insulated from the steel by a suitable protecting covering. The composition is to be effectively laid on the deck so that the composition may not cause cracks, exfoliation, etc.

CHAPTER 6
SINGLE BOTTOMS

SECTION 1
General

101. Application

1. The requirements in this Chapter are given for ships of less than 100 m in length. For ships of 100 m and above in length the requirements are to be determined at the discretion of the Society.
2. The bottom constructions in way of fore and after peaks are to be in accordance with the requirements in **Ch 13, 201.** and **301.**

SECTION 2
Centre Keelsons

201. Arrangement and construction

All single bottom ships are to have centre keelsons composed of girder plates and rider plates, and the centre keelsons are to extend as far forward and afterward as practicable.

202. Centre girder plates

1. The thickness of continuous plates or intercostal plates of centre keelsons is not to be less than that obtained from the following formula. Beyond the midship part, the thickness may be gradually reduced and it may be 85 % of the midship value at the ends of the ship.

$$t = 0.065L + 4.2 \quad (mm)$$

2. The girder plates are to extend to the top of floors.

203. Rider plates

The rider plates are to extend from the collision bulkhead to the aft peak bulkhead and the thickness is not to be less than that required for the continuous centreline plates amidships. The breadth of rider plates is not to be less than that obtained from the following formula or 400 mm whichever is the greater, and where it is more than 400 mm the breadth may be gradually reduced beyond the midship part to the ends where it may be 80 % of the required breadth or 400 mm, whichever is the greater.

$$b = 16.6L - 200 \quad (mm)$$

204. Centre keelsons in boiler rooms

The thickness of the members forming the centre keelson is to be increased by 1.5 mm in boiler rooms.

SECTION 3
Side Keelsons

301. Arrangements

1. Side keelsons are to be so arranged that their spacing is not more than 2.15 m between the centre keelson and the lower turn of bilge.
2. At least one row of shell stiffener of proper size is to be provided within 0 4 L amidships between the centre keelson and the side keelson, between the side keelsons, and between the side keelson and the lower turn of bilge.
3. In the space between the collision bulkhead and the position 0.05 L after the strengthened bottom forward, the spacing of side keelsons is not to exceed 0.9 m.

302. Construction

Side keelsons are to be composed of intercostal plates and rider plates and are to be extended as far forward and aftward as practicable.

303 Intercostal plates

1. The thickness of intercostal plates of side keelson is not to be less than that given by the following formula for the midship part. Beyond the midship part, the thickness may be gradually reduced to 85 % at the ends of the ship.

$$t = 0.042\,L + 4.8 \quad (mm)$$

2. In the machinery room the thickness of intercostal plates is not to be less than that required for the continuous centreline plates in **202.**

304. Rider plates

The thickness of rider plates for side keelson is not to be less than that of the midship intercostal plates and the sectional area of rider plates in the midship part is not to be less than that obtained from the following formula. The sectional area may be gradually reduced to 90% of the midship value at the ends of the ship.

$$A = 0.454\,L + 8.8 \quad (cm^2)$$

305. Side keelsons in boiler rooms

In the boiler rooms, the thickness of intercostal and rider plates is to be 1.5 mm greater than those required in **303.** and **304.** respectively.

SECTION 4
Floor Plates

401. Arrangements and scantlings

1. Floor plates are to be provided on every frame and the scantlings are not to be less than that obtained from the following formulae, but the thickness needs not exceed 12 mm.

Depth at the centre line: $d_0 = 62.5\,l \quad (mm)$
Thickness: $t = 0.01\,d_0 + 3 \quad (mm)$

where:

l = span between the toes of frame brackets measured amidships plus 0.3 m. Where curved floors are provided, the length l may be suitably modified. (See **Fig. 3.6.1**)

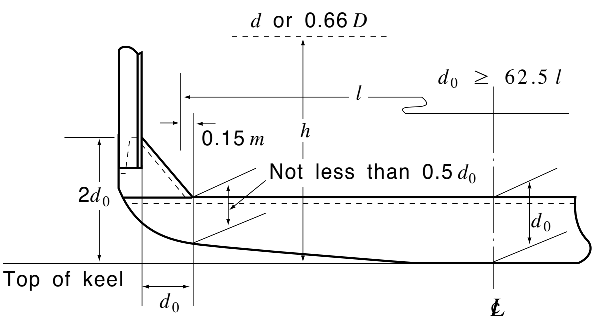


Fig. 3.6.1 Shape of Floors

2. Beyond 0.5 L amidships, the thickness of floor plates may be gradually reduced and at the end parts of the ship it may be 0.90 times the value specified in **Par 1.** In the flat part of bottom forward, this reduction is not to be made.

3. Floors under engines and thrust seats are to be of ample depth and to be specially strengthened. Their thickness is not to be less than that of the continuous centre girder plates.

4. The thickness of floors under boilers is to be increased by at least 2 mm above the thickness of midship floors. Where boilers are less than 457 mm clear of the floors, the thickness is to be further increased. This requirement may, however, be modified if the boiler is remote from floor plates or if the boiler is of such a type as well prevent excessive heat to the structures in the vicinity.

402. Depth of floors

1. Upper edges of floor plates at any part are not to be below the level of upper edge at the centre line.

2. In the midship part, the depth of floors measured at a distance d_0 specified in **401. 1** from the inner edge of frames along the upper edge of floors, is not to be less than 0.5 d_0. Where frame brackets are provided, the depth of floors at the inner edge of brackets may be 0.5 d_0. (See **Fig. 3.6.1**)

3. In ships having unusually large rise of floor, the depth of floor plates at the centre line is to be suitably increased.

403. Scantlings

1. Where face plates are fitted, the thickness of the face plate is not to be less than that required for the floor plate of that place. The sectional area of the face plates is not to be less than that given by the following formula:

$$A = 42.7\frac{Shl^2}{d_0} - \frac{d_0 t}{600} \quad (cm^2)$$

where:

l = as defined in **401.1.**
S = frame spacing (m).
h = d or 0.66 D, whichever is the greater (m).
d_0 = depth of floor plates at centre line (mm).
t = thickness of floor plates (mm).

2. Where the upper edge of floor plates is flanged, the breadth of flange is not to be less than that obtained from the following formula:

$$b = \frac{100\,A}{t} + 1.5\,t \quad (mm)$$

where:

A = sectional area of face plates defined in **Par 1.** (cm^2).

t = thickness of floor plates (mm).

3. The sectional areas of face plates are to be doubled for engine and boiler bearer floors. Flanging of floors at these parts is to be avoided.

404. Strengthened bottom forward

In the strengthening of bottom forward the floors are to be increased in their depth or the sectional areas of the face plates are to be doubled.

405. Frame brackets

The scantlings of frame brackets are to be determined in accordance with the requirements of the following. The free edge of the bracket is to be flanged.

(1) The height of the bracket measured from the top of keel is not to be less than twice the required depth of the floor plate at the centreline of the ship. (See **Fig. 3.6.1**)

(2) The arm of the bracket measured along the upper edge of the floor plate from the inner edge of frame is not to be less than the depth of the floor plate required at the centreline of the ship. (See **Fig. 3.6.1**)

(3) The thickness of frame brackets is not to be less than that of floor plates.

406. Drainage holes

Drainage holes are to be provided on the floor plates on both sides of the centreline and for ships with flat bottom also at the low parts of the turn of bilge.

407. Lightening holes

Lightening holes may be provided in floor plate. Where the holes are provided, appropriate strength compensation is to be made by increasing the floor depth or by some other suitable means.

408. Floor plates forming part of bulkheads

Floor plates forming part of bulkheads are to be in accordance with the requirements in **Chs 14** and **15.** ⚓

CHAPTER 7
DOUBLE BOTTOMS

Section

SECTION 1
General

101. Application

1. Ships, in principle, are to be provided with double bottoms extending from the collision bulkhead to the after peak bulkhead. The longitudinal system of framing is, in general, to be adopted.

2. Where, for special reasons, it is desired to omit double bottom partially, the arrangements are to be submitted to the Society for approval.

3. Double bottoms may be omitted in way of tanks of moderate size used exclusively for the carriage of liquids subject to the approval by the Society. Where the safety of ship is comfirmed although the bottom of ship is damages.

4. The scantlings of double bottom may be determined basing upon direct calculation, in case of special construction such as having inclined side shell or double side shell, where longitudinal bulkheads are provided, or for the parts beyond the midship part.

5. The scantlings of members in double bottom tanks intended to be deep tanks are to be correspondingly in accordance with the requirements in **Ch 15.** However, the thickness of inner bottom plating needs not be increased by one mm as given **Ch 15, 208.** for the top plating of deep tanks.

6. Wells for other purposes than draining water are not to be provided except where specially approved by the Society.

7. The requirements in this Chapter are to be applied, where the apparent specific gravity of cargoes in the loaded hold, γ is 0.9 and under. The requirements in **Pt 7, Ch 3** are to be correspondingly applied, where γ is more than 0.9, or to the holds which are empty in fully loaded condition, or to the ships which are provided with bilge hoppers. However, the specific gravity of cargoes, γ, is to be as obtained from the following formula:

$$\gamma = \frac{W}{V} \quad (t/m^3)$$

where:

W = mass of cargoes for the hold (t)
V = volume of the hold excluding its hatchway (m^3)

8. Double bottom structure of holds is to be subjected to special consideration, where intended to carry heavy cargoes or where the ratio of cargo weight per unit area (kN/m^2) of the inner bottom plating to d is less than 5.40.

102. Manholes and lightening holes

1. Manholes and lightening holes are to be provided in all non-watertight members to ensure access and ventilation except in way of pillars and where such openings are not permitted by the Rules. The size of holes should not in general exceed 50 % of the double bottom height, unless edge reinforcement is provided, and are to be shown in the plans submitted for approval. The edges of openings are to be made smooth.

2. Care is to be taken for locating the manholes in tank tops to avoid possibility of interconnection of main subdivision compartments through the double bottom so far as practicable.

3. Manhole covers in tank tops are to be of steel, and where no ceiling is provided in the cargo holds, the covers and their fittings are to be effectively protected against damages by cargoes.

103. Drainage

1. The bilge well in suitable size are to be provided for draining water which may gather on the double bottom.

2. The bottoms of bilge wells, except after the tunnel well, are to be situated at a distance of at least 460 mm from the top of keel.

3. The bilge well specified in **Par 2** are not to be formed by shell platings. Where, however, the bilge well are inevitably formed by shell platings due to the hull arrangements subject to the Society, the thickness of the shell platings forming of bilge well is to be increased by 2.5 mm to that of the adjacent shell plating.

104. Drain and air holes

Drain and air holes sufficient for the pumping rates are to be provided in all non-watertight members of the double bottom structure to give efficient passage of drain and air from all parts of the tank to the suction heads and air pipes.

105. Cofferdams

1. The following dedicated tanks are to be separated from adjacent tanks by cofferdams. However, these cofferdams may be omitted provided that the common boundaries of lubricating oil and fuel oil tank have full penetration welds.

   (1) Fuel oil
   (2) Lubricating oil
   (3) Vegetable oil
   (4) Fresh water

2. The cofferdams in **Par 1** are to be provided with the air pipes to comply with the requirements in **Pt 5, Ch 6, 201.** and with the manholes of adequate size which are well accessible.

106. Striking plates

Striking plates of adequate thickness or other approved arrangements are to be provided under sounding pipes to prevent from injuring the ship's bottom plating by striking of the sounding rod.

107. Strengthening under boilers

In the boiler room the thickness of structures in the tank under boilers are to be suitably increased. This requirement may, however, be modified if the boiler is remote from the tank top or if the boiler is of such a type as will prevent excessive heat to the structures in the vicinity.

108. Continuity of strength

1. Where the longitudinal system of framing is transformed into the transverse system, or the depth of double bottom changes suddenly, special care is to be taken for the continuity of strength by means of additional intercostal girders or floors.

2. In double bottoms under pillars or the toes of end brackets for bulkhead stiffeners, suitable reinforcement is to be provided by means of additional local side girders or floors.

109. Minimum thickness

No member of the double bottom structure is to be less than 6 mm in thickness.

SECTION 2
Centre Girders and Side Girders

201. Arrangement and construction

1. Centre girders are to be extended as far forward and afterward as practicable and centre girder plates are to be continuous for 0.5 L amidships.

2. Where double bottoms are used for carriage of fuel oil or fresh water, the centre girders are to be watertight and may be suitably modified in narrow tanks at the end parts of the ship or where other watertight longitudinal girders are provided at about 0.25 B from the centre line or where deemed appropriate by the Society.

3. Side girders in 0.5 L amidships and aft are to be so arranged that the distance from the centre girder to the first side girder, between girders, or from the outermost girder to the margin plate does not exceed approximately 4.6 $metres$ and to extend as far afterwards as practicable.

4. In the strengthened bottom forward of ships, side girders and half-height girders are to be provided as required by **802.**

5. Adequate strengthening is to be made under main engines and thrust seatings by means of additional full or half-height girders.

202. Depth of centre girders

The depth of centre girders is not to be less than that obtained from the following formula unless specially approved by the Society.

$$d_0 = 62.5\,B \quad (mm)$$

203. Thickness

The thickness of centre girder plates and side girder plates is not to be less than that obtained from the following requirements (1) and (2), whichever is the greater:

(1) The thickness is to be obtained from the following formula depending on the location in the hold:

$$t_1 = C_1 K \frac{SBd}{d_0 - d_1}\left(2.6\frac{x}{l_H} - 0.17\right) \times \left\{1 - 4\left(\frac{y}{B}\right)^2\right\} + 1.5 \quad (mm)$$

where:

S = distance between the centres of two adjacent spaces from the centre or side girder under consideration to the adjacent longitudinal girders or the line of toes of tank side brackets (m).
d_0 = depth of the centre or side girder under consideration (mm).
d_1 = depth of the opening at the point under consideration (mm).
l_H = length of the hold (m).
x = longitudinal distance between the centre of l_H of each hold and the point under consideration (m). Where, however, x is under $0.2\,l_H$, x is to be taken as $0.2\,l_H$, and where x is $0.45\,l_H$ and over, x may be taken as $0.45\,l_H$.
y = transverse distance from the centre line of ship to the longitudinal girder (m).
C_1 = coefficient given by the following formulae Where, however B/l_H is 1.4 and over, B/l_H is to be taken as 1.4, and where B/l_H is under 0.4, B/l_H is to be taken as 0.4.

Longitudinal framing: $C_1 = \dfrac{\left(3 - \dfrac{B}{l_H}\right)}{0.103}$

Transverse framing: $C_1 = \dfrac{\left(3 - \dfrac{B}{l_H}\right)}{0.09}$

(2) The thickness is to be obtained from the following formula:

$$t_2 = \frac{C'_1 d_0}{1000\sqrt{K}} + 1.5 \quad (mm)$$

where:

d_0 = depth of the girder at the point under consideration (mm). Where, however, horizontal stiffeners are provided at the half way of the depth of girder, d_0 is the distance from the horizontal stiffener to the bottom shell plating or inner bottom plating or the distance between the horizontal stiffeners (mm).
C'_1 = coefficient obtained from **Table 3.7.1** depending on S_1/d_0. For intermediate values of S_1/d_0, C'_1 is to be obtained by linear interpolation.
S_1 = spacing of the brackets or stiffeners provided on the centre girders or the side girders (mm).

Table 3.7.1 Coefficient C'_1

S_1/d_0	C'_1	
	Centre girders	Side girders
0.3 and under	4.4	3.6
0.4	5.4	4.4
0.5	6.3	5.1
0.6	7.1	5.8
0.7	7.7	6.3
0.8	8.2	6.7
0.9	8.6	7.0
1.0	8.9	7.3
1.2	9.3	7.6
1.4	9.6	7.9
1.6 and over	9.7	8.0

204. Brackets

1. Where longitudinal framing system is adopted in the double bottom, transverse brackets are to be provided between the solid floors with a spacing not more than 1.75 *metres* connecting the centre girder plates to the bottom shell plating as well as the adjacent bottom longitudinals. Where, however, the spacing of these brackets exceeds 1.25 *metres*, additional stiffeners are to be provided on the centre girder plates.

2. The thickness of the brackets specified in **Par 1** is not to be less than that obtained from the following formula. However, it need not be greater than that of the solid floors at the same location.

$$t = 0.6\sqrt{L} + 1.5 \quad (mm)$$

3. The stiffener specified in **Par 1** is to be a flat bar having the same thickness as that of the girder plates and the depth not less than 0.08 d_0, where d_0 is the depth of centre girder in mm or equivalent thereto.

205. Thickness of half-height girders

The thickness of half-height girders is not to be less than that obtained from the formula specified in **204. 2.**

206. Vertical stiffeners and struts

1. Vertical stiffeners are to be provided to side girders at every open floor where the double bottom is framed transversely or at a suitable distance where the double bottom is framed longitudinally and vertical struts are to be provided on half-height girders at every open floor.

2. The vertical stiffeners required by the previous **Par 1** are to be a flat bar having the same thickness as that of the girder plates and the depth

not less than $0.08d_0$ or the equivalent, where d_0 is the depth of the side girder at the point under consideration (m).

3. The sectional area of vertical struts required by **Par 1** is not to be less than that correspondingly in accordance with the requirements in **404.**

SECTION 3
Solid Floors

301. Arrangements

1. Solid floors are to be provided at a spacing not exceeding 3.5 *metres*.

2. In addition to complying with the requirements in **Par 1,** solid floors are to be provided at the following locations:

(1) At every frame in the main engine room. Solid floors may, however, be provided at alternate frames outside the engine seatings, if the double bottom is framed longitudinally.
(2) Under thrust seatings and boiler bearers.
(3) Under transverse bulkheads.
(4) At the location specified in **803.** between the collision bulkhead and the after end of the strengthened bottom forward.
(5) Every frame where the height of double bottom changes.

3. Watertight floors are to be so arranged that the subdivision of the double bottom generally corresponds to that of the ship.

302. Thickness

The thickness of solid floors is not to be less than that obtained from the following requirements (1) and (2), whichever is the greater:

(1) The thickness is to be obtained from the following formula depending on the location in the hold:

$$t_1 = C_2 K \frac{SB'd}{d_0 - d_1}\left(\frac{2y}{B''}\right) + 1.5 \quad (mm)$$

where:

S = spacing of solid floors (m).
B' = distance between the lines of toes of tank side brackets at the top of inner bottom plating at the midship part (m).
B'' = distance between the lines of toes of tank side brackets at the top of inner bottom plating at the position of the solid floor (m).
y = transverse distance from the centre line to the point under consideration (m). Where, however, y is under $B''/4$, y is to be taken as $B''/4$, and where y is $B''/2$ and over, y may be taken as $B''/2$.
d_0 = depth of the solid floor at the point under consideration (mm).
d_1 = depth of the opening at the point under consideration (mm).
C_2 = coefficient obtained from **Table 3.7.2** depending on B/l_H.
l_H = length defined in **203.**

Table 3.7.2 Coefficient C_2

<table>
<tr><td colspan="3" rowspan="2">B/l_H</td><td>and above</td><td></td><td>0.4</td><td>0.6</td><td>0.8</td><td>1.0</td><td>1.2</td></tr>
<tr><td>below</td><td>0.4</td><td>0.6</td><td>0.8</td><td>1.0</td><td>1.2</td><td></td></tr>
<tr><td rowspan="3">C_2</td><td colspan="3">Longitudinal framing</td><td rowspan="2">29</td><td rowspan="2">27</td><td rowspan="2">24</td><td rowspan="2">22</td><td rowspan="2">19</td><td rowspan="2">17</td></tr>
<tr><td rowspan="2">Transverse framing</td><td colspan="2">Where solid floors are provided at every frame</td></tr>
<tr><td colspan="2">Elsewhere</td><td>20</td><td>19</td><td>17</td><td>15</td><td>13</td><td>12</td></tr>
</table>

(2) The thickness is to be obtained from the following formula depending on the location in the hold:

$$t_2 = 0.086\sqrt[3]{\frac{H^2 d_0^{\,2}}{C_2' K}}\,(t_1 - 1.5) + 1.5 \quad (mm)$$

where:

t_1 = thickness obtained from the requirement in Sub-paragraph (1).
d_0 = depth defined in Sub-paragraph (1).
C'_2 = coefficient given in **Table 3.7.3** depending on the ratio of the spacing of stiffeners S_1 (mm) to d_0.
H = value obtained from **Table 3.7.4.**

Table 3.7.3 Coefficient C'_2

S_1/d_0	0.3 and under	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.4 and over
C'_2	64	38	25	19	15	12	10	9	8	7
For intermediate values of S_1/d_0, the value of C'_2 is to be determined by linear interpolation										

303. Vertical stiffeners

Vertical stiffeners are to be provided on the solid floors at a suitable spacing in case of the double bottom framed transversely, and at every longitudinal in case of the double bottom framed longitudinally. The vertical stiffener is to be a flat bar having the same thickness as that of the floor plate and the depth not less than $0.08d_0$ or the equivalent, where d_0 is the depth of the floor at the point under consideration (mm).

Table 3.7.4 Value of H

Case	H
(a) Where slots are provided on solid floors without reinforcement	$\sqrt{4.0\frac{d_1}{S_1}}-1.0$ but, where d_1/S_1 is 0.5 and under, H is to be 1.0.
(b) Where openings are provided on solid floors without reinforcement	$0.5\frac{\phi}{d_0}+1$
(c) Where slots and openings are provided on solid floors without reinforcement	Product of the values given by (a) and (b)
(d) Except where (a), (b) and (c) are applied	1.0

d_1 =depth of slot without reinforcement provided at the upper and lower parts of solid floors, whichever is the greater (mm).
ϕ =major diameter of the openings (mm).

SECTION 4 Bottom Longitudinals

401. Construction

Longitudinals are to be continuous through floors or to be attached to floors by brackets so as to effectively develop the resistance to tension and bending.

402. Spacing

The standard spacing of longitudinals is obtained from the following formula, but it is recommended not to exceed 1 m.

$$S = 2L + 550 \quad (mm)$$

403. Section modulus

1. The section modulus of bottom longitudinals is not to be less than that obtained from the following formula:

$$Z_b = \frac{CKSl^2}{24-15.0f_BK}(d+0.026L') \quad (cm^3)$$

where:
C = coefficient given in **Table 3.7.5.**
L' = length of ship (m). Where, however, L exceeds 230 m, L' is to be taken as 230 m.
l = spacing of solid floors (m).
S = spacing of longitudinals (m).

2. The section modulus of inner bottom longitudinals is not to be less than that obtained from the following formula. However, the section modulus of inner bottom longitudinals is not to be less than 0.75 times that of the bottom longitudinals as specified in **Par 1** at the same location.

Table 3.7.5 Coefficient C

Case		C
In case where no strut specified in **404.** is provided midway between floors		100
In case where a strut specified in **404,** is provided midway between floors	Lower part of deep tanks	62.5
	Elsewhere	50

NOTE:
Where, however, the width of vertical stiffeners provided on floors and that of struts are specially large, the coefficient may be properly reduced.

$$Z_i = \frac{CKShl^2}{24-11.4f_BK} \quad (cm^3)$$

where:
C = coefficient obtained from **Table 3.7.6.**
l, S = as specified in **Par 1.**
h = vertical distance from the top of inner bottom plating to the lowest deck at centre line (m). Where, however, the cargo is carried exceeding the lowest deck, h is to be taken from the top of inner bottom plating to the deck just above the top of cargo at centre line.

Table 3.7.6 Coefficient C

Case	C
In case where no strut specified in **404.** is provided midway between floors	90
In case where a strut specified in **404,** is provided midway between floors	54

NOTE:
Where, however, the width of vertical stiffeners provided on floors and that of struts are specially large, the coefficient may be properly reduced.

404. Vertical struts

1. Vertical struts are to be rolled sections other than flat bars or bulb plates and to be well overlapped with the webs of bottom and inner bottom longitudinals.

2. The sectional area of the above-mentioned vertical struts is not to be less than that obtained from the following formula:

$$A = 1.8\,CKSbh \quad (cm^2)$$

where:
S = spacing of longitudinals (m).

b = breadth of the area supported by the strut (m).
h = as obtained from the following formula (m). In no case is h to be less than d.

$$h = \frac{d + 0.026 L' + h_i}{2}$$

L' = as specified in **403.1.**
h_i = 0.9 times the value of h specified in **403. 2.** (m). However, under deep tanks, h is not to be less than the vertical distance from the upper surface of inner bottom to the midpoint between the top of overflow pipe and the top of inner bottom or 0.7 times the vertical distance from the upper surface of inner bottom to the point of 2.0 *metres* above the top of overflow pipe, whichever is the greater (m).
C = coefficient obtained from the following formula. In no case is the value of coefficient to be less than 1.43.

$$C = \frac{1}{1 - 0.5 \dfrac{l_s}{\sqrt{K k}}}$$

l_s = length of struts (m).
k = minimum radius of gyration of struts obtained from the following formula (cm).

$$k = \sqrt{\frac{I}{A}}$$

I = the least moment of inertia of the struts (cm^4).
A = sectional area of the struts (cm^2).

SECTION 5
Inner Bottom Plating, Margin Plates and Bottom Shell Plating

501. Thickness of inner bottom plating

1. The thickness of inner bottom plating is not to be less than that obtained from the following formula, whichever is the greater:

$$t_1 = \frac{CKB^2 d}{d_0} + 1.5 \qquad (mm)$$

$$t_2 = C'S\sqrt{hK} + 1.5 \quad (mm)$$

where:
d_0 = height of centre girders (mm).
S = spacing of inner bottom longitudinals for longitudinal framing or frame spacing for transverse framing (m).
h = as specified in **403. 2.**
C = coefficient obtained from **Table 3.7.7.**
C' = coefficient obtained from **Table 3.7.8.**

Table 3.7.7 Coefficient C

$\frac{B}{l_H}$	C
$\frac{B}{l_H} < 0.8$	b_0
$0.8 \le \frac{B}{l_H} < 1.2$	b_0 or αb_1, whichever is the greater
$1.2 \le \frac{B}{l_H}$	αb_1

l_H = as specified in **203.**
α = as given by the following formula.

$$\alpha = \frac{13.8}{24 - 10.6 f_B K}$$

b_0, b_1 = as given by the following Table according to the value of B/l_H. However, for transverse framing, b_1 is to be 1.1 times the value given in this Table.

$\frac{B}{l_H}$	b_0	b_1
$\frac{B}{l_H} < 0.4$	4.4	—
$0.4 \le \frac{B}{l_H} < 0.6$	3.9	—
$0.6 \le \frac{B}{l_H} < 0.8$	3.3	—
$0.8 \le \frac{B}{l_H} < 1.0$	2.2	2.2
$1.0 \le \frac{B}{l_H} < 1.2$	1.6	2.1
$1.2 \le \frac{B}{l_H} < 1.4$	—	1.9
$1.4 \le \frac{B}{l_H} < 1.6$	—	1.7
$1.6 \le \frac{B}{l_H}$	—	1.4

Tabie 3.7.8 Coefficient C'

$\frac{l}{S}$	C'
$1.0 \le \frac{l}{S} < 3.5$	$0.43\frac{l}{S} + 2.5$
$3.5 \le \frac{l}{S}$	4.0

l = distance between floors for longitudinal framing or distance between girders for transverse framing (m).

2. Where cargoes whose specific gravity is especially low are carried, the thickness of inner bottom plating may be suitably modified.

3. The thickness of inner bottom plating under hatchway, where no ceiling is provided, is to be increased by 2 mm above that obtained from the second formula in **Par 1** or that specified in **101. 5,** whichever is the greater, except where the provision in **Par 4** is applied.

4. In ships in which cargoes are handled by grabs or similar mechanical appliances, the thickness of inner bottom plating is to be increased by 2.5 mm above that specified in **Par 1** or in **101. 5,** whichever is the greater, except where ceiling is provided.

5. The thickness of inner bottom plating in main engine room is to be increased by 2 mm above that specified in **Par 1** or in **101. 5,** whichever is the greater.

502. Thickness of margin plates

The thickness of margin plates is to be increased by 1.5 mm above that obtained from the second formula in **501.** However, the thickness of margin plates is not to be less than that of the inner bottom plating at the location.

503. Arrangements of margin plates

1. It is recommended that the margin plates are to be of sufficient height to protect the bottom up to the turn of bilge and for forward 0.2 L from the stem the margin plates are to extend to the ship's sides horizontally as far as practicable.

2. Margin plates are to be of adequate breadth and to extend well inside from the line of toes of tank side brackets.

504. Margin brackets

1. Where the double bottom is framed longitudinally, transverse brackets are to be provided at every hold frame extending from the margin plate to the adjacent bottom and inner bottom longitudinals.

2. The thickness of brackets specified in **Par 1** is not to be less than that obtained from the formula in **204. 2** and free edges are to be strengthened by flanging or other suitable method.

505. Bottom shell plating

The thickness of bottom shell plating of cargo holds in way of double bottom is not to be less than that obtained from the formula in **Ch 4, 304.** or from the first formula in **501. 1,** whichever is the greater. However, in application of the latter formula, α is to be as given by the following formula:

$$\alpha = \frac{13.8}{24 - 15.0 f_B K}$$

SECTION 6
Hold Frame Brackets

601. Thickness and scantlings

1. The thickness of brackets connecting hold frames to margin plates is to be increased by 1.5 mm above that obtained from the formula in **204. 2.** The free edges of brackets are to be flanged.

2. Where the shape of ship requires exceptionally long brackets, the thickness of brackets is to be increased or additional stiffeness is to be provided by fitting angles longitudinally across the top of flanges, or by other suitable means.

602. Gusset plates

Hold frame brakcets and margin plates are to be connected by gusset plates of the same thickness as the margin plates. The gusset plates may be omitted where deemed dispensable in relation to structural arrangements.

SECTION 7
Open Floors

701. Arrangement

Where the double bottom is framed transversely, open floors composed of brackets fitted at centre girder and margin plate, and main frames and reverse frames are to be provided at every hold frame between solid floors.

702. Main frames

The section modulus of main frames is not to be less than that obtained from the following formula:

$$Z = CKShl^2 \quad (cm^3)$$

where:

l = distance between the brackets attached to the centre girder and the margin plate (m). Where side girders are provided, l is the greatest distance among the distances between the vertical stiffeners on side girders and brackets. (See **Fig. 3.7.1**).
S = spacing of frames (m).
h = $d + 0.026 L'$ (m).
L' = as specified in **403. 1.**
C = coefficient given in **Table 3.7.9.**

703. Reversed frames

The section modulus of reverse frames is not to be less than that obtained from the following formula:

Table 3.7.9 Coefficient C

Case		C
In case where no vertical strut specified in **705.** is provided		6.67
In case where vertical struts specified in **705.** are provided	For holds which are used as deep tanks or For holds which become empty in the full load condition	4.17
	Elsewhere	3.33

$$Z_i = C'KShl^2 \quad (cm^3)$$

where:

l, S =as specified in **702.**

h = as specified in **403. 2.**

C = coefficient given in **Table 3.7.10.**

Table 3.7.10 Coefficient C'

Case	C'
In case where no vertical strut specified in **705.** is provided	6.0
In case where vertical struts specified in **705.** are provided	3.6

704. Brackets

1. Frames and reverse frames are to be connected to the centre girder and margin plates by brackets of not less than thickness obtained from the formula in **204. 2.**
2. The breadth of brackets specified in **Par 1** is not to be less than $0.05B$ and the brackets are to be well overlapped with frames and reverse frames. The free edges of brackets are to be flanged.

705. Struts

Vertical struts are to be rolled sections other than flat bars or bulb plates and to be well overlapped with the frames and reverse frames. The sectional area of the struts is to be in accordance with the requirements of **404.**

SECTION 8 Construction of Strengthened Bottom Forward

801. Application

1. In ships having bow draught under $0.037L'$ at the ballast condition, the construction of strengthened bottom forward is to be in accordance with the requirements of this Section, where L' is as defined in **403. 1.**
2. Notwithstanding the requirements in **Par 1,** in ships of which L and C_b are not more than 150 m and 0.7 respectively and $V/\sqrt{L}$ is 1.4 and over, the part of strengthened bottom forward are to be reinforced to an extent in accordance with the discretion of the Society.
3. In ships having bow draught not less than $0.037L'$ at the ballast condition, the construction of strengthened bottom forward may be as specified in **Secs. 2** to **4.**

802. Definition

1. The strengthened bottom forward is the part of the ship's bottom up to a height of $0.05d_F$(d_F : Bow draught at the ballast condition) from the top of keel at forward from the position specified in **Table 3.7.11.**
2. Notwithstanding the requirement in **Par 1,** in case of ships of which C_b and especially small, the ships of which the draft in the ballast condition are especially small, and so on, the extent of the

Table 3.7.11 Range of Strengthened Bottom Forward

$V/\sqrt{L}(=a)$	Position(from Fore Perpendicular)
$a \le 1.1$	$0.15L$
$1.1 < a \le 1.25$	$0.175L$
$1.25 < a \le 1.4$	$0.2L$
$1.4 < a \le 1.5$	$0.225L$
$1.5 < a \le 1.6$	$0.25L$
$1.6 < a \le 1.7$	$0.275L$
$1.7 < a$	$0.3L$

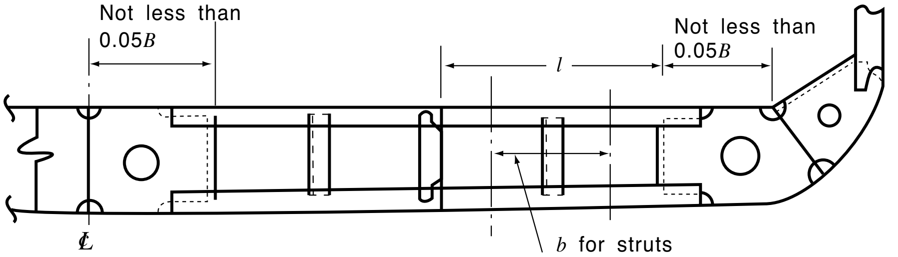


Fig. 3.7.1 Open Floors

strengthened bottom forward is to be extended up to the satisfaction of the Society.

803. Construction

1. Between the collision bulkhead and 0.05L abaft the aft end of strengthened bottom forward, side girders are to be provided with a spacing not more than 2.3m. Where transverse framing system is adopted between the collision bulkhead and 0.025L abaft the aft end of strengthened bottom forward, half height girders or longitudinal shell stiffeners are to be provided between the side girders.
2. Between the collision bulkhead and the aft end of strengthened bottom forward, solid floors are to be provided at every frame in transverse framing system, and at alternate frames in longitudinal framing system.
3. The solid floors are to be strengthened by fitting vertical stiffeners in way of half-height girders or longitudinal shell stiffeners except where the shell stiffeners are spaced considerably close and the solid floors are adequately strengthened, the vertical stiffeners may be provided on alternate shell stiffeners.
4. In ships having bow draught more than 0.025L' but less than 0.037L' at the ballast condition, where the construction and arrangement of strengthened bottom forward are impracticable to comply with each above mentioned requirement, suitable compensation is to be provided for floors and side girders.

804. Scantlings

1. In ships having bow draught not more than 0.025L' at the ballast condition, the section modulus of longitudinal shell stiffeners or bottom longitudinals in way of the strengthened bottom forward is not to be less than that obtained from the following formula:

$$Z = 0.53\,KCPal^2 \quad (cm^3)$$

where:

l = spacing of solid floors(m).

a = 0.774l. Where, however, the spacing of longitudinal shell stiffeners or bottom longitudinals in not more than 0.774l, a is to be taken as the spacing.

C = coefficient obtained from the following formula:

$$C = \frac{L}{1.9L - 45d_F}$$

Where, however, C is 1.0 or over, C is to be taken as 1.0.

P = slamming impact pressure obtained from the following formula:

$$P = 2.48 \times \frac{LC_1C_2C_3C_4}{\beta} \qquad (kPa)$$

C_1 = coefficient given in **Table 3.7.12.** For intermediate values of $V/\sqrt{L}$, C_1 is to be obtained by linear interpolation.

C_2 = coefficient given in **Table 3.7.13.**

C_3 = coefficient given in the following value.

C_3 = 1.0, when x is x_1 and above.

$C_3 = 0.5 + \frac{0.5x}{x_1}$, when x is less than x_1.

x = longitudinal distance from F.P. to cross section considered(m)

x_1 = as given in the following value.

x_1 = 0.1$L(m)$, when C_b is less than 0.7.

x_1 = (0.1 - 0.5(C_b - 0.7))L (m), where C_b is greater than 0.7 and less than 0.8.

x_1 = 0.05$L(m)$, when C_b is 0.8 and above.

C_4 = coefficient obtained from the following formula:

$$C_4 = 1.9 - 0.9\left(\frac{d_F}{0.02L}\right)$$

Where, however, C_4 is less than 1.0, C_4 is to be taken as 1.0.

d_F = bow draught at the ballast condition.

β = slope of the ship's bottom obtained from the following formula, but C_2/β need not be taken as greater than 11.43.

$$\beta = \frac{0.0025\,L}{b}$$

b = horizontal distance measured at the station 0.2L from the stem, from the center line of ship to the intersection of the horizontal line 0.0025L above the top of keel with the shell plating(m). (See **Fig. 3.7.2**)

β = slope of the ship's bottom obtained from the following formula, but C_2/β need not be taken as greater than 11.43.

b = horizontal distance measured at the station 0.2L from the stem, from the centre line of ship to the intersection of the horizon-

Table 3.7.12 Value of Coefficient C_1

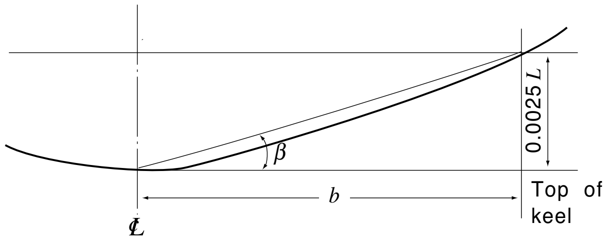
$\frac{V}{\sqrt{L}}$	1.0 and under	1.1	1.2	1.3	1.4	1.5 and above
C_1	0.12	0.18	0.23	0.26	0.28	0.29

Table 3.7.13 Value of Coefficient C_2

$\frac{V}{\sqrt{L}}$	less than 0.9	greater than 0.9 and less than 1.3	1.3 and above
C_2	0.333	$0.667\frac{V}{\sqrt{L}} - 0.267$	$1.5\frac{V}{\sqrt{L}} - 1.35$

tal line $0.0025L$ above the top of keel with the shell plating (m). (See **Fig. 3.7.2**)

2. In ships having bow draught more than $0.025L'$ but less than $0.037L'$ at the ballast condition, the section modulus of longitudinal shell stiffeners or bottom longitudinals in way of the strengthened bottom forward is to be obtained by linear interpolation from the values given by the requirements in **Par 1** and **Sec 4.** ⚓



(Hull section at the station $0.2L$ from the stem)

Fig. 3.7.2 Measurement of *b*

CHAPTER 8
FRAMES

Section

SECTION 1
General

101. Application

The requirements in this Chapter apply to ships having transverse strength due to bulkheads not less effective than that specified in **Ch 14.** Where the transverse strength due to bulkheads is less effective, additional stiffening is to be made by means of increasing the scantlings of frames, the number of web frames, etc.

102. Frames in way of deep tanks

The strength of frames in way of deep tanks are not to be less than those required for stiffeners on deep tank bulkheads.

103. Frames in way of tank tops

Frames are not to extend through tops of tanks, unless the effective watertight or oiltight arrangements are specially submitted and approved.

104. Increase of scantlings due to holes

Where large holes are cut in the webs of frames or holes are cut in the flanges of frames, the scantlings of the frames are to be appropriately increased.

105. Frames in boiler spaces and in way of bossing

1. In boiler spaces, the scantlings of frames and side stringers are to be appropriately increased.

2. The construction and scantlings of frames in way of bossing are to be to the satisfaction of the Society.

106. Frames and stringers fitted up at extremely small angles

Where the angle between the web of frames and shell plating is extremely small, the scantlings of frames are to be suitably increased above the normal requirements and where necessary, appropriate supports are to be provided to prevent tripping.

107. Lower end construction of frames

Thorough considerations are to be given to stress concentration, etc. at lower end construction of frames.

108. Direct calculation

Where approved by the Society, the scantlings of frames may be determined basing upon direct calculation as specified in **Ch 1, 206.**

SECTION 2
Frame Spacing

201. Transverse frame spacing

1. The standard spacing of transverse frames is obtained from the following formula:

$$S = 2L + 450 \quad (mm)$$

2. Transverse frame spacing in peaks or cruiser sterns is not to exceed 610 mm.

3. Transverse frame spacing between $0.2L$ from the fore end and the collision bulkhead is not to exceed 700 mm or the standard spacing specified in **Par 1,** whichever is the smaller.

4. The requirements in **Pars 2** and **3** may be modified, where structural arrangement or scantlings are suitably considered.

202. Longitudinal frame spacing

The standard spacing of longitudinal frames is obtained from the following formula:

$$S = 2L + 550 \quad (mm)$$

203. Maximum frame spacing

Frame spacing is recommended not to exceed 1 *metre*.

204. Consideration for frame spacing exceeding the standard

Where the spacing of frames is equal to or above the spacing of 250 *mm* greater than the standard spacing in **201.** and **202.,** the scantlings and structural arrangement of single and double bottoms and of other relevant structures are to be specially considered.

SECTION 3
Hold Frames

301. Application

1. The transverse hold frame is the frame provided below the lowest deck from the collision bulkhead to the aft peak bulkhead, including the machinery space.
2. The provisions in **302.** to **304.** are applicable to the transverse hold frames of ordinary construction.
3. The transverse hold frames of ships which have hopper side tanks, top side tanks, or which have a special construction such as inner hulls, will be specially considered.
4. Special considerations are to be given to the scantlings of transverse hold frames, where the specific gravity of cargoes γ defined in **Ch 7, 101. 7** in the loaded hold exceeds 0.9.

302. Scantlings of transverse hold frames

1. The section modulus of transverse hold frames is not to be than that obtained from **Table 3.8.1.**
2. Where the depth of double bottom centre girder is less than $B/16$, the scantlings of frames are to be suitably increased.
3. Where long hatchways or multi-row hatchways are provided on the deck at the top of frames, special considerations are to be given to the scantlings of transverse hold frames and their upper end construction of frames.

303. Hold frames supported by web frames and side stringers

1. Where transverse hold frames are supported by web frames and side stringers specified in **Ch 9,** the section modulus of frames is not to be less than that obtained from the following formula:

$$Z = C_0 CKShl^2 \quad (cm^3)$$

where:

S = spacing of frames (m).

h = as specified in **302. 1.**

l = vertical distance from the top of inner bottom plate at side to the line of the lowest side stringers (m) and it is to be measured at the measuring point for l stipulated in **301. 1.** Where this distance is less than 2 m, l is to be 1 m greater than one half of the distance. (See **Fig. 3.8.1** and **3.8.2** (c))

C_0 = coefficient given in **Table 3.8.2.**

Table 3.8.2 Coefficient C_0

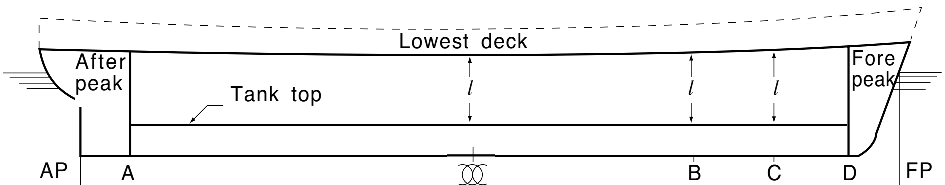
Location of frames	C_0
Between 0.15 L from the fore end and the after peak bulkhead	2.1
Between 0.15 L from the fore end and the collision bulkhead	3.2

C = as obtained from the following formula, but to be taken as 1.0, where C is less than 1.0.

$$C = \left\{ \alpha_1 \left(3 - \frac{l_2}{l} \right) - \alpha_2 \frac{e}{l} \right\} C_4$$

l_2 = vertical distance at side from the lowest side stringer to the one immediately above or to the deck (m). (See **Fig. 3.8.2.** (c)).

e = height of the lower bracket measured from the lower end of l, where, however, this height exceeds 0.25 l, e is to be taken as 0.25 l (m). (See **Fig 3.8.2** (c))



For frames between A and B, l is to be measured at ⌀.
For frames between B and C, l is to be measured at B.
For frames between C and D, l is to be measured at C.

Fig. 3.8.1 Measuring Points of l for Hold Frames

Table 3.8.1 Section Modulus

Location	Section modulus (cm^3)
(1) Between 0.15L from the fore end and the after peak bulkhead	$Z = KC_0CShl^2$
(2) Between 0.15L from the fore end and the collision bulkhead	$Z = 1.3KC_0CShl^2$
(3) For the frames under deck transverse supporting deck longitudinls	$Z = 2.4Kn\left\{0.17 + \frac{1}{9.81}\frac{h_1}{h}\left(\frac{l_1}{l}\right)^2 - 0.1\frac{l}{h}\right\}Shl^2$

S = frame spacing (m).

l = vertical distance from the top of inner bottom plating at side to the top of deck beams above the frames (m). For frames abaft 0.25L from the fore end, l is to be measured at midship. For frames between 0.25L and 0.15L from the fore end, l is to be measured at 0.25L from the fore end. For frames provided to the shell with a remarkable flare, l is to be the unsupported length of frames. Where the length of frames is markedly different from that measured at the aforementioned place on account of discontinuity in the lowest deck or change in the height of double bottom, lines extended from the lowest deck or the top of double bottom in parallel with the upper deck or keel respectively are to be taken as the lowest deck or double bottom top and l is to be measured at the corresponding place of measurement. (see **Fig. 3.8.1** and **Fig. 3.8.2**).

h = vertical distance from the lower end of l at the place of measurement to a point of $d + 0.038L'$ above the top of keel (m). (see **Fig. 3.8.2**).

L' = length of ship (m). Where, however, L exceeds 230 m, L' is to be taken as 230 m.

C_0 = coefficient obtained from the following formula, but not to be less than 0.85.

$$C_0 = 1.25 - 2\frac{e}{l}$$

e = height of the tank side bracket measured from the lower end of l (m).

n = ratio of the deck transverse spacing to the frame spacing.

h_1 = deck load stipulated in **Ch 10, Sec 2** for the deck transverse at the top of frame (kN/m^2).

l_1 = total length of the transverse web beam (m). (see **Fig. 3.8.2** (a)).

C = coeffcient obtained from the following formula:

$$C = C_1 + C_2$$

Framing systems	C_1	C_2
For ordinary framing systems without top side tanks	$2.1 - 1.2\frac{l}{h}$	$0.022k\alpha\frac{d}{h}$
For framing systems with top side tanks	$3.4 - 2.4\frac{l}{h}$	$0.27\alpha\frac{d}{h}$ (*1)

(*1) Where B/l exceeds 4.0, the value of C_2 is to be suitably increased.

α = coefficient given in the following table. For intermediate values of B/l_H, α is to be obtained by linear interpolation.

l_H = length of hold (m)

B/l_H	0.5 and under	0.6	0.8	1.0	1.2	1.4 and over
α	2.3	1.8	1.0	0.6	0.34	0.2

k = coefficient given in the following table according to the number of layers of deck:

No. of layers of deck	k	Value of B/l (*2)
For single deck systems	13	2.8
For double deck systems	21	4.2
For triple deck systems	50	5.0

(*2) Where B/l exceeds the value given in the above table according to the deck systems, the value of k is to be suitably increased:

NOTE:
Where the ratio of the depth of frame to the length measured from the deck at the top of frame to the toe of lower bracket is less than 1/24 and 1/22 in case of the frame prescribed in line (1) and of that in line (2) respectively, the scantlings of such frames are to be suitably increased.

α_1, α_2 = as given in **Table 3.8.3.**

Table 3.8.3 Values 0f α_1 and α_2

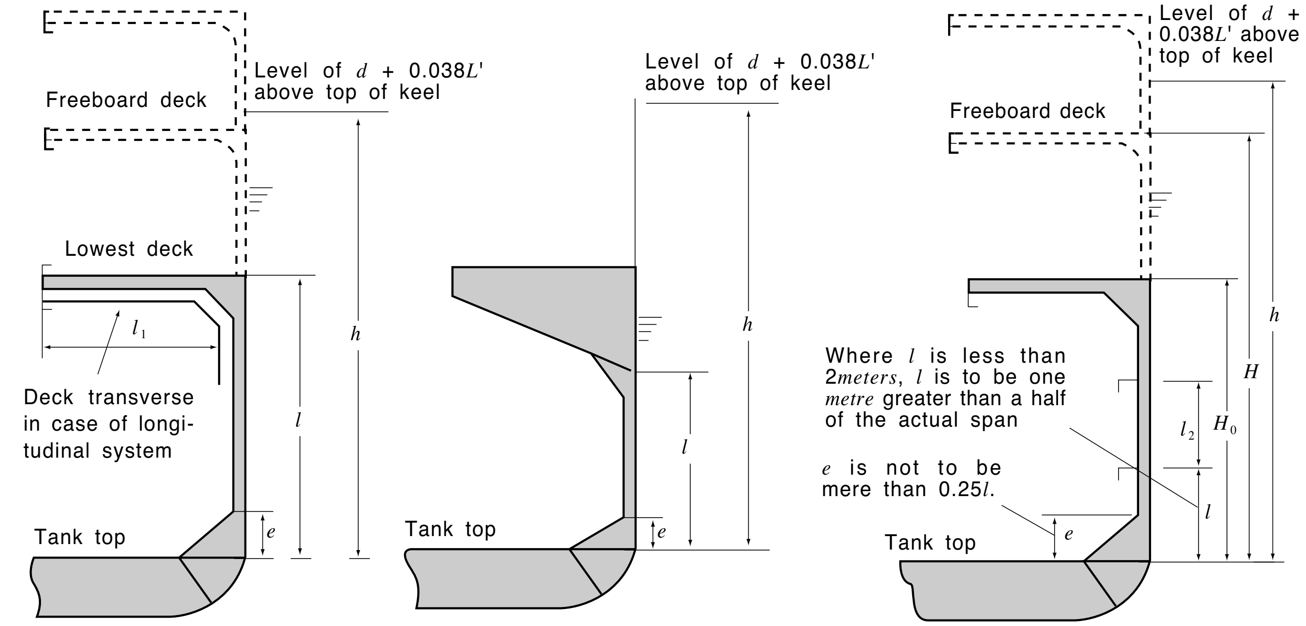
Nos. of side stringers provided below the lowest deck	α_1	α_2
1	0.75	2.0
2	0.90	1.8
3 and more	1.25	1.3

C_4 = as obtained from the following formula, but to be taken as 1.0, where C_4 is less than 1.0, and as 2.2 where C_4 exceeds 2.2.

$$C_4 = 2\frac{H}{H_0} - 1.5$$

H_0 = vertical distance from the top of inner bottom plate at side to the lowest deck (m). (See **Fig. 3.8.2** (c))

H = vertical distance from the lower end of H_0 to the freeboard deck at side (m). (See **Fig. 3.8.2** (c))



(a) Ordinary framing system without top side tanks (b) Framing system with top side tanks (c) Web and stringer system

Fig. 3.8.2 Measurement of l, h, H, etc.

2. The difference between any two adjacent unsupported spans of the frames in the preceding paragraph is not to be more than 25 % nor is it to be more than 50 % between the largest and smallest spans in case of more than two stringers.

3. Where the height of lower brackets of frames is less than 0.05 times l specified in **Par 1,** special considerations are to be given to the scantlings of transverse hold frames and their lower end construction of frames.

304. Connection

1. Transverse hold frames are to be overlapped with tank side brackets by at least 1.5 times the depth of frame sections and are to be effectively connected thereto.

2. The upper ends of transverse hold frames are to be effectively connected by brackets with the deck and deck beams, and where the deck at the top of frames is longitudinally framed, the upper end brackets are to be extended and connected to the deck longitudinals adjacent to the frames.

SECTION 4
Side Longitudinals

401. Section modulus

The section modulus of side longitudinals in the midship part below the freeboard deck is not to be less than that obtained from the following formula, whichever is the greater:

$$Z_1 = 100\,CKShl^2 \quad (cm^3)$$
$$Z_2 = 2.9K\sqrt{L}\,Sl^2 \quad (cm^3)$$

where:

S = spacing of longitudinals (m).

l = distance between the web frames or between the transverse bulkhead and the web frame including the length of connection (m).

h = vertical distance from the side longitudinal concerned to a point $d + 0.038\,L'$ above the top of keel (m).

L' = length of ship (m). Where, however, L exceeds 230 m, L' is to be taken as 230 m.

C = coefficient given by the following formula:

$$C = \frac{K}{24 - \alpha K}$$

α = either α_1 or α_2 according to value of y. However, value of α is not to be less than β.

$$\alpha_1 = 15.0 f_D \left(\frac{y - y_B}{Y\copyright}\right) \text{ for } y \geq y_B$$

$$\alpha_2 = 15.0 f_B \left(\frac{y_B - y}{y_B}\right) \text{ for } y < y_B$$

β = coefficient determined according to value of L as specified below:

$\beta = 6/a$ when L is 230 m and under
$\beta = 10.5/a$ when L is 400 m and above

For intermediate values of L, β is to be obtained by linear interpolation.

Y' = the greater of the value specified in **Pt 3, Ch 3, 203.,** (5) (a) or (b)

a = $\sqrt{K}$, when high tensile steels are used for not less than 80 % of side shell platings at the transverse section amidship and 1.0 for other parts.

2. Beyond the midship part, the section modulus of side longitudinals may be gradually reduced towards the ends of ships, and may be 0.85 times that obtained from the formula in **Par 1** at the ends. However, the section modulus of side longitudinals between 0.15 L from the fore end and the collision bulkhead is not to be less than that obtained from the formula in **Par 1.**
3. The depth of flat bars used for longitudinals is not to exceed 15 times the thickness of flat bars.
4. Side longitudinals on sheer strakes in the midship part are to be, as far as possible, of slenderness ratio not greater than 60.
5. The section modulus of bilge longitudinals need not exceed that of bottom longitudinals.

402. Attachment

1. Side longitudinals are to be continuous at transverse bulkheads or to be attached thereto by brackets so as to provide adequate fixity and continuity of longitudinal strength.
2. Webs of longitudinals and web frames are to be attached to each other.

SECTION 5
Tween Deck Frames

501. General

The scantlings of tween deck frames are based on the standard structural arrangement which the maintenance of general transverse stiffness is kept by means of efficient tween deck bulkheads provided above the hold bulkheads or by web frames extended to the tops of superstructures at proper intervals. Tween deck frames are to be considered in relation to hold frames and care is to be given to the maintenance of continuity of strength in the framing from the bottom to the top of hull.

502. Scantlings of tween deck frames

The section modulus of tween deck frames is not to be less than that obtained from **Table 3.8.4.**

503. Special care to tween deck frames

1. Care is to be taken so that the strength and stiffness of framing at the ends of ship may be increased in proportion to the actual unsupported length of frame as well as the vertical height of tween decks.

Table 3.8.4 Section Modulus

Locations		Section modulus (cm^3)
(1)	Tween deck frames below the freeboard deck	$Z = 6KShl^2$
(2)	Tween deck frames except those specified in (1)	$Z = CKSlL$
(3)	Tween deck frames supporting deck transverse	$Z = 2.4K\left(0.143n\frac{h_1}{h}+1.0\right)Shl^2$

S = frame spacing (m).
l = tween deck height (m).
h = vertical distance from the middle of l to the point $d + 0.038L'$ above top of keel (m). Where, however, h is less than 0.03 L (m), h is to be taken as 0.03 L (m).
L' = length of ship (m). Where, however, L exceeds 230 m, L' is to be taken as 230 m.
h_1, n = as specified in **Table 3.8.1.**
C = coefficient given in the following table.

Description of tween deck frames	C
Superstructure frames (excluding the following two lines)	0.44
Superstructure frames for 0.125 L from aft end	0.57
Superstructure frames for 0.125 L from fore end and cant frames at stern	0.74

NOTES:
1. The scantlings of tween deck frames below the freeboard deck within 0.15 L from the fore end and within 0.125 L from the after end are to be appropriately increased above those given by line (1).
2. The section modulus of tween deck frames supporting web beams is not to be less than that obtained from the above line (1).

2. In ships having specially large freeboard, the scantlings of tween deck frames may be properly reduced.

504. Superstructure frames

1. Superstructure frames are to be provided at every frame located below.

2. Superstructure frames for four frame spaces at the ends of bridges and of detached superstructures within $0.5L$ amidships are to be of the section modulus obtained from the formula in **Table 3.8.4** (2) using 0.74 as the coefficient C.

3. Web frames or partial bulkheads are to be provided above the bulkheads or at other positions such as may be considered necessary to give effective transverse rigidity to the superstructures.

505. Frames of cruiser sterns

Cruiser sterns are to have frames of section modulus not less than 86 % of that required for frames under freeboard deck in aft peak in **Ch 13, 302.** ⚓

CHAPTER 9
WEB FRAMES AND SIDE STRINGERS

SECTION 1
General

101. Application

1. The requirements in **Secs 2** and **3** apply to the structures stiffened by side stringers supporting the transverse ordinary frames specified in **Ch 8, 303.** and web frames supporting side stringers.
2. The requirements in **Sec 4** apply to the structures stiffened by side transverse supporting the longitudinal frames specified in **Ch 7, 401.**

102. Arrangement

1. Web frames and side stringers are to be arranged to provide effective stiffness to the ship side structures.
2. Side stringers are to be in line with bulkhead stringers, if fitted, as far as possible.

103. Minimum strength

The strength of web frames and side stringers in way of deep tanks is not to be less than that required for vertical or horizontal girders on deep tank bulkheads.

104. Direct calculation

Where approved by the Society, the scantlings of structural members may be determined basing upon direct calculation as specified in **Ch 1, 206.**

SECTION 2
Web Frames

201. Scantlings

1. The scantlings of web frames supporting side stringers are not to be less than those obtained from the following formulae:

Depth: $d = 125\,l \quad (mm)$

Section modulus: $Z = C_1 KShl^2 \quad (cm^3)$

Thickness of web:

t_1 or t_2, whichever is the greater.

$$t_1 = \frac{C_2 KShl}{d_0} + 1.5 \quad (mm)$$

$$t_2 = 0.086\sqrt[3]{\frac{d_0^2(t_1 - 1.5)}{kK}} + 1.5 \quad (mm)$$

where:

S = web frame spacing(m).
l = unsupported length of web frame (m)
h = vertical distance from the lower end of l to a point $d + 0.038L'$ above the top of keel (m).
L' = length of ship (m). Where, however, L exceeds 230 m, L is to be taken as 230 m.
d_0 = depth of web frame (mm). Where the webs are provided with vertical stiffeners, the divided web depth may be used for d_0 in the formula for t_2.
C_1, C_2 = coefficients given in **Table 3.9.1.**
k = coefficient given in **Table 3.9.2** according to the ratio of S_1 (mm) to d_0, where S_1 is the spacing of stiffeners or tripping brackets provided on web plates of web frames. For the intermediate values of S_1/d_0, k is to be obtained by linear interpolation.

Tabla 3.9.1 Coefficiants C_1 and C_2

Location	C_1	C_2
For web frames abaft 0.15 L from the fore end	3.0	23
For web frames between 0.15 L from the fore end and the collision bulkhead	3.8	28

2. Where the web frames are in the close proximity to boilers, the thickness of webs and face bars is to be suitably increased.

Table 3.9.2 Coefficient k

S_1/d_0	k
0.3 and under	60.0
0.4	40.0
0.5	26.8
0.6	20.0
0.7	16.4
0.8	14.4
0.9	13.0
1.0	12.3
1.5	11.1
2.0 and over	10.2

202. Stiffeners of webs

1. Stiffeners or tripping brackets are to be provided on deep webs as may be required.

2. Tripping brackets are to be arranged at an interval of about 3 *metres*. Where the breadth of face plates on either side of the web exceeds 180 *mm*, the tripping brackets are to be arranged to support the face bars.

203. Continuity of transverse strength

Tween deck web frames are to be provided below the bulkhead deck over the hold web frames as may be required, to provide continuity of transverse strength above the main web frames in holds and machinery space.

204. Beams at the top of web frames

Beams at the top of web frames are to be suitably increased in both strength and stiffness.

SECTION 3
Side Stringers

301. Scantlings

1. The scantlings of side stringers are not to be less than those obtained from the following formulae:

Depth:

d = 125 l (mm) added by one quarter of the depth (mm) of slot for ordinary frames.

Section modulus:

$$Z = C_1 KShl^2 \quad (cm^3)$$

Thickness of web:

t_1 or t_2, whichever is the greater

$$t_1 = \frac{C_2 KShl}{d_0} + 1.5 \quad (mm)$$

$$t_2 = 0.086\sqrt[3]{\frac{d_0^2(t_1 - 1.5)}{kK}} + 1.5 \quad (mm)$$

where:

S = distance between the mid-points of the spaces from the side stringer concerned to the adjacent side stringers or to the top of inner bottom plating at side or to the top of deck beams at side (m).

l = web frame spacing (m). Where, however, effective brackets are provided, the span l may be modified as specified in **Ch 1, 605.**

h = vertical distance from the middle of S to a point $d + 0.038L'$ above the top of keel (m). Where, however, h is less than 0.05 L (m), h is to be taken as 0.05 L (m).

L' = as specified in **201. 1.**

d_0 = depth of side stringer (mm). Where, however, the depth of the web is divided by providing a stiffener in parallel to the face bar, the divided depth may be taken as d_0 in the calculation of t_2.

C_1, C_2 = coefficients given in **Table 3.9.3.**

k = coefficient given in **Table 3.9.2** according to the ratio of S_1 (mm) to d_0, where S_1 is the spacing of stiffeners or tripping brackets provided on web plates of side stringers. For the intermediate values of S_1/d_0, k is to be obtained by linear interpolation.

Tabla 3.9.3 Coefficiants C_1 and C_2

Location	C_1	C_2
For web frames abaft 0.15 L from the fore end	5.1	42
For web frames between 0.15 L from the fore end and the collision bulkhead	6.4	52

2. In boiler spaces, the thickness of web plates, face bars, etc. of stringer plates is to be suitably increased.

302. Stiffeners on webs

Stiffeners, the length of which is equal to the web depth, are to be provided on the webs of side stringers at alternate frames.

303. Tripping brackets

1. Tripping brackets are to be provided on side stringers at an interval of about 3 *metres*.

2. Where the breadth of face bar on either side of the side stringer exceeds 180 *mm*, tripping brackets are to be arranged to support the face bars.

304. Connections

1. Connection of side stringers to web frames is to extend for the full depth of web frame.
2. Where stringers are of the same depth as web frames, the face bars of side stringers are to be connected with the face bars of web frames by efficient gussets.
3. Side stringers are to be effectively connected to the transverse bulkheads by brackets of proper size.

SECTION 4
Side Transverse

401. Arrangements

Side transverses supporting the side longitudinal frames are to be provided at places where solid floors are located.

402. Scantlings

The scantlings of side transverses are not to be less than that obtained from the following formulae:

Depth:

d = 100 l (mm) or 2.5 times the depth of slot for the longitudinals, whichever is the greater.

Section modulus:

$Z = C_1 KShl^2 \quad (cm^3)$

Thickness of web:

t_1 or t_2, whichever is the greater.

$$t_1 = \frac{C_2 KShl}{d_0} + 1.5 \quad (mm)$$

$$t_2 = 0.086 \sqrt[3]{\frac{d_0^2 (t_1 - 1.5)}{kK}} + 1.5 \quad (mm)$$

where:

S = side transverses spacing (m).

l = unsupported length of side transverse (m).

d_0 = depth of side transverses (mm). In the calculation of t_1, however, the depth of slots for side longitudinals, if any, is to be deducted from the web depth. Where the depth of webs is divided by vertical stiffeners, the divided depth may be taken as d_0 in the calculation of t_2.

h = vertical distance from the lower end of l to a point $d + 0.038L'$ above the top of keel (m), where, however, the distance is less than 1.43 l (m), h is to be taken as 1.43 l (m).

L' = as specified in **201. 1.**

C_1, C_2 = coefficients given in **Table 3.9.4.**

k = coefficient given in **Table 3.9.2** according to the ratio of S_1 (mm) to d_0, where S_1 is the spacing of stiffeners or tripping brackets provided on web plates (mm). For the intermediate values of S_1/d_0, k is to be obtained by linear interpolation.

Table 3.9.4 Coefficients C_1 and C_2

Location	For side transverses abaft 0.15 L from the fore end	For side transverses between 0.15 L from the fore end and the collision bulkhead
C_1	$6.6\left(1 - 0.4\frac{l}{h}\right)$	$8.6\left(1 - 0.4\frac{l}{h}\right)$
C_2	$35\left(1.43 - 0.43\frac{l}{h}\right)$	$45.5\left(1.43 - 0.43\frac{l}{h}\right)$

403. Tripping brackets

1. Side transverses are to be provided with tripping brackets at an interval of above 3 *metres*.
2. Where the breadth of face plates of side transverses exceeds 180 mm on either side of the web, the tripping brackets are to support the face plates as well.

404. Attachments

1. A stiffener is to be provided on the web at every longitudinal except for the middle part of the span of where stiffeners may be provided at alternate longitudinals.
2. Webs of longitudinals and side transverses are to be connected each other.

SECTION 5
Cantilever Beam Systems

501. Cantilever Beams

Cantilever beams are to comply with the following requirements:

(1) The root depth of centilever beams measured at the toes of end brackets at side is not to be less than one fifth of the horizontal distance from the inboard end of cantilever beam to the toe of end bracket at side.

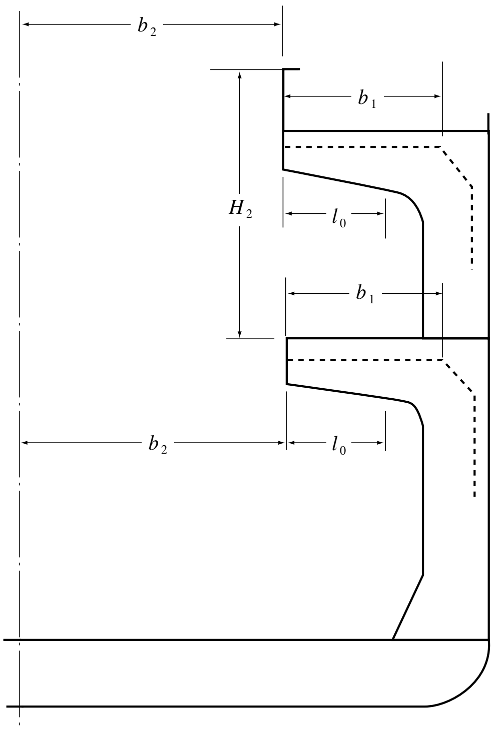
(2) The depth of cantilever beams may be gradually tapered from the root towards the inboard end where it may be reduced to about a half of the root depth.

(3) The section modulus of cantilever beams at the toe of end brackets is not to be less than that obtained from the following formula: (see **Fig. 3.9.1**)

$$Z = 7.1\,KSl_0\left(\frac{1}{2}b_1h_1 + b_2h_2\right) \quad (cm^3)$$

where:

S = cantilever beam spacing (m).



The loading height of cargo, H_2, shown in the figure, is to be taken into consideration when h_2 of the lower deck is assumed.

Fig. 3.9.1 Measurement of l_0, b_1, b_2, etc

l_0 = horizontal distance from the inboard end of cantilever beams to the toe of end brackets (m).

b_1 = horizontal distance from the inboard end of cantilever beams to the inner edge of beam knees or end brackets of transverse beams at side (m). Where, however, the deck is framed longitudinally and no deck transverse is provided between the cantilever beams, b_1 is to be taken as l_0.

b_2 = one-half of the breadth of hatch opening in the deck supported by the cantilever beams (m).

h_1 = deck load stipulated in **Ch 10, Sec 2** for the deck transverses of the deck supported by the cantilever beams (kN/m^2).

h_2 = load on hatch covers of the deck supported by the cantilever beams which is not to be less than that obtained from the following (a) to (c), depending on the type of the deck (kN/m^2):

(a) For the weather deck, h_2 is the deck load stipulated in **Ch 10, 201. 2** for the deck transverses or the maximum design cargo weight on hatches per unit area (kN/m^2), whichever is the greater. In **Ch 10, 201. 2** (1), the value of y may be taken as the vertical distance from the load line to the upper edge of hatch coaming. In either case, h_2 is not to be less than 17.5 (kN/m^2) for hatches at Position I and 12.8 (kN/m^2) for those at Position II, specified in **Pt 4, Ch 2,** respectively.

(b) For decks other than the weather deck where ordinary cargoes or stores are intended to be carried, h_2 is the deck load stipulated in **Ch 10, 201.1.**

(c) For decks other than those specified in (a) or (b) above, h_2 is the value equal to h_1.

(4) The sectional area of face bars of cantilever beams may be gradually tapered from the inner edge of end brackets towards the inboard end of cantilever beams, where it may be reduced to 0.60 times that at the inner edge of end brackets.

(5) The web thickness of cantilever beams at any place of it is not to be less than that obtained from the following formula, whichever is the greater:

$$t_1 = 9.5\frac{S\left(\frac{1}{2}b_1h_1 + b_2h_2\right)\sqrt{K}}{d_c} + 1.5 \qquad (mm)$$

$$t_2 = 0.058\sqrt[3]{\frac{d_c^2(t_1 - 1.5)}{K}} + 1.5 \qquad (mm)$$

where:

S, b_1, b_2, h_1, h_2 = as stipulated in (3). Where, however, the deck is framed longitudinally and no deck transverse is provided between the cantilever beams, $b_1/2$ is to be substituted by the horizontal distance in *metres* from the inboard end of cantilever beams to the section under consideration in the formula for t_1.

d_c = depth of the cantilever beam at the section under consideration (mm). In the calculation of t_1, however, the depth of slots for deck longitudinals, if any, is to be deducted from the depth of cantilever beams. Where the webs are provided with horizontal stiffeners, the divided web depth may be used for d_c in the formula for t_2.

(6) Cantilever beams are to be provided with tripping brackets at an interval of about 3 *metres*. Where the breadth of face bars of cantilever beams exceeds 180 *mm* on either side of the web, the tripping brackets are to support the face bars as well. And a stiffener is to be provided on the web at every deck longitudinal adjacent to the root of cantilever beams and at alternate longitudinals elsewhere.

(7) Web plates adjacent to the inner edge of end brackets are to be specially reinforced.

502. Web frames

Web frames supporting cantilever beams are to comply with the following requirements:

(1) The depth of web frames is not to be less than one eighth the length including the length of connection at both ends.

(2) The section modulus of web frames is not to be less than that obtained from the following for-

mula. Where, however, a tween deck web frame in association with cantilever beam supporting the deck above is provided at the top of web frame, the value of the formula may be reduced to 60%.

$$Z = 7.1\,KSl_1\left(\frac{1}{2}b_1h_1 + b_2h_2\right) \quad (cm^3)$$

where:

S = web frames spacing (m).

l_1 = horizontal distance from the end of supported cantilever beams to the inside of web frames (m).

b_1, b_2, h_1, h_2 = as stipulated in **501.** (3) for the supported cantilever beams, where, however, the deck is framed longitudinally and no deck transverse is provided between the cantilever beams, l_1 is to be substituted for b_1.

(3) The section modulus of tween deck web frames is to be in accordance with the requirements in (2), and additionally, it is not to be less than that obtained from the following formula:

$$Z = 7.1\,KC_1Sl_1\left(\frac{1}{2}b_1h_1 + b_2h_2\right) \quad (cm^3)$$

where:

S, l_1, b_1, b_2, h_1, h_2 = as stipulated in (2).

C_1 = coefficient obtained from the following formula:

$$C_1 = 0.5\left(\frac{\frac{1}{2}b'_1h'_1 + b'_2h'_2}{\frac{1}{2}b_1h_1 + b_2h_2}\right) + 0.15$$

b'_1, b'_2, h'_1, h'_2 = b_1, b_2, h_1, and h_2 respectively stipulated in (2) in respect of cantilever beams to be provided below the web frames concerned.

(4) The web thickness is not to be less than that obtained from the following formula, whichever is the greater:

$$t_1 = 9.5\,K\frac{C_2S\left(\frac{1}{2}b_1h_1 + b_2h_2\right)}{d_w}\cdot\frac{l_1}{l} + 1.5 \quad (mm)$$

$$t_2 = 0.058\sqrt[3]{\frac{d_w^2(t_1 - 1.5)}{K}} + 1.5 \quad (mm)$$

where:

S, b_1, b_2, h_1, h_2 l_1 = as stipulated in (2).

d_w = the smallest depth of web frame (mm). In the calculation of t_1, however, the depth of slots for side longitudinals, if any, is to be deducted from the web depth. Where the depth of webs is divided by vertical stiffeners, in the calculation of t_2, the divided depth may be used for d_w.

l = length of web frame including the length of connections at both ends (m).

C_2 = coefficient given in **Table 3.9.5,** where, however, C_1, as specified in (3).

(5) Where web frames supporting cantilever beams also support side longitudinals or side stringers, the scantlings are to comply with the following requirements in addition to those in **Ch 2, Ch 3** and **Ch 4.**

Table 3.9.5 Coefficient C_2

Location		C_2
For hold web frames	Where web frame in association with cantilever beam supporting the deck above is provided at the top of them	0.9
	Elsewhere	1.5
For tween deck web frames		C_1+0.6

(a) The section modulus is not to be less than that obtained from the formula in (2), multiplied by the following coefficient:
Where tween deck web frame together with cantilever beam is provided above:

$$\alpha = 9.81\left\{\frac{0.05hl^2 + 0.09\,h_ul_u^2}{1.4\left(\frac{1}{2}b_1h_1 + b_2h_2\right)l_1}\right\} + 0.6$$

Elsewhere: $\alpha = 1.0$

where:

l = length of hold web frame including the length of connections at both ends (m).

l_u = length of tween deck web frame provided directly above, including the length of connections at both ends (m).

h = vertical distance from the middle of l to a point $d + 0.038L'$ above the top of keel (m).

h_u = vertical distance from the middle of l_u to a point to which h is to be measured (m). Where, however, the point is below the middle of l_u, h_u is to be taken as zero.

L' = as specified in **201. 1.**

b_1, b_2, h_1, h_2 l_1 = as given by (2).

(b) The web thickness is not to be less than that given by (4), in which the value of t_1 is to be increased by the amount obtained from the following formula:

$$\beta = 25.5\frac{Shl}{d_w} \quad (mm)$$

where:

S = web frame spacing (m).
h, l = as stipulated in (a) above.
d_w = as stipulated in (4).

(6) Web frames are to be provided with tripping brackets at an interval of about 3 *metres*. Where the breadth of face bars of web frames exceeds 180 *mm* on either side of the web, the tripping brackets are to support the face bars as well. And a stiffener is to be provided on the webs at every side longitudinal except for the middle part of the span of web frames where stiffeners may be provided at alternate longitudinals. Webs of longitudinals and web frames are to be connected each other.

(7) Web frames are to be effectively connected with those located beneath or solid floors so as to maintain strength continuity.

503. Connections

Cantilever beams and their supporting web frames are to be effectively connected by brackets to meet the following requirements:

(1) The radius of curvature of the free edges of brackets is not to be less than the depth of cantilever beams at the toe of brackets.
(2) The thickness of brackets is not to be less than that of webs of cantilever beams or web frames, whichever is the greater.
(3) The brackets are to be sufficiently strengthened by stiffeners.
(4) The free edges of brackets are to have face bars of sectional area not less than that of cantilever beams or web frames, whichever is the greater, and the face bars are to be connected with those of cantilever beams and web frames. ⚓

CHAPTER 10
BEAMS

SECTION 1
General

101. Standard camber

The standard camber of weather decks is $0.02B$ at midship.

102. Connections of ends of beams.

1. Longitudinal beams are to be continuous or to be connected with brackets at their ends in such a manner as to effectively develop the sectional area and to have sufficient strength to bending and tension.
2. Transverse beams are to be connected to frames by brackets.
3. Transverse beams provided at positions where frames are omitted in tween decks or superstructures, are to be connected to the side plating by brackets.
4. Transverse beams on boat decks, promenade decks, etc. may be connected by clips at their ends.

103. Beams on bulkhead recesses and others

The section modulus of beams at deck forming the top of bulkhead recesses, tunnels and tunnel recesses is not to be less than that obtained from the formula in **Ch 14, 309.,** using h measured from the top of beams to the top of bulkhead deck at the centre line of ship. Where, however, h is less than 6.0 *metres*, h is to be taken as 0.8 times the actual height plus 1.2 *metres*.

104. Beams on the top of deep tanks

The section modulus of beams at deck forming the top of deep tanks is to be in accordance with this Chapter, and not to be less than that obtained from the formula in **Ch 15, 203.,** taking the top of deck beams as the lower end of h and beams as stiffeners.

105. Special heavy loads

The deck beams supporting special heavy loads or arranged at the ends of superstructures or deckhouses, in way of masts, winches, windlasses and auxiliary machineries, etc. are to be properly reinforced by increasing the scantlings of beams, or by the additional deck girders or pillars.

106. Long machinery opening

For unusually long machinery opening, suitable strengthening is to be made by means of adequate cross ties provided at each level of deck or equivalent arrangement.

107. Loaded by wheeled vehicles

The section modulus of beams on deck loaded by wheeled vehicles is to be determined by considering the concentrated loads from the wheeled vehicles.

108. Continuity of strength

In parts where longitudinal systems are transformed to transverse systems, special care is to be taken to keep the continuity of strength.

SECTION 2
Deck Load

201. Value of h

1. Deck load h (kN/m^2) for decks intended to carry cargoes or stores, etc. on them is to be as specified in the following (1) to (3):

   (1) h is to be equivalent to the standards given by 7 times the tween deck height at side of the space (m), or 7 times the height from the deck concerned to the upper edge of hatch coaming of the above deck (m). However, h may be specified as the maximum design cargo weight per unit area of deck (kN/m^2). In this

case, the value of h is to be determined by considering the loading height of cargo.

(2) Where timber and other cargoes are intended to be carried on the weather deck, h is cargo weight per unit area of the deck (kN/m^2) or the value stipulated in **Par 2,** whichever is the greater.

(3) Where cargoes are suspended from the deck beams, or deck machinery is installed, h is to be suitably increased.

2. Deck load h (kN/m^2) for the weather deck is to be as specified in the following (1) to (4):

(1) h for the freeboard deck and the superstructure deck and the top of deckhouses on the freeboard deck is not to be less than that obtained from the following formula:

$$h = a\ (bf - y) \quad (kN/m^2)$$

where:

a, b = as given by **Table 3.10.1** according to the position of decks.

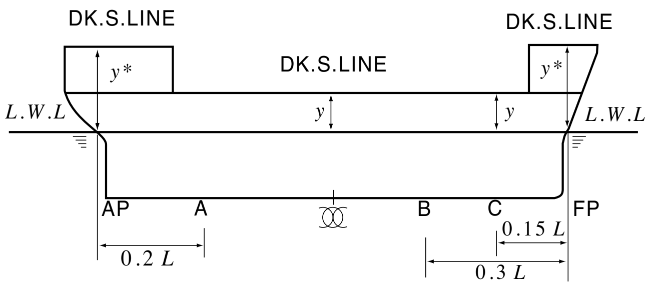
C_{b1} = block coefficient, however, where C_b is less than 0.6, C_{b1} is to be taken as 0.6, and where C_b is 0.8 and over, C_{b1} is to be taken as 0.8.

f = as given in **Table 3.10.2.** (see **Fig. 3.16. 1**):

y = vertical distance from the load line to weather deck at side (m), and y is to be measured at fore end for deck forward of 0.15L abaft the fore end; at 0.15L abaft the fore end for deck between 0.3L and 0.15L abaft the fore end; at midship for deck between 0.3L abaft the fore end and 0.2L afore the aft end; and at aft end for deck aftward of 0.2L afore the aft end (see **Fig. 3.10.1**):

Table 3.10.2 Coefficient f

Length of ship	f
$L < 150\ m$	$\frac{L}{10} e^{-\frac{L}{300}} + \left(\frac{L}{150}\right)^2 - 1.0$
$150\ m \le L < 300\ m$	$\frac{L}{10} e^{-\frac{L}{300}}$
$300\ m \le L$	11.03



Abaft A — y is to be measured at AP.
Between A and B — y is to be measured at ⌀.
Between B and C — y is to be measured at C.
Afore C — y is to be measured at FP.
y^* : In case of no superstructure, y is the distance to the upper deck.

Fig. 3.10.1 Position of measuring y

(2) h for deck in Line II in **Table 3.10.1,** need not exceed that in Line I.

(3) h is not to be less than that obtained from the formulae in **Table 3.10.3,** irrespective of

Table 3.10.1 Values of a and b

Line	Position of deck	a			b
		Beams(1), Deck plating	Pillars	Deck girders	
I	Forward of 0.15L abaft the fore end	14.7	4.90	7.35	$1 + \frac{0.338}{(C_{b1} + 0.2)^2}$
II	Forward of 0.15L and 0.3L abaft the fore end	11.8	3.90	5.90	$1 + \frac{0.158}{(C_{b1} + 0.2)^2}$
III	Between 0.3L abaft the fore end and 0.2L afore the aft end	6.90	2.25	2.25(2) 3.45(3)	1.0
IV	Afterward of 0.2L afore the aft end	9.80	3.25	4.90	$1 + \frac{0.123}{(C_{b1} + 0.2)^2}$

NOTE:
(1) Where L is 150 *metres* or less, value a may be multiplied by the value of following formula:

$$C = 0.0055L + 0.175$$

(2) In case of longitudinal deck girders outside the line of hatchway opening of the strength deck for midship part.
(3) In case of deck girders other than (2).

Table 3.10.3 Minimum Values of h

Line	Position of deck	$h^{(1)}$	C	
			Beams[2], Deck plating	Pillars, Deck girders
I and II	Forward of 0.3L abaft the fore end	$C\sqrt{L'+50}$	4.20	1.37
III	Between 0.3L abaft the fore end and 0.2L afore the aft end		2.05	1.18
IV	Afterward of 0.2L afore the aft end	$C\sqrt{L'}$	2.95	1.47
Second tier superstructure deck above the freeboard deck			1.95	0.69

NOTES:
(1) L' = length of ship (m). Where, however, L exceeds 230 m, L' is to be taken as 230 m.
(2) Where L is 150 *metres* or less, value C may be multiplied by the value of following formula:

$$C = 0.0055L + 0.175$$

the provisions in (1) and (2).

(4) Value of h is to be in accordance with the discretion of the Society, where the ship has an unusual large freeboard.

3 For an enclosed part of superstructure decks and of top of deckhouses in accommodation or navigation spaces, at the first and second tier above the freeboard deck, h is to be 12.8.

SECTION 3 Longitudinal Beams

301. Spacing

1. The standard spacing of the longitudinal beams is obtained from the following formula:

$$S = 2L + 550 \quad (mm)$$

2. It is recommended that the spacing of the longitudinal beams should not exceed 1 *metre*.

302. Proportion

1. Longitudinal beams are to be supported by deck transverses of appropriate spacing. In midship part of the strength deck, the slenderness ratio of deck longitudinals is not to exceed 60. This requirement may, however, be suitably modified where longitudinal beams are given a sufficient strength to prevent buckling.

2. Flat bars used for longitudinals are not to be of depth-thickness ratio exceeding 15.

303. Section modulus

1. The section modulus of longitudinal beams outside the line of openings of the strength deck for the midship part is not to be less than that obtained from the following formula:

$$Z = 1.14KShl^2 \quad (cm^3)$$

where:

S = spacing of longitudinal beams (m).
h = deck load specified in **Sec 2** (kN/m^2).
l = horizontal distance between bulkhead and deck transverse or between deck transverses (m).

2. The section modulus of longitudinal beams outside the line of openings of strength deck at 0.1L from fore end and aft end is not to be less than that obtained from the following formula:

$$Z = 0.43KShl^2 \quad (cm^3)$$

where:
S, h, and l = as specified in **Par 1.**

3. The section modulus of longitudinal beams outside the line of openings of strength deck for the parts forward and aftward the midship part may be gradually reduced from the value given in **Par 1,** and may be taken as **Par 2** at 0.1L from fore end and aft end.

304. Deck transverses

In single deck ships, the deck transverses are to be provided in line with the solid floors in double bottom, and in two deck ships, the transverses are also to be provided in line with the solid floors in double bottoms as far as practicable.

SECTION 4 Transverse Beams

401. Arrangements

Transverse beams are to be provided on every frame.

402. Proportion

It is preferable that the length-depth ratio of transverse beams be 30 or less at the strength deck, and 40 or less at effective decks (the decks below the strength deck which are considered as strength members in the longitudinal strength of hull) and superstructure decks as far as practicable.

403. Section modulus

The section modulus of transverse beams is not to be less than that obtained from the following formula:

$$Z = 0.43\,KShl^2 \quad (cm^3)$$

where:

S = spacing of transverse beams (m).
h = deck load specified in **Sec 2** (kN/m^2).
l = horizontal distance from the inner edge of beam brackets to the longitudinal deck girder, or between the longitudinal deck girders (m). ⚓

CHAPTER 11
DECK GIRDERS

SECTION 1
General

101. Application

Transverse deck girders supporting longitudinal deck beams and longitudinal deck girders supporting transverse deck beams are to be in accordance with the requirements in this Chapter.

102. Arrangement

In way of the bulkhead recesses and the top of tanks, deck girders are to be arranged at an interval not exceeding 4.6 *metres* as far as practicable.

103. Construction

1. Deck girders are to be composed of face plates provided along the lower edge.
2. Tripping brackets are to be provided at an interval of about 3 *metres* and where the breadth of face plates exceeds 180 *mm* on either side of the girder, these brackets are to be so arranged as to support the face plates as well.
3. The thickness of face plates forming girders is not to be less than that of web plates and the width of the face plates is not to be less than that obtained from the following formula:

$$b = 2.7\sqrt{d_0 l} \qquad (mm)$$

where:

d_0 = depth of webs (mm).
l = span of girders specified in **201.** (m).

4. The depth of girders is more than 2.5 times that of slots for beams, and is to be kept constant between two adjacent bulkheads for the longitudinal girders.
5. The girders are to have a sufficient rigidity to prevent excessive deflection of decks and excessive additional stresses in deck beams.

104. End connection

1. End connections of deck girders are to be in accordance with the requirements in **Ch 1, 604.**
2. Bulkhead stiffeners or girders at the ends of deck girders are to be suitably strengthened to support deck girders.
3. Longitudinal deck girders are to be continuous or to be effectively connected so as to maintain the continuity at ends.

SECTION 2
Longitudinal Deck Girders

201. Section modulus

1. The section modulus of longitudinal deck girders outside the lines of hatchway opening of the strength deck for midship part is not to be less than that obtained from the following formula:

$$Z = 1.29Kl\ (bhl + kW) \qquad (cm^3)$$

where:

l = distance between supporting points (m). Where the deck girder is effectively bracketed to bulkhead, l may be modified as specified in **Ch 1, 605.** (See **Fig. 3.11.1**)
b = distance between the centres of two adjacent spans of beams supported by the girders or the frames (m). (See **Fig. 3.11.1**)
h = deck load specified in **Ch 10, Sec 2** for the deck supported (kN/m^2).
W = deck load supported by the tween deck pillar as specified in **Ch 12, 201.** (kN).
k = as specified in the following (a) and (b):
(a) Coefficient obtained from the following formula according to the ratio of the horizontal distance from the pillar or bulkhead supporting the deck girder to the tween deck pillar a (m) and l. (See **Fig. 3.11.1**)

$$12\frac{a}{l}\left(1-\frac{a}{l}\right)^{2}$$

(b) Where there is only one tween deck pillar, k is to be obtained basing upon the smaller value of a. Where there are two or more tween deck pillars, a is to be measured from the same end of l for each tween deck pillar, and the sum of kW is to be used for the computation of the formula. In this case, the greater value between the sums of kW obtained basing upon a measured from each end of l is to be used.

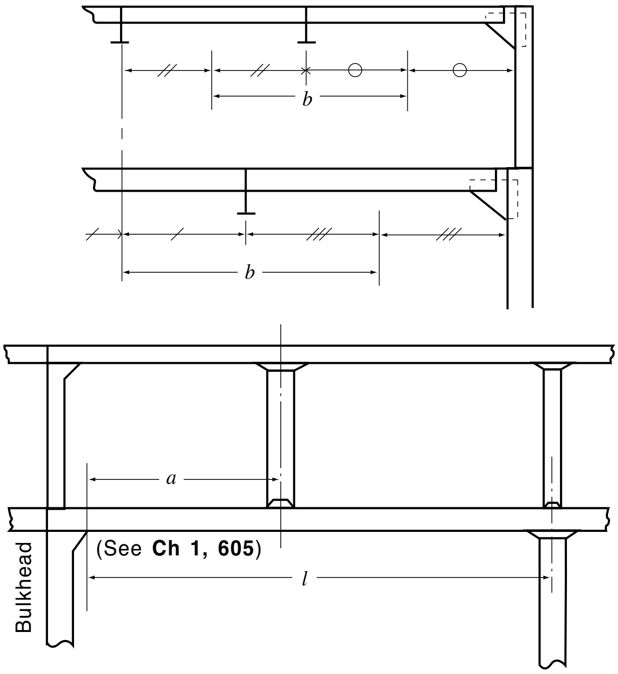


Fig. 3.11.1 Measurement of b, l and a

2. The section modulus of longitudinal deck girders outside the lines of hatchway opening of the strength deck for the parts forward and afterward the midship part may be gradually reduced. In no case, however, is the section modulus to be less than that obtained from the following formula:

$$Z = 0.484Kl\,(bhl + kW) \quad (cm^3)$$

where:
l, b, h, W and k = as specified in **Par 1.**

3. The section modulus of longitudinal deck girders for the parts other than that stipulated in **Pars 1** and **2** is not to be less than obtained from the formula in **Par 2.**

202. Moment of inertia

It is advised that the moment of inertia of girders is not to be less than that obtained from the following formula:

$$I = CZl \quad (cm^4)$$

where:
C = coefficient obtained from the following formulae:

For deck girders arranged outside the line of deck openings of strength deck of midship part of ship ········· 1.6

For other deck girders ········· 4.2

Z = required section modulus of girders specified in **201.** (cm^3).

l = as specified in **201. 1.**

203. Thickness of web plates

1. The thickness of web plates of longitudinal deck girders outside the line of openings of strength deck amidship is not to be less than that obtained from the following formula. This thickness, however, is not to be less than that obained from the formula in **Par 2.**:

$$t = 10\sqrt{f_D S_1} + 1.5 \quad (mm)$$

where:
S_1 = spacing of web stiffeners or depth of girders, whichever is the smaller (m).

2. The thickness of web plates of longitudinal deck girders other than those in parts specified in **Par 1** is not to be less than that obtained from the following formula:

$$t = 10\frac{S_1}{\sqrt{K}} + 1.5 \quad (mm)$$

where:
S_1 = as specified in **Par 1.**

3. The thickness of web plates at both end parts of $0.2l$ is not to be less than that specified in **Pars 1, 2** or that obtained from the following formula in (1) and (2) according to kinds of steel, whichever is the greatest:

(1) For mild steel

$$t = \frac{4.43Kbhl}{d_0} + 1.5 \quad (mm)$$

where:
d_0 = depth of webs (mm).
b, h and l = as specified in **201. 1.**

(2) For high tensile strength steel, this thickness, however, is not to be less than that obtained from (1).

$$t = 0.813\sqrt[3]{\frac{bhlS_1^2}{d_0}} + 1.5 \quad (mm)$$

where:
S_1 = as specified in **Par 1.**
d_1, b, h and l = as specified in (1).

SECTION 3
Transverse Deck Girders

301. Section modulus

The section modulus of transverse deck girders is not to be less than that obtained from the following formula:

$$Z = 0.484\,Kl\,(bhl + kW) \quad (cm^3)$$

where:
- l = distance between the centres of pillars or from the centre of pillar to the inner edge of beam bracket (m).
- b = distance between the centres of two adjacent girders or bulkhead (m).
- h, W and k = in accordance with **201.**

302. Moment of inertia

It is advised that the moment of inertia of girders is not to be less than that obtained from the following formula:

$$I = 4.2\,Zl \quad (cm^4)$$

where:
- Z = required section modulus of girders specified in **301.** (cm^3).
- l = as specified in **301.**

303 Thickness of web plates

The thickness of web plates is to be in accordance with the requirements in **203.**

SECTION 4
Deck Girders in Tanks

401. Section modulus

The section modulus of deck girders in tanks is to be in accordance with the requirements in **201.** or **301.,** and is to be in compliance with the requirements in **Ch 15, 204. 1** as well.

402. Moment of inertia

The moment of inertia of girders is to be in accordance with the requirement in **Ch 15, 204. 2.**

403. Thickness of web plates

The thickness of web plates is to be in accordance with the requirements in **203.** or **303.** and is to be in compliance with the requirements in **Ch 15, 204. 3** as well.

SECTION 5
Hatch Side Girders

501. Deep coamings on decks

Where deep coamings are provided on decks as in the case of hatchway on weather deck, the horizontal coaming stiffener and the coaming up to its stiffener may be included in the calculation of the section modulus, subject to the approval by the Society.

502. Strength continuity

At hatchway corners, the face plates of hatch coamings and longitudinal deck girders or their extension parts and the face plates on both sides of hatch end girders are to be effectively connected so as to maintain the strength continuity.

SECTION 6
Hatch End Girders

601. Scantling

The scantlings of hatch end girders are to be in accordance with the requirements in **Secs 2 to 5.** ⚓

CHAPTER 12
PILLARS

SECTION 1
General

101. Pillars in tween decks

Pillars in tween decks are to be arranged directly above those under the deck, or effective means are to be provided for transmitting their loads to the supports below.

102. Pillars in holds

Pillars in holds are to be provided in line with the keelsons or double bottom girders or as close thereto as practicable, and the structure under pillars is to be of ample strength to provide effective distribution of the load.

103. End connection of pillars

The head and heel of pillars are to be secured by thick doubling plates and brackets as necessary. Where the pillars which may be subjected to tensile loads such as under bulkhead recesses, tunnel tops or deep tank tops, the head and heel of pillars are to be efficiently secured to withstand the tensile loads.

104. Reinforcements

Where the pillars are connected to the deck plating, the top of shaft tunnels, or the frames, these structures are to be efficiently strengthened.

SECTION 2
Scantling of Pillars

201. Sectional area

1. The sectional area of pillars is not to be less than that obtained from the following formula:

$$A = \frac{0.223\,W}{2.72 - \dfrac{l}{k_0\sqrt{K}}} \qquad (cm^2)$$

where:

l = distance from the top of inner bottom, deck or other structures on which the pillars are based to the underside of beam or girder supported by the pillars (m). (See **Fig. 3.12.1**)

k_0 = minimum radius of gyration of the section of pillars (m).

W = deck load (kN) supported by the pillar obtained from the following formula:

$$W = kw_0 + Sbh \qquad (kN)$$

S = distance between the mid-points of two adjacent spans of girders supported by the pillars or the bulkhead stiffeners or bulkhead girders (m). (See **Fig. 3.12.1**)

b = mean distance between the mid-points of two adjacent spans of beams supported by the pillars or the frames (m). (See **Fig. 3.12.1**)

h = deck load specified in **Ch 10, Sec 2** for the deck supported (kN/m^2).

w_0 = deck load supported by the upper tween deck pillar (t).

k = as obtained from the following formula according to the ratio of the horizontal

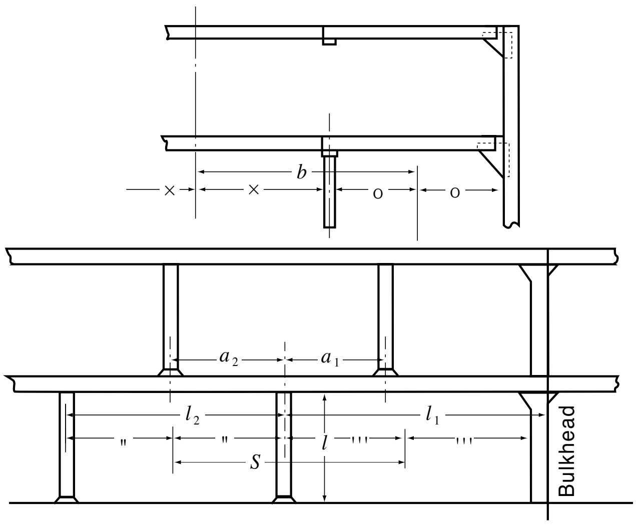


Fig. 3.12.1 Measurement of S, b, l, etc.

distance a_i (m) from the pillar to the tween deck pillar above to the distance l_j (m) from the pillar to the pillar or bulkhead. (See **Fig. 3.12.1**)

$$k = 2\left(\frac{a_i}{l_j}\right)^3 - 3\left(\frac{a_i}{l_j}\right)^2 + 1$$

2. Where there are two and over tween deck pillars provided on the deck girder supported by a line of lower pillars, the lower pillar is to be of the scantlings required by **Par 1,** taking kw_0 for each tween deck pillar provided on two adjacent spans supported by the lower pillars.
3. Where tween deck pillars are shifted from the lower pillars in athwartship direction, the scantlings of lower pillars are to be determined in accordance with the principle in **Pars 1** and **2.**

202. Thickness

1. The plate thickness of tubular pillars is not to be less than that obtained from the following formula. This requirement may, however, be suitably modified for the pillars provided in accommodation spaces.

$$t = 0.022\, d_p + 3.6 \quad (mm)$$

where:
d_p = outside diameter of the tubular pillar (mm).

2. The thickness of web and flange plates of built-up pillars is to be sufficient for the prevention of local buckling.

203. Outside diameter of round pillars

The outside diameter of solid round pillars and tubular pillars is not to be less than 50 mm.

204. Pillars provided in deep tank

1. Pillars provided in deep tank are not to be tubular pillars.
2. The sectional area of pillars is not to be less than that specified in **201.** or that obtained from the following formula, whichever is the greater.

$$A = 1.09\, Sbh \quad (cm^2)$$

where:
S and b = as specified in **201.**
h = 0.7 times the vertical distance from the top of deep tank to the point of 2 $metres$ above the top of overflow pipe (m).

205. Longitudinal bulkheads and others provided in lieu of pillars

The transverse bulkheads supporting longitudinal deck girders and the longitudinal bulkheads provided in lieu of pillars are to be stiffened in such a manner as to provide supports not less effective than required for pillars.

206. Casings provided in lieu of pillars

The casings provided in lieu of pillars are to be of sufficient scantlings to withstand the deck load and side pressure. ⚓

CHAPTER 13
ARRANGEMENTS TO RESIST PANTING

Section

SECTION 1
General

101. Application

In way of the spaces from the fore end of ship to a proper place beyond the collision bulkhead and from the aft end of ship to a proper place beyond the aft peak bulkhead, suitable arrangements to resist panting are to be provided according to the ship form at the place.

102. Swash plate

In fore and aft peak tanks to be used as deep tanks, effective swash plates are to be provided at the centre line of ship or the scantlings of structural members are to be suitably increased.

103. Stringers fitted up with extremely small angle

Where the angle between the web of stringers and the shell plating is extremely small, the scantlings of stringers are to be suitably increased above the normal requirements and, where necessary, appropriate supports are to be provided to prevent tripping.

SECTION 2
Arrangements to Resist Panting Forward the Collision Bulkhead

201. Arrangement and construction

1. Deep centre girders, etc. are to be provided forward the collision bulkhead.

2. In fore peaks of transverse framing, floors of sufficient height are to be arranged at the frame spacing stipulated in **Ch 8, 201. 2** and side girders are to be arranged at an interval not exceeding about 2.5 *metres*. Transverse frames are to be supported by the structures specified in **203. 2** at an interval not exceeding 2.5 *metres*.

3. In fore peaks of longitudinal framing, bottom transverses supporting bottom longitudinals and side transverses supporting side longitudinals are to be arranged at an interval not exceeding about 2.5 *metres*. Bottom transverses and side transverses are to be effectively connected each other and deck transverses are to be arranged on the deck in the same section to providing structures.

202. Floors and centre girders

1. The thicknesses of floors and centre girders in fore peaks are not to be less than those obtained from the following formula:

$$t = 0.6\sqrt{L} + 3 \quad (mm)$$

2. Floors are to extend to such a height as being necessary to give adequate stiffness to the structure and are to be properly stiffened with stiffeners as may be required.

3. The upper edges of the floors and centre girders are to be properly stiffened.

4. The thickness of side girders is to be approximately equal to that of centre girders and side girders are to extend to such a proper height as may be required according to the height of floors.

203. Transverse framing

1. Transverse frames below the freeboard deck.

The section modulus of transverse frames below the freeboard deck is not to be less than that obtained from the following formula.

$$Z = 8Shl^2 \quad (cm^3)$$

where:

S = frame spacing (m).

l = distance between the supports of transverses (m), but to be taken as 2.15 *metres* where the height is less than 2.15 *metres*.

h = vertical distance from the midpoint of l to a point of $0.12L$ above the top of keel (m), but to be taken as $0.06L$ *metres* where the height is less than $0.06L$ *metres*.

2. Side construction to resist panting

(1) Where panting beams are provided at alternate frames together with stringer plates connected to the shell plating:

(a) beams are to be angles or channel sections of sectional area not less than that obtained from the following formula, being connected effectively with frames by means of brackets having the thickness not less than that of the frames. And further, the panting beams are to be sufficiently connected vertically and longitudinally at the centre line of ship by means of angles as may be required in consideration of the span.

$$A = 0.3L \quad (cm^2)$$

(b) The scantlings of stringer plates are not to be less than those obtained from the following formula, and their inner edges are to be suitably stiffened by flanging or by angle sections.

Breadth: $b = 2.5L + 500 \quad (mm)$

Thickness: $t = 0.02L + 5.5 \quad (mm)$

(c) The frames to which no panting beam is provided are to be connected to the stringer plates by brackets. The length of each arm of brackets is to be at least equal to one half of the breadth of stringer plates required in (b) and the thickness of brackets at least equal to that of the stringer plates. In this case, the stringer plates are to be stiffened by providing flat bars extending from the toe of brackets to the inner edge of stringer plates.

(d) Stringer plates are to be connected by effective brackets to the breast hooks and the horizontal girders of transverse bulkhead.

(2) Where panting beams are provided at every frame together with perforated steel plates completely fitted up thereon from side to side:

(a) The sectional area of panting beams is not to be less than that obtained from the following formula:

$$A = 0.1L + 5 \quad (cm^2)$$

(b) The thickness of perforated steel plates completely plated on the panting beams is not to be less than that obtained from the following formula:

$$t = 0.02L + 4.5 \quad (mm)$$

(3) Where transverse frames are supported by side stringers:

(a) The scantlings of side stringers are not to be less than those obtained from the following formula:

Web depth:

d_1 = $200l$ (mm), $2.5L + 500$ (mm) or 2.5 times the depth of slot for the transverse frames, whichever is the greatest.

Section modulus:

$$Z = 8Shl^2 \quad (cm^3)$$

Web thickness :

t_1 or t_2, whichever is the greater.

$$t_1 = 42\frac{Shl}{d_0} + 1.5 \quad (mm)$$

$$t_2 = 0.11\sqrt[3]{\frac{d_0^2(t_1 - 1.5)}{k}} + 1.5 \quad (mm)$$

where:

S = spacing of side stringers (m).

l = horizontal distance between the supporting points of side stringers (m).

h = vertical distance from the middle of S to a point $0.12L$ above the top of keel (m). Where, however, h is less than $0.06L$ (m), h is to be taken as $0.06L$ (m).

d_0 = depth of side stringers (mm). In the calculation of t_1, however, the depth of slot for longitudinals, if any, is to be deducted from the depth of side stringers. Where the depth of side stringers is divided by horizontal stiffeners, the divided depth may be taken as do in the calculation of t_2.

k = coefficient given in **Table 3.13.1** according to the ratio of S_1 to d_o, where S_1 (mm) is the spacing of stiffeners or tripping brackets provided on web plates of side stringers. For the intermediate values of S_1/d_0, k is to be obtained by linear interpolation.

Table 3.13.1 Coefficient k

S_1/d_0	k
0.3 and under	60.0
0.4	40.0
0.5	26.8
0.6	20.0
0.7	16.4
0.8	14.4
0.9	13.0
1.0	12.3
1.5	11.1
2.0 and over	10.2

(b) Side stringers are to be provided with tripping brackets at an interval of about three *metres*. Where the breadth of face bars of side stringers exceeds 180 mm on either side of the web the tripping brackets are to support the face bars as well. And stiffeners are to be provided on the webs at every longitudinal except for the middle part of the span of side stringers where they may be provided at alternate transverse frames.

(c) Where the side stringers are supported by cross ties, the scantlings of cross ties are not to be less than those obtained from the formula given in **Table 3.13.2.**

Table 3.13.2 Scantlings of Cross Ties

$\frac{l}{k_0}$	Sectional area (cm^2)	Web thickness (mm)
$\frac{l}{k_0} \geq 0.6$	$A = \dfrac{0.77\,Sbh}{1 - 0.5\dfrac{l}{k_0}}$	$t_w = 0.016\,d_w\sqrt{\dfrac{Sbh}{A}}$
$\frac{l}{k_0} < 0.6$	$A = 1.1\,Sbh$	

S = spacing of side stringers (m).
b = breadth of area supported by the cross tie (m)
h = vertical distance from the middle of b to a point 0.12 L above the top of keel (m). Where, however, h is less than 0.06 L (m), h is to be taken as 0.06 L (m).
l = length of cross tie (m).
k_0 = minimum radius of gyration of cross tie, obtained from the following formula (cm).

$$k_0 = \sqrt{\frac{I}{A}}$$

I = the least moment of inertia of cross tie (cm^4)
A = sectional area of cross tie (cm^2).
d_w = web depth of cross tie (mm). Where, however, stiffeners are fitted up horizontally, the largest divided web depth may be taken as d_w.

(d) Cross ties are to be effectively connected with the side stringers by brackets or by other suitable arrangements and the side stringers are to be provided with tripping brackets in way of the cross ties.

(e) the breadth of face bars of cross ties on either side of the web exceeds 150 mm, stiffeners are to be provided on the webs at a suitable interval, to be connected with the face bars and to support the face bars.

204. Longitudinal framing

1. Longitudinal frames below the freeboard deck are to comply with the following requirements:

(1) The section modulus is not to be less than that obtained from the following formula. However, the section modulus obtained from the formula is to be increased by 25 % between 0.05 D and 0.15 D from the top of keel and 50 % below 0.05 D from the top of keel.

$$Z = 8\,Shl^2 \quad (cm^3)$$

where:
S = longitudinal frame spacing (m).
l = distance between side transverse or between side transverse and transverse bulkhead (m), but where it is less than 2.15 m, l is to be taken as 2.15 m.
h = vertical distance from longitudinal frames to a point 0.12 L above the top of keel (m), but where it is less than 0.06 L (m), h is to be taken as 0.06 L (m).

(2) Longitudinal frames are to be connected at each end to breast hooks or transverse bulkheads by efficient brackets.

2. The side transverses supporting longitudinal frames are to comply with the following requirements. However, where these are found impractical to apply these requirement are to be to the satisfaction of the Society.

(1) Side transverses on both sides are to be connected providing cross ties at a vertical interval not greater than that obtained from the following formula:

$$S = 0.0125\,L + 2.5 \quad (m)$$

(2) The scantlings of transverses are not to be less than those obtained from the following formula:

Web depth:
d_1 = 200 l (mm), $2.5\,L + 500$ (mm) or 2.5 times the depth of slots for longitudinals, whichever is the greatest.

Section modulus:

$$Z = 8\,Shl^2 \quad (cm^3)$$

Web thickness:
t_1 or t_2, whichever is the greater.

$$t_1 = 42\frac{Shl}{d_0} + 1.5 \quad (mm)$$

$$t_2 = 0.11\sqrt[3]{\frac{d_0^2(t_1 - 1.5)}{k}} + 1.5 \quad (mm)$$

where
l = vertical distance between supporting points of side transverses (m).
S = spacing of side transverses (m).
h = vertical distance from the middle of l to a point 0.12 L above the top of keel (m). Where, however, h is less than 0.06 L (m), h is to be taken as 0.06 L (m).
d_0 = depth of side transverse (mm). In the calculation of t_1, however, the depth of slot for longitudinals, if any, is to be deducted from the depth of transverses. Where the depth of side trans-

verses is divided by vertical stiffeners, the divided depth may be taken as d_o in the calculation of t_2.

k = coefficient given in **Table 3.13.1** according to the ratio of S_1 to d_0, where S_1 (mm) is the spacing of tripping brackets or stiffeners provided on web plates of side transverses. For the intermediate values of S_1/d_0, k is to be obtained by linear interpolation.

(3) Side transverses are to be connected effectively with the bottom transverses. Where side transverses are connected with bottom transverses, the scantlings of webs and face bars in the lowest span are to be so decided as to provide strength continuity in the transient from side to bottom transverse; the sum of effective sectional area of web and area of face bar in the lower half of the lowest span is not to be less than the required sectional area of web of the bottom transverse.

(4) Side transverses are to be provided with tripping brackets at an interval of about three *metres*. Where the breadth of face bars of side transverses exceeds 180 mm on either side of the web, the tripping brackets are to support the face bars as well. And stiffeners are to be provided on the webs at every longitudinal, except that these stiffeners may be provided at alternate longitudinals in the middle part of spans other than the lowest span.

3. Cross ties specified in **Par 2** (1) are to comply with the requirements in items **203. 2** (3) (c), (d) and (e). In this case, side stringers of quotable paragraph are to be replaced with side transverse. Where, however, it is found impracticable to apply these requirements, the constructions are to be at the discretion of the Society.

4. Bottom transverses supporting bottom longitudinals are to be of the construction specified in (1) to (6) or to be of that deemed equivalent thereto by the Society. In case of ships capable of maintaining adequate fore draught in rough seas, however, the section modulus of transverses and the sectional area of webs specified in (1) to (3) may be reduced by 10 % respectively.

(1) The scantlings of bottom transverses are not to be less than that obtained from the following formula, and the bottom transverses are to be supported by struts at the centre line, and further the adjacent bottom transverses are to be connected each other by a centre girder of about the same scantlings as those of the bottom transverses or to be supported by a specially deep centre girder or a longitudinal bulkhead.

Web depth: $d_0 = 5.5\,L + 450$

Section modulus: $Z = 1.2\,SLl^2 \quad (cm^3)$

Web thickness: $t_w = 0.6\sqrt{L} + 3 \quad (mm)$

where:

S = spacing of bottom transverses (m).

l = distance between the supporting points of bottom transverses (m).

(2) Where bottom transverses and centre girders are of scantlings exceeding those obtained from the following formula, notwithstanding the requirements in (1), the centre line struts may be arranged at alternate bottom transverses.

(a) Centre girders:

Web depth: $d_0 = 8\,L + 680 \quad (mm)$

Web thickness: $t_w = 0.65\sqrt{L} + 3.5 \quad (mm)$

Section modulus:

Value obtained from the formula in (1). In the formula, however, the average load bearing width (m) of the centre girder is to be taken as S and the distance between the supporting points of the centre girder (m) as l.

(b) Bottom transverses:

Web depth: $d_0 = 5.5\,L + 450 \quad (mm)$

Web thickness: $t_w = 0.65\sqrt{L} + 3.5 \quad (mm)$

Section modulus:

Value obtained from the formula in (1).

(3) Where the scantlings of bottom transverses are greater than those obtained from the following formula, notwithstanding the requirements in (1) the centre line struts or longitudinal bulkheads may be dispensed with. In this case, the scantlings of web plates of centre girders are not to be less than those required in (1) for bottom transverses and free edges of web plates are to be suitably stiffened.

Web depth: $d_0 = 8\,L + 680 \quad (mm)$

Web thickness: $t_w = 0.7\sqrt{L} + 4 \quad (mm)$

Section modulus:

Value obtained from the formula in (1).

(4) Where the web depths of bottom transverses and centre girders are greater than those obtained from (3) their thicknesses may be reduced from the thicknesses prescribed in (3) notwithstanding the requirements in (3). However, in no case is the thickness to be less than that obtained from the following formula:

$$t_w = 0.55\sqrt{L} + 2.5 \quad (mm)$$

(5) Where the length of bottom transverses measured between their supporting points at each side exceeds 0.045 L (m) or the spacing of bottom transverses exceeds 2.5 *metres*, the scantlings of bottom transverses and centre girders prescribed in (1) to (4) are to be suitably increased.

(6) Bottom transverses are to be provided with tripping brackets at an interval of about 3

metres. Where the breadth of face bars of bottom transverses exceeds 180 *mm* on either side of the web, the tripping brackets are to support the face bars as well. And stiffeners are to be provided on the webs at every longitudinal.

5. The struts stipulated in **4** (1) and (2) are not to be less effective than those required by the following (1) to (3) or equivalent thereto.

(1) The scantlings of struts are not to be less than that obtained from the formula given in **Table 3.13.3.**

Table 3.13.3 Scantlings of Struts

$\frac{l}{k_0}$	Sectional area (cm^2)	Web thickness (mm)
$\frac{l}{k_0} \geq 0.6$	$A = \frac{0.115\,SbL}{1 - 0.5\frac{l}{k_0}}$	$t_w = 0.0062\,d_w\sqrt{\frac{SbL}{A}}$
$\frac{l}{k_0} < 0.6$	$A = 0.164\,SbL$	

S = length in longitudinal direction of the area supported by strut (m).
b = breadth of the area supported by strut (m).
l = length of strut (m).
k_0 = minimum radius of gyration of struts, obtained from the following formula (cm).

$$k_0 = \sqrt{\frac{I}{A}}$$

I = the least moment of inertia of strut (cm^4).
A = sectional area of strut (cm^2).
d_w = breadth of web (mm). Where, however, the web is provided with stiffeners along the length of strut, the maximum spacing of such stiffeners is to be taken as d_w.

(2) As a rule, the struts are to extend to the lowest deck, and are to be effectively connected with the cross ties by brackets.

(3) Where the breadth of face bars on either side of the webs exceeds 150 *mm*, stiffeners are to be provided on the webs and so arranged as to support the face bars at a suitable interval.

6. Side girders are to be provided in line with those abaft collision bulkhead in order to give additional stiffness to the structure of flat bottom.

205. Bulbous bow

Structural arrangements at the fore end part of ship having bullbous bow or other similar unusual form of bow section will be specially considreded by the Society.

SECTION 3
Arrangements to Resist Panting Abaft aft Peak Bulkhead

301. Floors

The scantling and arrangement of floors in aft peak are to be in accordance with the requirements in **202.** of this Chapter. The floors are to extend well above the stern tubes.

302. Frames

1. The section modulus of transverse frames below the freeboard deck is not to be less than that obtained from the following formula:

$$Z = 8\,Shl^2 \quad (cm^3)$$

where:
S = frame spacing (m).
l = unsupported length of frame (m). Where, however, the length is less than 2.15 *metres*, l is to be taken as 2.15 *metres*.
h = vertical distance from the middle of l to a point $d + 0.038\,L'$ above the top of keel (m). Where, however, the distance is less than 0 04 L (m), h is to be taken as 0.04 L (m).
L' = length of ship (m). Where, however, L exceeds 230 m, L' is to be taken as 230 m.

2. Where the speed of ship exceeds 14 *kts*, the section modulus of side frames is to be increased over the value required by **Par 1** at the rate of 2 % per *knot* excess, but the increase need not exceed 12 %.

303. Panting beams and stringers

1. The structure below the lowest deck is to be effectively stiffened by means of panting beams and stringers as required for the fore peak in **203. 2.**

2. Where the distance between supports at any part of the girth of the frame exceeds 2.5 m, the scantlings of frames are to be increased, or side stringers or struts are to be additionally provided to give adequate stiffness to the structure.

304. Cruiser sterns

Cruiser sterns are to be strengthened by means of web frames, side stringers, etc. as may be required.

SECTION 4
Arrangements to Resist Panting between both Peaks

401. Abaft collision bulkhead

Between the collision bulkhead and 0.15L from the fore end, side stringers are recommended to be provided in line with stringer plates or side stringers in way of the fore peak tanks, in association with web frames provided at a suitable interval. Even in case where no web frame and side stringer are provided, brackets, etc. are to be provided to provide continuity at sections where side stringers or perforated steel plates in the fore peak tanks are located.

402. Forward after peak bulkhead

As for forward of the aft peak bulkhead, side stringers are to be provided or the frames are to be increased in size in a similar manner as prescribed in the preceding Article, where the frames have specially long unsupported spans as compared with the span amidships. ⚓

CHAPTER 14
WATERTIGHT BULKHEADS

Section

SECTION 1
General

101. Application

In general all ships are to be provided with strength and watertight bulkheads in accordance with the requirements in this Chapter. In ships of special types, arrangements where it is impracticable to be in accordance with the requirements of this Chapter, are to be specially approved by this Society.

102. Symbols

Watertight bulkheads constructed in accordance with the requirements in this Chapter will be recorded in the Register Book as WT the symbols being prefixed in each case by the number of such bulkheads.

SECTION 2
Arrangement of Watertight Bulkheads

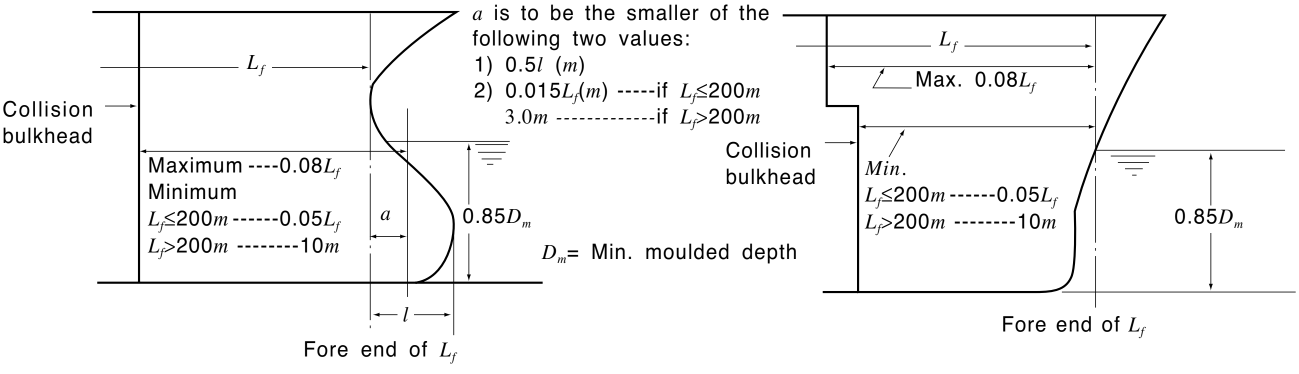
201. Collision bulkheads

1. All ships are to have a collision bulkhead, at a position not less than $0.05L_f$ or $10\,m$, whichever is the lesser, but not more than $0.08L_f$ except where the larger distance be accepted by the Society due to special structural reasons from the forward terminal of the length for freeboard. However, where any part of the ship below the waterline at 85 % of the least moulded depth extends forward beyond the forward terminal of the length for freeboard, the above-mentioned distance is to be measured from a point either: (See **Fig. 3.14.1**)

(a) at the mid-length of such extension; or
(b) at a distance of $0.05L_f$ forward from the above mentioned forward terminal; or
(c) at a distance of $3\,m$ forward from the forward terminal; whichever gives the smallest measurement.

2. For ships having a collision bulkhead with steps or recesses, the measurement of the distance may be observed in accordance with **Fig. 3.14.1** (B).

3. Arrangement of collision bulkhead in a ship provided with bow door is to be at the discretion of the Society. However, where a slopping ramp forms a part of the collision bulkhead above the freeboard deck, the part of the ramp which is more than $2.3\,m$ above the freeboard deck may extend forward of the limit specified in the above **Par 1.** In this case, the ramp is to be weathertight over its complete length.



(A) (B)

Fig. 3.14.1 Measuring Positions of Collision Bulkhead Location

202. Aft peak bulkheads

1. All ships are to have an after peak bulkhead situated at a suitable positions.

2. The stern tube is to be enclosed in a watertight compartment by the after peak bulkhead or other suitable arrangements.

203. Machinery bulkheads

1. Watertight bulkhead is to be provided at each end of the machinery space.

2. In ships having the machinery room at aft body, aft end bulkhead of macinery room specified in **Par 1** may be regarded as aft peak bulkhead specified in **202.**

204. Hold bulkheads

1. Cargo ships of ordinary type, are to have hold bulkheads in addition to the bulkheads specified in **201.** to **203.** at a reasonable interval so that the total number of the watertight bulkheads including the bulkheads specified in **201.** to **203.** may not be less than that given by **Table 3.14.1.**

Table 3.14.1 Number of watertight Bulkheads

Length of ship (m)	Total number of bulkhead	
	Ships with machinery room at aft body	Elsewhere
$90 \le L < 102$	4	5
$102 \le L < 123$	5	6
$123 \le L < 143$	6	7
$143 \le L < 165$	7	8
$165 \le L < 185$	8	9
$186 \le L$	to be considered individually	

2. The requirements in **Par 1** may be not applied to the arrangements of bulkhead subject to the approval of the Society.

205. Height of watertight bulkheads

The watertight bulkheads required in **201.** to **204.** are the extend to the freeboard deck with the following exceptions:

(1) A watertight bulkhead in way of raised quarter or sunken forecastle deck is to extend up to the said deck.

(2) Where a forecastle having openings without closing appliances led to a space below the freeboard deck is provided, or where a forecastle of 0.25 L_f or above in length is provided, the collision bulkhead is to extend up to the forecastle deck. However, the extended part above freeboard deck may have steps within the limit of bulkhead position specified in **201.** and may be weathertight.

(3) Aft peak bulkhead may terminate at a deck above the load line, provided that this deck is made watertight to stern or to watertight stern floor of the ship.

206. Construction

1. Where the watertight bulkheads required in **201.** to **204.** are not extended up to the strength deck, deep webs or partial bulkheads situated immediately or nearly above the main watertight bulkheads are to be provided so as to maintain the transverse strength and stiffness of the hull.

2. Where the length of a hold exceeds 30 *metres*, suitable means are to be provided so as to maintain the transverse strength and stiffness of the hull.

207. Chain lockers

1. Chain lockers located abaft the collision bulkhead or in forepeak tanks are to be watertight and to be provided with means for effective drainage by pumps.

2. Chain lockers are to be subdivided by centre line screen walls.

SECTION 3
Construction of Watertight Bulkheads

301. Thickness

1. The thickness of bulkhead plating is not to be less than that obtained from the following formula:

$$t = 3.2S\sqrt{hK} + 1.5 \qquad (mm)$$

where:
S = spacing of stiffeners (m).
h = vertical distance from the lower edge of plate to the bulkhead deck at centre (m). but in no case is it to be less than 3.4 m.

2. Notwithstanding the requirements in **Par 1**. In no case is the thickness of watertight bulkhead platings to be less than that obtained from following fomrula:

$$t_{\min} = 5.9S + 1.5 \quad (mm)$$

where:
S = as specified in **Par 1.**

302. Increase of thickness

1. The thickness of lowest strake of plating is not to be less than that obtained from the above formula given in **301.** plus 1 *mm*.

2. The lowest strake of bulkhead plating is to extend at least 610 *mm* above the top of inner bottom plating in way of double bottom or 915 *mm* above the top of keel in way of single bottom. Where the double bottom is provided only on one side of the bulkhead, the extension of the lowest strake is to be of the greater value among the two cases above.
3. The bulkhead platings in way of bilge wells are to be at least 2.5 *mm* thicker than given by **301.**
4. The bulkhead plating is to be doubled or increased in thickness in way of stern tube opening, notwithstanding the requirements in the preceding Article.

303. Stiffeners

The section modulus of bulkhead stiffeners is not to be less than that obtained from the following formula:

$$Z = CKShl^2 \quad (cm^3)$$

where:

l = span measured between the adjacent supports of stiffeners including the length of connection (mm). Where girders are provided, it is the distance from the heel of end connection to the first girder or the distance between the girders.

S = spacing of stiffeners (m).

h = vertical distance measured from the midpoint of l for vertical stiffeners, and from the midpoint of distance between the adjacent stiffeners for horizontal stiffeners, to the top of bulkhead deck at the centre line of ship (mm). Where the vertical distance is less than 6.0 m, h is to be taken as 0.8 times the vertical distance plus 1.2 *metres*.

C = coefficient given in **Table 3.14.2** according to the type of end connection.

304. Corrugated bulkheads

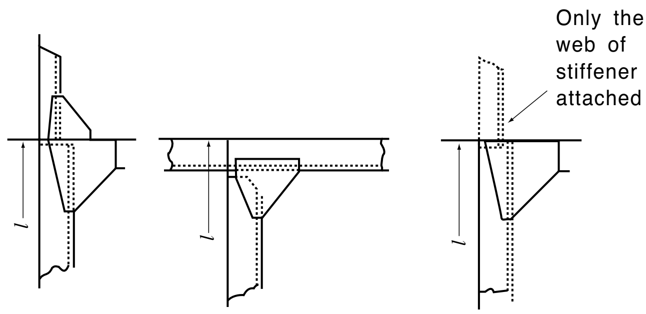
1. The plate thickness of corrugated bulkheads is not to be less than that obtained from the following formula, whichever is the greater:

$$t_1 = 0.0034CS_1\sqrt{hK} + 1.5 \qquad (mm)$$
$$t_2 = 0.0059CS_1 + 1.5 \quad (mm)$$

where:

h = as specified in **301.**

S_1 = breadth of face part and web part, respectively (mm), indicated as a and b in **Fig. 3.14.3.**



(a) (b)

Fig. 3.14.2 Types of End Connection

Table 3.14.2 Valua of *C*

<table>
<tr><td rowspan="6">Vertical Stiffener</td><td rowspan="2">Upper end / Lower end</td><td rowspan="2">Lug-connection or supported by horizontal girders</td><td colspan="2">Connection</td><td rowspan="2">End of stiffener unattached</td></tr>
<tr><td>Type A</td><td>Type B</td></tr>
<tr><td>Lug-connection or supported by horizontal girders</td><td>2.80</td><td>2.80</td><td>3.22</td><td>3.78</td></tr>
<tr><td>Connected by bracketed</td><td>2.24</td><td>2.24</td><td>2.52</td><td>2.80</td></tr>
<tr><td>Only the web of stiffener attached at end</td><td>3.22</td><td>3.22</td><td>3.78</td><td>4.48</td></tr>
<tr><td>End of stiffener unattached</td><td>3.78</td><td>3.78</td><td>4.48</td><td>5.60</td></tr>
<tr><td rowspan="3">Horizontal Stiffener</td><td>One end / The other end</td><td colspan="2">Lug-connection, connected by bracketed or supported by vertical girders</td><td colspan="2">End of stiffener unattached</td></tr>
<tr><td>Lug-connection, connected by bracketed or supported by vertical girders</td><td colspan="2">2.80</td><td colspan="2">3.78</td></tr>
<tr><td>End of stiffener unattached</td><td colspan="2">3.78</td><td colspan="2">5.60</td></tr>
</table>

NOTES:
1. “Lug-connection” is such a connection as both web and face bar of stiffener are effectively attached to the bulkhead plating, decks or inner bottoms which are strengthened by effective supporting members on the opposite side of plating.
2. “Connection-Type A” of vertical stiffeners is a connection by bracket to the longitudinal members or to the adjacent members, in line with the stiffeners, of the same or larger sections, (See **Fig. 3.14.2** (a))
3. “Connection-Type B’’ of vertical stiffeners is a connection by bracket to the transverse members such as beams, or other connections equivalent to the connections mentioned above. (See **Fig, 3.14.2** (b))

C = coefficient given below:
Face part:

$$C = \frac{1.5}{\sqrt{1+\left(\frac{t_w}{t_f}\right)^2}}$$

Web part: $C = 1.0$

t_f and t_w = thickness of plates of face part and web part, respectively (mm).

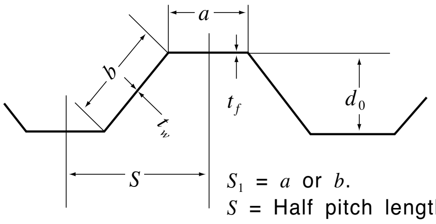


Fig. 3.14.3 Measurement of S

2. The section modulus per half pitch of corrugated bulkheads is not to be less than that obtained from the following formula:

$$Z = 3.6\,KCShl^2 \quad (cm^3)$$

where:

S = half pitch length of the corrugation (m). (See **Fig. 3.14.3**)
h = as specified in **303.**
l = length between the supports (m), as indicated in **Fig. 3.14.4.**
C = coefficient given in **Table 3.14.3,** according to the type of end connection.

e = 0.5A or 0.5B. whichever is smaller.

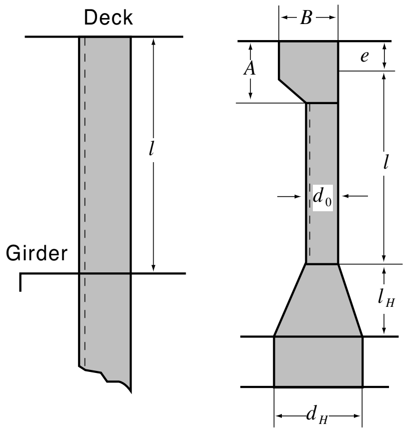


Fig. 3.14.4 Measurement of l

3. Where the end connection of corrugated bulkheads is remarkably effective, the value of C specified in **Par 2** may be adequately reduced.

4. The thickness of plates at end parts for 0.2l in line with l is not to be less than that obtained from the following formulae respectively:
Web part:

$$t_1 = 41.7\frac{CKShl}{d_0} + 1.5 \quad (mm)$$

In no case is the web thickness to be less than that obtained from the following formula:

$$t_{min} = 0.174\sqrt[3]{\frac{CShlb^2}{d_0}} + 1.5 \quad (mm)$$

Table 3.14.3 Values of C

Line	One end of bulkhead / The other end of bulkhead	Supported by horizontal or vertical girders	Upper end welded directly to deck	Upper end welded to stool efficiently supported by ship structure
(1)	Supported by horizontal or vertical girders or Lower end of bulkhead welded directly to decks or inner bottoms	$\frac{4}{2+\frac{Z_1}{Z_0}+\frac{Z_2}{Z_0}}$	$\frac{4}{2.2+\frac{Z_2}{Z_0}}$	$\frac{4}{2.6+\frac{Z_2}{Z_0}}$
(2)	Lower end of bulkhead welded to stool efficiently supported by ship structure	$\frac{4.8\left(1+\frac{l_H}{l}\right)^2}{2+\frac{Z_1}{Z_0}+\frac{d_H}{d_0}}$	$\frac{4.8\left(1+\frac{l_H}{l}\right)^2}{2.2+\frac{d_H}{d_0}}$	$\frac{4.8\left(1+\frac{l_H}{l}\right)^2}{2.6+\frac{d_H}{d_0}}$
		In no case is the value of C less than that obtained from line (1)		

Z_0 = minimum section modulus per half pitch of mid part for 0.6l of the corrugated bulkhead (cm^3).
Z_1, Z_2 = section modulus per half pitch of end part (cm^3). In case of vertical corrugation, Z_1 is the section modulus of the upper end part and Z_2 is that of the lower end part. Where the plate thickness is increased in accordance with **Par 5** the section modulus is to be that for the plate thickness reduced by the increment.
l_H = height of stool measured from the inner bottom plating (m).
d_H = breadth of stool measured on the inner bottom plating (mm).
d_0 = depth of corrugation (mm).

Face part, except the upper end part of vertically corrugated bulkheads:

$$t_f = \frac{0.012\,a}{\sqrt{K}} + 1.5 \quad (mm)$$

where:

S, h, l and d_0 = as specified in **Par 2.**

a and b = breadth of face part and web part, respectively (mm).

C = coefficient given in **Table 3.14.4.** Where the vertically corrugated bulkheads are constructed with single span, the value of C may be taken as the value for the uppermost span in the Table.

Table 3.14.4 Values of C

Position		Upper end	Lower end
Vertically corrugated bulkhead	Uppermost span	0.4	1.6
	Other spans	0.9	1.1
Both ends of horzontally corrugated bulkhead		1.0	

5. The thickness of the plates specified in the preceding Paragraphs are to be in accordance with **302.**

6. The actual section modulus per half pitch of corrugated bulkheads is to be calculated by the following formula:

$$Z_a = \frac{at_f d_0}{2} + \frac{bt_w d_0}{6} \quad (cm^3)$$

where:

a and b = breadth of face part and web part respectively (m).

t_f and t_w = thickness of plates of face part and web part respectively (mm).

d_0 = depth of corrugation (mm).

305. Collision bulkheads

For collision bulkheads, the plate thickness and section modulus of stiffeners are not to be less than those specified in **301., 303.** and **304.** taking h as 1.25 times the specified height.

306. Girders

1. The section modulus of girders supporting bulkhead stiffeners (hereinafter referred to as "girder") is not to be less than that obtained from the following formula:

$$Z = 4.75\,KShl^2 \quad (cm^3)$$

where

S = breadth of the area supported by the girder (m).

h = vertical distance measured from the mid-point of l for vertical girders, and from the mid-point of S for horizontal girders, to the top of bulkhead deck at the centre line of ship (m). Where the vertical distance is less than 6.0 $metres$, h is to be taken as 0.8 times the vertical distance plus 1.2 $metres$.

l = span measured between the adjacent supports of girders (m). l may be modified in accordance with **Ch 1, 605.** Where brackets with curved free edge are attached the effective arm length of the brackets is to be taken as b indicated in **Fig. 3.14.5.**

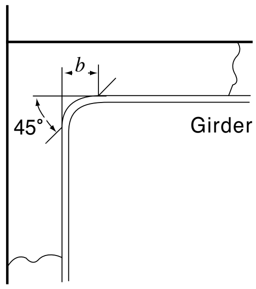


Fig. 3.14.5 Measurement of b

2. The moment of inertia of girders is not to be less than that obtained from the following formula. In no case is the depth of girders to be less than 2.5 times the depth of slots for stiffeners.

$$I = 10\,hl^4 \quad (cm^4)$$

where:

h and l = as specified in **Par 1.**

3. The thickness of web plates is not to be less than that obtained from the following formula:

$$t = 0.01\,S_1 + 1.5 \quad (mm)$$

where:

S_1 = spacing of web stiffeners or depth of girders, whichever is the smaller (mm).

4. The thickness of web plates at both end parts for 0.2 l is not to be less than that obtained from the following formulae, whichever is the greater:

$$t_1 = 41.7\frac{CKShl}{d_0} + 1.5 \quad (mm)$$

$$t_2 = 0.174\sqrt[3]{\frac{CShlS_1^2}{d_0}} + 1.5 \quad (mm)$$

where:

S, h and l = as specified in **Par 1.**

d_0 = depth of girders (mm).

S_1 = as specified in **Par 3.**

C = as specified in **304. 4.**

5. Tripping brackets are to be provided at an interval of about 3 *metres* and where the breadth of face plates exceeds 180 *mm* on either side of the girder, these brackets are to be so arranged as to support the face plates.

6. The actual section modulus and moment of inertia of girders are to be calculated in association with the steel plates specified in **Ch 1, 602.** Where stiffeners are provided within the effective breadth, they may be included in the calculation.

307. Brackets

The scantlings of the effective brackets at the ends of bulkhead stiffener are to be in accordance with the requirement in **Ch 1, 604. 2.**

308. Strengthening of bulkhead plating, deck plating, etc.

Platings of bulkheads, decks, inner bottoms, etc. are to be, if necessary, strengthened at the location of the end brackets of stiffeners and the end of girders.

309. Bulkhead recesses

1. In way of bulkhead recesses, beams are to be provided at every frame and under the upper bulkhead in accordance with the requirements in **Ch 10, 403.** and **Ch 14, 303.** taking the beam spacing as the stiffener spacing. Where the lower end of upper bulkhead is specially strengthened, the beam under the upper bulkhead may be dispensed with.

2. The thickness of deck plating in way of bulkhead recesses is to be at least 1 *mm* greater than that given by **301.,** regarding the deck plating as bulkhead plating and the beams as stiffeners respectively. In no case is the thickness to be less than that required for deck plating in that location.

3. The thickness of pillars supporting bulkhead recesses are to be determined taking account of the water pressure which might be applied on the upper surface of recesses, and their end connections are to be sufficient to withstand the water pressure which might be applied on the under surface.

310. Construction of bulkheads in way of watertight doors

Where stiffeners are cut or the spacing of stiffeners is increased in order to provide the watertight door in the bulkhead, the opening is to be suitably framed and strengthened as to maintain the full strength of the bulkhead. In this case the door frames are not to be considered as stiffeners.

SECTION 4
Watertight Doors

401. General

1. Any access openings, doors, manholes or ducts for ventilation, etc. are not to be cut in the collision bulkhead below freeboard deck. The number of openings in collision bulkheads above the freeboard deck is to be kept to a minimum as possible and all such openings are to be provided with weathertight means of closing.

2. Watertight doors are to be provided for all access openings in the watertight bulkheads in accordance with the requirements in the following **402.** to **405.**

402. Type of watertight doors

1. Watertight doors are to be of sliding type. Hinged or rolling type may, however, be accepted having regard to the position or the service condition of the door.

2. Doors which are closed by dropping or by the action of a dropping weight are not permitted.

403. Strength and watertightness

1. Watertight doors are to be of ample strength and watertightness for water pressure to a head up to the bulkhead deck, and door frames are to be effectively secured to the bulkheads. Where deemed necessary by the Society, watertight doors are to be tested by water pressure before they are fitted.

2. The frames of vertical sliding watertight doors are to have no groove at the bottom in which dirt might lodge and prevent the door from closing.

404. Sliding doors

1. Sliding watertight doors are to be capable of being operated from an accessible position above the bulkhead deck and are to have an index at the operating positon showing whether the door is open or closed. This remote control of the door may, however, be omitted where the Society is satisfied with such an arrangement having regard to the service condition of the door.

2. Where the above control means is operated by rods, the lead of operating rods is to be as direct as possible and the screw is to work in a nut of gun-metal or other approved material.

3. Sliding doors controlled from remote positions are also to be capable of being operated at the position of the door.

405. Hinged and rolling doors

Hinged and rolling doors are to be capable of being closed and secured from both sides of the bulkhead. The hinge pins of these doors are to be of gun-metal or other approved material.

406. Others

For fitting of valves or cocks to a watertight bulkhead, see **Pt 5, Ch 6, 107. 11.** For pipes passing through bulkheads, see **Pt 5, Ch 6, 107. 8** and **10.** For electric cables passing through bulkhead, see **Pt 6, Ch 1, 408.1** to **3.** ⚓

CHAPTER 15
DEEP TANKS

Section

SECTION 1
General

101. Definition

The deep tank is a tank used for carriage of water, fuel oil and other liquids, forming a part of the hull in holds or tween decks. The deep tanks used for carriage of oils are designated as "deep oil tank", if necessary.

102. Application

1. The constructions of all deep tanks are to be in accordance with the requirements in this Chapter. Where the bulkhead of deep tank partly serves as a watertight bulkhead, the part of the bulkhead is to be in accordance with the requirement in **Ch 14.**

2. The requirements in **Pt 7, Ch 1** are to be applied to the bulkheads of the deep tanks for carriage of oils having flash a point below 60°C, in addition to those in this Chapter.

103. Divisions in tanks

1. In deep tanks extending from side to side of the ship, a centre line watertight bulkhead, wash bulkhead, or deep wash plate is to be fitted as may be required.

2. Tanks for fresh water or fuel oil or those which are not intended to be kept entirely filled in service conditions are to have additional divisions or deep wash plates as necessary to minimize the dynamic forces acting on the structure.

3. Where it is impracticable to comply with the requirements in **Par 2,** the scantlings required in this Chapter are to be properly increased.

4. Longitudinal watertight divisions which will be subjected to pressure from both sides, in tanks which are to be entirely filled or emptied in service conditions, may be of the scantlings required for ordinary watertight bulkheads by **Ch 14.** In such cases, the tanks are to be provided with deep hatches, etc., fitted with inspection plugs in order to ensure that the tanks are kept full in service conditions.

104. Minimum thickness

In wing tanks and hold tanks with the length or breadth which exceeds $0.1L + 5.0$ (m) and in topside tanks and hopper tanks, the thickness of girders, struts and the brackets and bulkhead plates is not to be less than that given by **Table 3.15.1** in accordance with the length of ship.

Table 3.15.1 Minimum Thickness

Length of ship (m)	Thickness (mm)
$90 \le L < 105$	8.0
$105 \le L < 120$	8.5
$120 \le L < 135$	9.0
$135 \le L < 150$	9.5
$150 \le L < 165$	10.0
$165 \le L < 180$	10.5
$180 \le L < 195$	11.0
$195 \le L < 225$	11.5
$225 \le L < 275$	12.0
$275 \le L < 325$	12.5
$325 \le L < 375$	13.0
$375 \le L$	13.5

105. Additional strengthening of bulkheads in large tanks

As for large tank boundaries, the scantlings of bulkhead plates, stiffeners, girders and cross ties are not to be less than that obtained from the relevant formulae in **202.** to **205.** and **207.,** where the value of h is the one specified in each requirement or that given by the following formula, whichever is the greater.

$$H = 0.85\ (h + \Delta h) \quad (m)$$

where:

h = water head as specified in each requirement

Δh = additional water head given by the following formula:

$$\Delta h = \frac{16}{L}\left(l_t - 10\right) + 0.25\left(b_t - 10\right) \quad (m)$$

l_t = tank length (m). It is not to be less than 10 m.
b_t = tank breadth (m). It is not to be less than 10 m. but may be $2/3B$ in case of ballast hold of bulk carrier with top side tanks.

SECTION 2
Bulkheads of Deep Tanks

201. Application

The construction of bulkheads and decks forming boundaries of deep tanks is to be in accordance with the requirements in **Ch 14,** unless otherwise specified in this Chapter.

202. Bulkhead plates

The thickness of deep tank bulkhead plating is not to be less than that obtained from the following formula:

$$t = 3.6S\sqrt{hK} + 2.5 \quad (mm)$$

where:
S = spacing of stiffeners. (m).
h = distance given below, whichever is the greater:
(1) Vertical distance measured from the lower edge of plate to the midpoint of the distance between the top of tanks and the top of overflow pipes (m).
(2) 0.7 times the vertical distance measured from the lower edge of plate to the point of 2.0 *metres* above the top of overflow pipes (m).

203. Bulkhead stiffeners

The section modulus of bulkhead stiffeners is not to be less than that obtained from the following formula:

$$Z = CKShl^2 \quad (cm^3)$$

where:
S and l = as specified in **Ch 14, 303.**
h = vertical distance given below, whichever is the greater, the lower end being regarded as the midpoint of l for vertical stiffeners and as the midpoint of distance between the adjacent stiffeners for horizontal stiffeners.
(1) Vertical distance measured from the lower end to the mid-point of the distance between the top of tanks and the top of overflow pipes (m).
(2) 0.7 times the vertical distance measured from the lower end to the point of 2.0 *metres* above the top of overflow pipes (m).
C = coefficient given in **Table 3.15.2** according to the type of end connections.

204. Girders supporting bulkhead stiffeners

1. The section modulus of girders supporting bulkhead stiffeners (hereinafter referred to as "girder") is not to be less than that obtained from the following formula:

$$Z = 7.13\,Shl^2 \quad (cm^3)$$

where:
S = breadth of the area supported by the girders (m).
h = vertical distance measured from the mid-point of S for horizontal girders, and from the mid-point of l for vertical girders, to the top h specified in **203.** (m).
l = span specified in **Ch 14, 306** (m).

2. The moment of inertia of girders is not to be less than that obtained from the following formula. The

Table 3.15.2 Value of C

The other end of stiffeners \ One end of stiffeners	Connection by hard bracket	Connection by soft bracket	Supported by girders or lug connection	Snip
Connection by hard bracket	4.90	8.05	5.95	9.10
Connection by soft bracket	8.05	5.95	9.10	8.05
Supported by Rule girders or lug connection	5.95	9.10	7.00	10.50
Snip	9.10	8.05	10.50	10.50

NOTES:
1. Connection by hard bracket is a connection by bracket to the double bottoms or to the adjacent members, such as longitudinals or stiffeners in line, of the same or larger sections, or a connection by bracket to the equivalent members mentioned above. (see **Fig, 3.14.2** (a))
2. Connection by soft brackets is a connection by bracket to the transverse members such as beams or equivalent thereto. (see **Fig, 3.14.2** (b))

depth of girders is not to be less than 2.5 times the depth of slots for stiffeners.

$$I = 30\,hl^4 \quad (cm^4)$$

where:
h and l = as specified in preceding Paragraph.

3. The thickness of plates of web part is not to be less than that obtained from the following formulae, whichever is the greater:

$$t_1 = 41.7\frac{CKShl}{d_1} + 2.5 \quad (mm)$$

$$t_2 = 0.174\sqrt[3]{\frac{CShlS_1^2}{d_1}} + 2.5 \quad (mm)$$

$$t_3 = 0.01S_1 + 2.5 \quad (mm)$$

where:
S, h and l = as specified in **Par 1.**
S_1 = spacing of web stiffeners or the depth of girders, whichever is the greater (mm).
d_1 = depth of the girder at the location considered, reduced by the depth of slots for stiffeners (mm)
C = coefficient obtained from the following formulae. It is not to be less than 0.5.
For horizontal girders:

$$C = \left|1 - 2\frac{x}{l}\right|$$

For vertical girders:

$$C = \left|1 + \frac{1}{5}\cdot\frac{l}{h} - \left(2 + \frac{l}{h}\right)\frac{x}{l} + \frac{l}{h}\left(\frac{x}{l}\right)^2\right|$$

x = distance measured from the end of l for horizontal girders, and from the lower end l for vertical girders, to the location considered (m)

4. The actual section modulus and moment of inertia of girders are to be calculated in accordance with the provisions in **Ch 14, 306. 6.**

205. Cross ties

1. Where efficient cross ties are provided across deep tanks connecting girders on each side of the tanks, the span l of girders specified in **204.** may be measured between the end of girder and the centre line of cross tie or between the centre lines of adjacent cross ties.

2. The sectional area of cross ties is not to be less than that obtained from the following formula:

$$A = 1.3\,Sb_sh \quad (cm^2)$$

where:
S and h = as specified in **204.**
b_s = breadth of the area supported by the cross ties (m).

3. The end of cross ties are to be bracketed to girders.

206. Brackets

The scantlings of effective brackets on both end of stiffeners are to be in accordance with the requirements in **Ch 14, 307.**

207. Corrugated bulkheads

1. The thickness of plates of corrugated bulkheads is not to be less than that obtained from the following formula:

$$t = 0.0036CS_1\sqrt{hK} + 2.5 \quad (mm)$$

where:
S_1, t_f and t_w = as specified in **Ch 14, 304. 1.**
h = as specified in **202.**
C = coefficient given below:

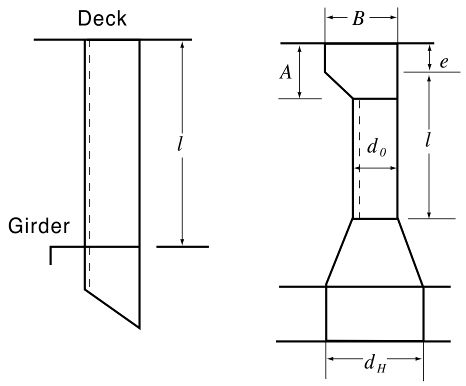
For face part: $C = \dfrac{1.4}{\sqrt{1 + \left(\dfrac{t_w}{t_f}\right)^2}}$

For web part: $C = 1.0$

2. The section modulus per half pitch of corrugated bulkheads is not to be less than that obtained from the following formula:

$$Z = 7\,CKShl^2 \quad (cm^3)$$

where:
S = as specified in **Ch 14, 304. 2.**
l = length between the supports (m), as indicated in **Fig. 3.15.1.**



$$e = A - \frac{d_0}{2B}\cdot A$$

Fig 3.15.1 Measurement of l

h = as specified in **203.**
C = coefficient given in **Table 3.15.3,** according to the type of end connection.

As for bulkheads with lower stools of which the width in longitudinal direction at the lower end, d_H is less than 2.5 times of web depth of the bulkhead, d_0 (See **Fig. 3.15.1**), the measurement of l and the values of C are to be at the discretion of the Society.

3. The thickness of plates at end parts for $0.2l$ in line with l is not to be less than that obtained from the following formulae:

Thickness of web part:

$$t = 41.7\frac{CKShl}{d_0} + 2.5 \quad (mm)$$

It is not to be less than that obtained from the following formula:

$$t_{\min} = 0.174\sqrt[3]{\frac{CShlb^2}{d_0}} + 2.5 \quad (mm)$$

Thickness of the face part except the upper end part of vertically corrugated bulkheads:

$$t_f = \frac{0.012a}{\sqrt{K}} + 2.5 \quad (mm)$$

where:
h = as specified in **203.**
C, l = as specified in **Par 2.**
S, d_0, a and b = as specified in **Ch 14, 304. 4.**

208. Top and bottom construction

The scantlings of the members forming the top or the bottom of deep tanks are to be in accordance with the requirements in this Chapter, regarding the members as the members forming the deep tank bulkheads at the location. They are not to be less than that required for the deck plating or the bottom plating at the location. For top plating of deep tanks the thickness of plates is to be at least 1 mm greater than the thickness specified in **202.**

209. Scantling of members not in contact with sea water

The thickness of plates of bulkheads and girders which are not in contact with sea water in service conditions may be reduced from the requirements in **202., 204.** and **207.** by the values given below:

For the plates of which only side is in contact with sea water .... 0.5 mm

For the plates of which neither side is in contact with sea water .... 1.0 mm

However, bulkhead plate in way of the location such as bilge wells are to be regarded as the plates in contact with sea water.

SECTION 3
Fittings of Deep Tanks

301. Limbers and air holes

Limbers and air holes are to be cut suitably in the structural members to ensure that air or water does not remain stagnated in any part of the tank.

302. Drainage

Efficient arrangement is to be made for draining bilge water on the top of deep tanks.

303. Inspection plug

The inspection plugs provided on deep tank tops as required in **103. 4** are to be located in readily accessible positions.

304. Cofferdam

1. The following dedicated tanks are to be separated from adjacent tanks by cofferdams. However, these cofferdams may be omitted provided that the common boundaries of lubricating oil and fuel oil tank have full penetration welds.

(1) Fuel oil
(2) Lubricating oil
(3) Vegetable oil
(4) Fresh water

2. The cofferdams in **Par. 1** are to be provided with the air pipes to comply with the requirements in **Pt 5, Ch 6, 201** and with the manholes of adequate size which are well accessible.

3. Crew spaces and passenger spaces are not to be

Table 3.15.3 Values of C

Column	Loser end \ Upper end	Supported by Girders	Welded directly to deck	Welded to stool efficiently supported by ship structure
(1)	Supported by girders or welded directly to deck or inner bottoms	1.00	1.50	1.35
(2)	Welded to stool efficiently supported by ship structure	1.50	1.20	1.00

directly adjacent to the tanks for carrage of fuel oil. Such compartments are to be separated from the fuel oil tanks by cofferdams which are well ventilated and is not less than 600 mm in width for easy access. Where the top of fuel oil tanks has no opening and is coated with incombustible coverings of 38 mm and over in thickness, the cofferdam between such compartments and the top of fuel oil tanks may be omitted. ⚓

CHAPTER 16
SUPERSTRUCTURES

SECTION 1
General

101. General

1. All ships are to have forecastles, or increased sheer so that the vertical distance at F.P. measured from the summer load water line to the top of exposed deck at side is not to be less than that obtained from the formula given in **Table 3.16.1.**

Table 3.16.1 Minimum Bow Height

Length of ship	Min. bow height (mm)
$L < 250\,m$	$H = 56L\left(1 - \dfrac{L}{500}\right) \cdot \dfrac{1.36}{(C_b + 0.68)}$
$L \geq 250\,m$	$H = 7000\,\dfrac{1.36}{(C_b + 0.68)}$
NOTE: Where C_b is less than 0.68, C_b is to be taken as 0.68	

2. The length of forecastles is to be extended to a point not less than 0.07L abaft the forward perpendicular. Where an increase of sheer is adopted in lieu of forecastle, the sheer is to continue to a point not less than 0.15L abaft the forward perpendicular.

102. Application

1. The construction and scantlings of superstructures are to be in accordance with the relevant Chapters in addition to this Chapter.
2. The requirements in this Chapter are prescribed for the superstructures up to the third tier above the freeboard deck. As for the superstructures above the third tier, the construction and scantlings thereof are to be as deemed appropriate by the Society.
3. As for the superstructures in ships with specially large freeboard, the construction of end bulkheads may be suitably modified subject to the approval by the Society.

SECTION 2
Superstructure End Bulkheads

201. Head of water

1. The head of water for the calculation of the scantlings of superstructure end bulkheads is not to be less than that obtained from the following formula:

$$h = a\ (bf - y) \quad (m)$$

where:
- a = as given in **Table 3.16.2.**
- b = as given in **Table 3.16.3.**
- f = as given by **Fig. 3.16.1.**
- y = vertical distance from the summer waterline to the mid-point of span of stiffener in case where the scantlings of stiffeners are determined, and to the mid-point of plate in case where the thickness of bulkhead plating is determined (m).

2. The head of water is not to be less than that obtained from the formulae in **Table 3.16.4,** irrespective of the provisions in **Par 1.**

Table 3.16.2 Values of *a*

Bulkhead	Superstructure	a
Exposed front bulkhead	First tier	$\dfrac{L'}{120} + 2.0$
	Second tier	$\dfrac{L'}{120} + 1.0$
	Third tier	$\dfrac{L'}{150} + 0.5$
Protected end bulkheads of the all tiers		
Aft bulkhead	Afterward of the midship	$\dfrac{L'}{1000} - 0.8\dfrac{x}{L} + 0.7$
	Forward of the midship	$\dfrac{L'}{1000} - 0.4\dfrac{x}{L} + 0.5$
L' = length of ship (m). Where, however, L exceeds 300m, L' is to be taken as 300m. x = distance from the bulkhead to the after perpendicular (m).		

Table 3.16.3 Values of b

$\frac{x}{L}$	b
$\frac{x}{L} < 0.45$	$\left(\frac{0.45 - \frac{x}{L}}{C_{b1} + 0.2}\right)^2 + 1.0$
$\frac{x}{L} \geq 0.45$	$1.5\left(\frac{\frac{x}{L} - 0.45}{C_{b1} + 0.2}\right)^2 + 1.0$

x = distance from the bulkhead to the after perpendicular (m).
C_{b1} = block coefficient. Where, however, C_b is less than 0.6, C_{b1} is to be taken as 0.6, and where C_b is 0.8 or over, C_{b1} is to be taken as 0.8. And in calculating b for aft bulkhead located forward of the midship, C_{b1}, is to be taken as 0.8.

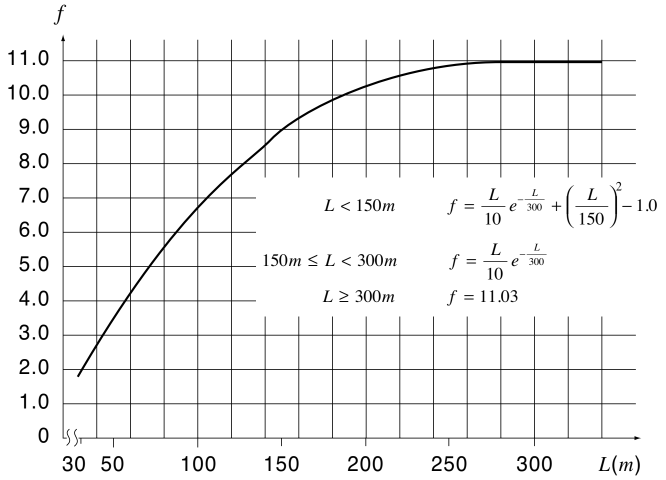


Fig. 3.16.1 Value of f

Table 3.16.4 Head of Water h (m)

Length of ship	Exposed front bulkhead of the first tier superstructure	Others
$L \leq 250\,m$	$\frac{L}{100} + 2.5$	$\frac{L}{200} + 1.25$
$L > 250\,m$	5.0	2.5

202. Thickness of Bulkhead Plating

1. The thickness of superstructure end bulkhead plating is not to be less than that obtained from the following formula:

$$t = 3S\sqrt{hK} \quad (mm)$$

where:
h = head of water specified in **201.** (m).
S = spacing of stiffeners. (m)

2. The thickness of bulkhead plating is not to be less than that obtained from the following formula, irrespective of the provisions in **Par 1.**
Bulkhead plating of the first tier superstructure:

$$t = \frac{L'}{100} + 4.0 \quad (mm)$$

Plating of other bulkheads:

$$t = \frac{L'}{100} + 3.0 \quad (mm)$$

where:
L' = as specified in **Table 3.16.2.**

203. Stiffeners

1. The section modulus of stiffeners on superstructure end bulkheads is not to be less than that obtained from the following formula:

$$Z = 3.5\,KShl^2 \quad (cm^3)$$

where:
S and h = as specified in **202.**
l = tween deck height (m). Where, however, l is less than $2m$, l is to be taken as $2m$.

2. Both ends of stiffeners on the exposed bulkheads of superstructures are to be connected to the deck by welding except where otherwise approved by the Society.

204. End bulkheads of raised decks

1. The fore ends of the raised decks are to be provided with intact bulkheads.

2. The thickness of plating and the scantlings of stiffeners of the bulkhead specified in **Par 1** are not to be less than those required in **202.** and **203.** taking this bulkhead as that of the first-tier superstructure.

SECTION 3
Access Openings in Superstructure End Bulkheads

301. Closures for access openings

1. The doors to be provided on the access openings in the end bulkheads of enclosed superstructures are to be in accordance with the requirements in (1) through (5).

(1) The doors are to be made of steel or other equivalent materials and to be permanently and rigidly fitted up to the bulkheads;
(2) The doors are to be rigidly constructed, to be of equivalent strength to that of intact bulk-

head and to be weathertight when closed;

(3) The means for securing weathertightness are to consist of gaskets and clamping devices or other equivalent devices and to be permanently fitted up to the bulkhead or the door itself;

(4) The doors are to be operated from the both sides of the bulkheads;

(5) Hinged doors are, as a rule, to open outward.

2. The height of sills of access openings specified in **Par 1** is not to be less than 380 mm above the upper surface of the deck except where higher sills may be required when deemed necessary by the Society. ⚓

CHAPTER 17
DECKHOUSES

Section

SECTION 1
General

101. Application

1. The construction and scantlings of deckhouses are to be in accordance with the relevant Chapters in addition to this Chapter.
2. The requirements in this Chapter are prescribed for the deckhouses up to the third tier above the freeboard deck. As for the deckhouses above the third tier, the construction and scantlings thereof are to be as deemed appropriate by the Society.
3. As for the deckhouses in ships with specially large freeboard the construction of bulkhead may be suitably modified subject to the approval by the Society.

SECTION 2
Construction

201. Head of water

1. The head of water for the calculation of the scantlings of boundary walls of deckhouses is not to be less than that obtained from the following formula:

$$h = ac\ (bf - y) \quad (m)$$

where:

a = as given by **Table 3.17.1.**
b = as given by **Table 3.17.2.**
f = as given in **Fig. 3.16.1.**
c = as given by the following formula, where, however, b'/B' is less than 0.25, b'/B' is to be taken as 0.25.

$$c = 0.7\frac{b©}{B©} + 0.3$$

b' = breadth of deckhouse at the position under consideration (m).
B' = breadth of ship on the exposed deck at the position under consideration (m).

Table 3.17.1 Values of a

Walls	Deckhouse	a
Exposed front wall	First tier	$\frac{L'}{120}+2.0$
	Second tier	$\frac{L'}{120}+1.0$
	Third tier	$\frac{L'}{150}+0.5$
Side walls and protected front walls of the all tiers		
Aft walls	Afterward of the midship	$\frac{L'}{1000}-0.8\frac{x}{L}+0.7$
	Forward of the midship	$\frac{L'}{1000}-0.4\frac{x}{L}+0.5$
L' and x = as specified in **Table 3.16.2**		

Table 3.17.1 Values of b

$\frac{x}{L}$	b
$\frac{x}{L} < 0.45$	$\left(\frac{0.45-\frac{x}{L}}{C_{b1}+0.2}\right)^2+1.0$
$\frac{x}{L} \geq 0.45$	$1.5\left(\frac{\frac{x}{L}-0.45}{C_{b1}+0.2}\right)^2+1.0$

x = bistance from the end wall to the after perpendicular, however, in case of side wall, distance from the mid-point of side wall to the after perpendicular (m). Where, however, the length of side wall exceeds $0.15L$, the side wall is to be nearly equally subdivided as not to exceed $0.15L$ and the distance from the mid-point of the subdivision to the after perpendicular to be taken.
C_{b1} = block coefficient. Where, however, C_b is 0.6 and under, C_{b1} is to be taken as 0.6 and where C_b is 0.8 and over, C_b is to be taken as 0.8. And, in calculating b for the aft wall located forward of the midship, C_{b1} is to be taken as 0.8.

y = vertical distance from the summer waterline to the mid-point of span of stiffener in case where the scantlings of stiffeners are determined, and to the mid-point of plate in case where the thickness of boundary wall plating is determined (m).

2. The head of water is not to be less than that obtained from the requirements in **Ch 16, 201. 2,** irrespective of the provisions in **Par 1.**

202. Scantlings

1. The thickness of boundary wall plating and the scantlings of stiffeners are not to be less than those required in **Ch 16, 202.** and **203.** taking the head of water specified in **201.** as h.

2. Both ends of stiffeners on exposed boundary walls of deckhouses are to be connected to the deck by welding except where otherwise approved by the Society.

203. Closing means

Access openings of deckhouses protecting companionways giving access to the spaces under the freeboard deck or the spaces in the enclosed superstructures are to be provided with the closing means at least complying with the requirements in **Ch 16, 301.** Where, however, stairways are enclosed with boundary walls fitted with closing means complying with the requirements in **Ch 16, 301.** the external doors need not be weathertight.

204. Long deckhouses

1. Where transverse bulkheads are provided under deckhouses, special consideration is to be paid not to have discontinuity in the construction of deckhouses just above the transverse bulkheads as far as practicable.

2. On the side walls and end walls of large deckhouses, partial bulkheads or special stiffeners are to be arranged at intervals not exceeding about 9 *metres* just above the bulkheads, web frames or under deck girders underneath.

3. In the vicinity of both ends of long deckhouses, special consideration is to be paid to the construction connecting boundary walls of deckhouses to the decks. The side walls are to be suitably constructed so as to maintain strength continuity and to avoid stress concentratlon.

205. Loaded with heavy equipment articles

Deckhouses under the spaces loaded with specially heavy equipment articles such as lifeboats, deck machineries and so on are to be suitably strengthened.

206. Deckhouses on the upper tiers of deck

As for deckhouses on the upper tiers of deck, suitable measures are to be taken to prevent vibration in such a manner as to arrange the side walls and pillars of respective tiers of deckhouses in a same plane as far as practicable. ⚓

CHAPTER 18
MACHINERY SPACES AND ENGINE CASINGS

SECTION 1
General

101. Application

The construction of machinery space in addition to this Chapter is to be in accordance with the requirements in relevant Chapters.

102. Compensation

Machinery space is to be sufficiently strengthened by means of web frames, strong beams and pillars or other suitable arrangements.

103. Construction

Machineries, shafting, etc. are to be efficiently supported and the adjacent structures are to be adequately stiffened.

104. Twin screw ships and others of high power

In twin screw ships and others of high power, the structure and attachments of the seatings are to be specially strengthened in relation to the proportion of the height of engines to their length or width, weight, power, type, etc.

105. Means of escape

1. In each engine room and boiler room, at least two means of escape are to be provided. These means are to be formed by steel ladders as widely separated as possible leading to doors in the casing similarly separated and from which an access is provided to the lifeboat embarkation deck.

2. Where a watertight door is available as a means of escape from each engine room or boiler room to other spaces from which an access is provided to the embarkation deck, one of the means specified in the preceding Paragraph may be dispensed with.

3. In case of ships of less than 2,000 *tons gross*, where it is difficult to separate ladders or doors from each other, the requirement in **Par 1** may be suitably modified.

SECTION 2
Main Engine Foundation

201. Single bottoms

In ships with single bottoms, the main engine are to be seated upon thick seat plates laid on heavy foundation girders efficiently bracketed and stiffened and having sufficient strength in proportion to the power and size of engines. Transverse rigidity of the seat plates is to be provided by means of tripping brackets fitted at the position of each floor.

202. Double bottoms

In ships with double bottoms, the main engines are to be seated directly upon thick inner bottom plating or thick seat plates on top of heavy foundation girders so arranged as to effectively distribute the weight. Transverse rigidity of the seat plates is to be provided by means of tripping brackets fitted at the position of each floor.

SECTION 3
Construction of Boiler Rooms

301. Boiler foundations

1. Boilers are to be supported by deep saddle type floors or by transverse or longitudinal girders so arranged as to effectively distribute the weight.

2. Where boilers are supported by transverse saddles or girders, the floors in way of same are to be specially stiffened.

302. Boiler location

1. Boilers are to be so placed as to ensure accessibility and proper ventilation.

2. Boilers are to be at least 457 mm clear of tank tops, etc. The thickness of adjacent members is to be increased as may be required where the clear space is unavoidable less. The available clearance is to be indicated on the plans submitted for approval.

3. Hold bulkheads and decks are to be kept well clear of the boilers and uptakes, or provided with suitable insulating arrangements.

4. Side sparrings are to be provided on the bulkheads adjacent to the boilers, keeping suitable clearance on **502.** their hold sides.

SECTION 4
Thrust Blocks and Foundations

401. Thrust blocks and foundations

1. Thrust blocks are to be bolted to efficient foundations extending well beyond the thrust blocks and so arranged as to effectivley distribute the loads into the adjacent structures.

2. Additional intercostal girders are to be provided in way of the foundations as necessary.

402. Plummer blocks and auxiliary machinery seats

Plummer blocks and auxiliary machinery seats are to be of ample strength and stiffness in proportion to the weight supported and to the height of foundations.

SECTION 5
Engine Casings

501. Plates

1. The thickness of casing plates on exposed decks or within not enclosed superstructures is not to be less than that obtained from the requirements in **Ch 17, 201.** and **202.** with such modifications that 1.0 is substituted for c.

2. The thickness of casing plates below the freeboard deck or within enclosed superstructures is not to be less than 6.5 mm in cargo spaces and not to be less than 4.5 mm in accommodation spaces. Where the spacing of stiffeners exceeds 760 mm, the thickness is to be increased at the rate of 0.5 mm per 100 mm excess in spacing.

502. Stiffeners

1. The section modulus of stiffeners of the casings on exposed decks or within not enclosed superstructures is not to be less than that obtained from the requirements in **Ch 17, 201.** and **202.** with such modifications that 1.0 is substituted for c. The ends of stiffeners are to be attached to decks.

2. The stiffeners of casings below the freeboard deck or within enclosed superstructures are to be provided at the position of every deck beam in cargo spaces and their section modulus is not to be less than that obtained from the following formula:

$$Z = 1.2\,Sl^3 \quad (cm^3)$$

where:
l = tween deck height (m).
S = spacing of stiffeners (m).

503. Casing top

The thickness of top plating of exposed casings is not less than that obtained from the following formulae:

Position I $\quad t = 6.3\,S + 1.5 \quad (mm)$
Pos ition II $\quad t = 6.0\,S + 1.5 \quad (mm)$

where:
S = spacing of stiffeners (m). ⚓

CHAPTER 19
TUNNELS AND TUNNEL RECESSES

Section
1 General

SECTION 1
General

101. Arrangement

1. In ships with machinery amidships, the shafting is to be enclosed by watertight tunnels of sufficient dimensions.
2. Watertight doors are to be provided at the fore end of the tunnel. The closing and construction of the watertight doors are to be as required in **Ch 14.**
3. In tunnels which are provided with watertight doors in accordance with the requirement in the preceding paragraph, escape trunks are to be provided at a suitable location and they are to be led to the bulkhead deck or above.

102. Flat side plating

The thickness of plating on flat sides of tunnel is not to be less than that obtained from the following formula:

$$t = 2.9\,S\sqrt{h} + 1.5 \quad (mm)$$

where:

S = spacing of stiffener (m).

h = vertical distance at the mid-length of each hold from the lower edge of the side wall plating to the bulkhead deck at the centre line of ship (m).

103. Flat top plating

1. The thickness of flat plating on the top of tunnels or tunnel recesses is not to be less than that obtained from the formula given in **102.** h being taken as the height from the top plates to the bulkhead deck at the centre line of ship.
2. Where the top of the tunnel or tunnel recess forms part of deck, the thickness is to be increased by at least one mm above that obtained from the requirements in **Par 1,** but in no case is it to be less than that required for the deck plating at the same position.

104. Curved top or side plating

The thickness of curved top or side plating is to be determined by the requirements in **102.** in association with stiffener spacing reduced by 150 mm from the actual spacing.

105. Top plating under hatchways

Top plating of tunnel under hatchways is to be increased by at least 2 mm or to be protected by wood sheathing not less than 50 mm in thickness.

106. Wood sheathings

The wood sheathing prescribed in **105.** is to be so secured as to keep watertightness of tunnel where it might be damaged by cargo.

107. Stiffeners

1. Stiffeners are to be provided not more than 915 mm apart on the top and side plating of tunnels.
2. The section modulus of stiffeners is not to be less than that obtained from the following formula.

$$Z = 4\,Shl^2 \quad (cm^3)$$

where:

I = distance from the heel of the lower edge of side wall to the top of flat side (m).

S = spacing of stiffeners (m).

h = vertical distance at mid-length of each hold from the mid-point of l to the bulkhead deck (m).

3. Where the ratio of the radius of the rounded tunnel top to the distance between the bottom and top of the tunnel is comparatively large, the section modulus of the stiffeners is to be adequately increased over that specified in the preceding Paragraph.
4. The lower ends of stiffeners over 150 mm in depth are to be connected to the inner bottom plating, etc. by lug connection.

108. Construction under masts, stanchions, etc.

Where masts, stanchions, etc. are based upon tunnels or tunnel recesses, local strengthening is to be provided in proportion to the weight carried.

109. Construction under top of tunnels or tunnel recesses

Beams, pillars and girders under the top of tunnels or tunnel recesses are to be of the scantlings as required for similar members of bulkhead recesses.

110. Ventilators and escape trunks

Escape trunks and ventilators provided on tunnels or tunnel recesses are to be made watertight up to the bulkhead deck and are to be strong enough to withstand the pressure to which they may be subjected.

111. Tunnels in water or oil tanks

Tunnels in water or oil tanks are to be of equivalent construction and strength to those required for deep tank bulkheads.

112. Watertight tunnels

Where watertight tunnels similar to the shaft tunnels are provided, they are to be of similar construction to the shaft tunnels.

113. Tunnels of curved form

Where the tunnels of curved form pass through deep tanks, the thickness of the plating in way of the tanks is not to be less than that obtained from the following formula.

$$t = 0.134\, d_t h + 8.1 \quad (mm)$$

where:

d_t = diameter of tunnel (m).

h = vertical distance measured from the bottom of tunnel to the mid-point between the top of tanks and the top of overflow pipes, or 0.7 times the vertical distance measured from the bottom of tunnel to the point of 2.0 $meters$ above the top of overflow pipes, whichever is the greater (m). ⚓

CHAPTER 20
STRENGTHENING FOR NAVIGATION IN ICE

SECTION 1
General

101. Application

1. The construction and equipment of ship intended to be registered and classed as the ship strengthened for navigation in ice are to be in accordance with the requirements in this Chapter, in addition to the general requirements.
2. Where an ice class notation is desired, the main propelling machinery, etc. are to be in accordance with the requirements in this Chapter and the discretion of the Society.
3. The requirements in this chapter are framed for the ice strengthening of ships which are intended to navigate in the Northern Baltic complying with the **Finnish-Swedish Ice Class Rules 1985** or in the Canadian Arctic complying with the **Arctic Shipping Pollution Prevention Regulations** However, where the ships are intended to navigate in other sea areas, this Chapter may be applied.
4. The low temperature of the ship's ambience is to be considered for designing structures, equipment and arrangements essential for the safety and operation of the ship, e.g. the functioning of hydraulic systems, hazard of freezing of water piping and tanks, starting of emergency diesels, etc.

102. Documentation

1. Forward region, midship region, aft region, ice belt, LWL and BWL defined in **202.** are to be indicated in the Shell Expansion.
2. The engine output defined in **202.**, the displacement defined in **203. 3** and the dimensions necessary for the engine output calculation required in **204.** are to be described in the General Arrangement.

SECTION 2
Ice Strengthening

201. Classification of Ice Strengthening

1. Strengthening for navigation in ice is classified into the following 5 classes dependent on the degree of reinforcement and engine output of the ship.
   (1) Class ISS Ice Strengthening
   (2) Class IS1 Ice Strengthening
   (3) Class IS2 Ice Strengthening
   (4) Class IS3 Ice Strengthening
   (5) Class IS4 Ice Strengthening
2. It is the responsibility of Owner to determine which class in **Par 1** is most suitable for his requirement.

202. Definitions

The definitions of terms which appear in this Chapter are to be as specified as the following, unless otherwise specified elsewhere.

1. The forward, midship, and aft regions in way of hull part are defined for ships of ice classes ISS, IS1, IS2 and IS3 and the forward region is defined for ships of ice class IS4 as follows:
   (1) Forward region: From the stem to a line parallel to and $0.04L$ aft of the forward borderline of the part of the hull where the waterlines run parallel to the centerline. For ice classes ISS and IS1 the overlap over the borderline need not exceed $6\,m$, and for ice classes IS2, IS3 and IS4 this overlap need not exceed $5\,m$.
   (2) Midship region: From the aft boundary of the Forward region to a line parallel to and $0.04L$ aft of the aft borderline of the part of the hull where the waterlines run parallel to the centreline. For ice classes ISS and IS1 the overlap over the borderline need not exceed $6\,m$, and for ice classes IS2 and IS3 this overlap need not exceed $5\,m$.
   (3) Aft region: From the aft boundary of the Midship region to the stern.
2. The ice belt is the part of the shell plating which has to be reinforced. (see **Fig. 3.20.1**)
3. The load waterline (LWL) is the line defined by the draught amidships on the fresh water load line in summer (If the ship has the timber load lines determined, the draught on the fresh water timber load line in summer is to be used) and the

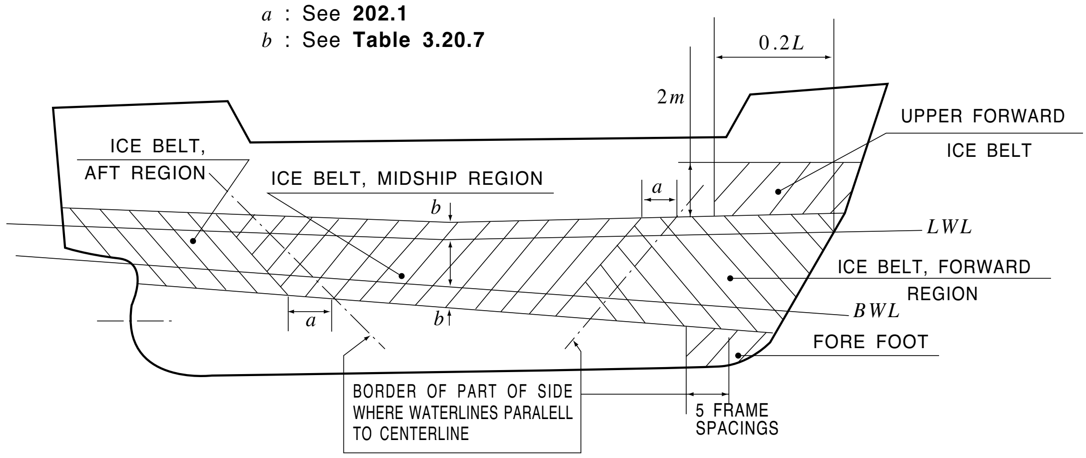


Fig 3.20.1 Ice Belt at Each Region

maximum draughts for and aft considering the trim of ship and the salinity of the sea water along the intended route.

4. The ballast waterline (BWL) is the line defined by the minimum draughts fore and aft, where regard is to be paid to the need for ensuring a reasonable degree of ice going capability.

5. The engine output (P) is the maximum output the propulsion machinery can continuously deliver. If the output of the propulsion machinery is restricted by technical means or by any regulations applicable to the ship, P is to be taken as the restricted output.

203. Secure of Minimum Draught

1. Any ballast tank, situated above the BWL and needed to load down the ship to this water line is to be equipped with proper devices to prevent the water from freezing.

2. The propeller is to be fully submerged, if possible, entirely below the ice.

3. The minimum forward draught is not to be less than that obtained from the following formula, which needs not exceed $4h_0$.

$$d_f = (2.0 + 0.00025\,\Delta)h_0 \quad (m)$$

Δ = the displacement (ton) of ship at the maximum draught amidships on the Fresh Water Load Line.
h_0 = constant given in **Table 3.20.1** according to the respective ice class.

204. Engine Output

1. General

The engine output(P) is to comply with the following requirements in (1) and (2).

Table 3.20.1 Value of Constant h_o

Ice Class	h_o
ISS	1.0
IS1	0.8
IS2	0.6
IS3	0.4
IS4	0.4

(1) For ships of ice classes ISS and IS1
The engine output(P) is not to be less than that obtained from the following formula. The dimensions of the ship, defined below, are measured on the load waterline(LWL) as defined in **202. 2.**

$$P = K_e \frac{(R_{CH}/1000)^{3/2}}{D_P}$$

P = engine output (kW)
K_e = as given in **Table 3.20.2**

Table 3.20.2 Values of Constant K_e

	CPP or electric or hydraulic propulsion machinery	FP propeller
1 propeller	2.03	2.26
2 propellers	1.44	1.60
3 propellers	1.18	1.31

D_P = diameter of the propeller (m)
R_{CH} = the resistance of the ship in a channel with brash ice and a consolidated layer (N):

$$R_{CH} = C_1 + C_2 + C_3(H_F + H_M)^2(B + 1.85H_F - 2H_F/\tan\psi)(0.15\cos\phi_2 + \sin\psi\sin\alpha) + C_4 L_{PAR} H_F^2 + C_5(LT/B^2)^3 \frac{A_{wf}}{L} \quad (N)$$

C_1 and C_2 = coefficients obtained by taking into account a consolidated upper layer of the brash ice

(a) For ships of ice classes IS1

$$C_1 = 0, \; C_2 = 0$$

(b) For ships of ice classes ISS

$$C_1 = f_1 BL_{PAR}/(2T/B+1) + (1+0.021\phi_1)(f_2 B + f_3 L_{BOW} + f_4 BL_{BOW})$$

$$C_2 = (1+0.063\phi_1)(g_1 + g_2 B) + g_3(1+1.2T/B)B^2\sqrt{L}$$

B = maximum breadth of the ship (m)

L = length of the ship on the waterline (m)

T = maximum ice class draught according to **202. 3** (m)

However, the following shall apply :

$$5 \le (LT/B^2)^3 \le 20$$

L_{PAR} = length of the parallel midship body (m), **Fig. 3.20.2**

L_{BOW} = length of the bow (m), **Fig. 3.20.2**

H_M = thickness of the brash ice in mid channel (m):

$$H_M = 1.0$$

H_F = thickness of the brash ice layer displaced by the bow (m)

$$H_F = 0.26 + (H_M B)^{0.5}$$

A_{wf} = area of the waterline of the bow (m^2), **Fig. 3.20.2**

α = the angle of the waterline at B/4 (°), **Fig. 3.20.2**

ϕ_1 = the rake of the stem at the centerline (°), **Fig. 3.20.2.** For a ship with a bulbous bow, ϕ_1 shall be taken as 90°

ϕ_2 = the rake of the bow at B/4 (°), **Fig. 3.20.2**

ψ = arctan(tanϕ_2/sinα)

f_1, f_2, f_3, f_4, g_1, g_2, g_3, C_3, C_4, and C_5 = values given in **Table 3.20.3**

Table 3.20.3 f_1, f_2, f_3, f_4, g_1, g_2, g_3, C_3, C_4 **and** C_5

$f_1(N/m^2)$	23	$g_1(N)$	1530	$C_3(kg/(m^2s^2))$	845
$f_2(N/m)$	45.8	$g_2(N/m)$	170	$C_4(kg/(m^2s^2))$	42
$f_3(N/m)$	14.7	$g_3(N/m^{1.5})$	400	$C_5(kg/s^2)$	825
$f_4(N/m^2)$	29				

(2) For ships of ice class IS2, IS3 and IS4
The engine output(P) is not to be less than that obtained from the following formula and in no case less than 740 kW.

$$P = c_1 c_2 c_3 (c_4 \Delta + P_0) \quad (kW)$$

c_1 = following value according to the type of propeller.

For a fixed pitch propeller = 1.0
For a controllable pitch propeller = 0.9

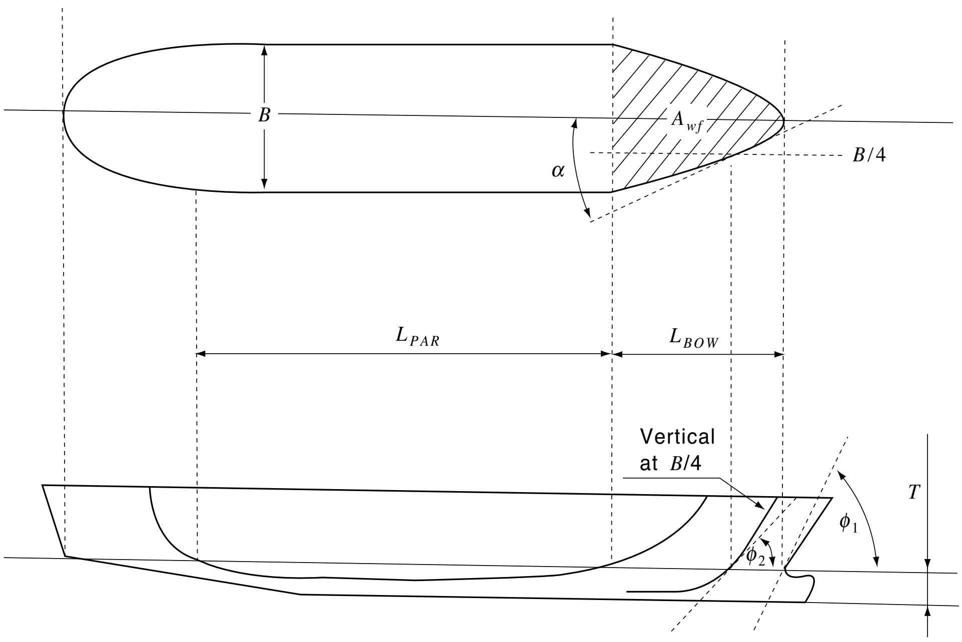


Fig. 3.20.2 Dimensions

c_2 = following value according to the form of bow but not more than 1.1

For a bulbus bow = 1.1
Others = (ϕ / 200 + 0.675)

ϕ = the forward facing angle between the stem and the LWL. If the stem forms a fair curve within the ice belt as specified in **206. 1**, it may be presented by a straight line between the points of intersection of the stem and the upper and lower limits of the ice belt. If there are sharp changes in the inclination of the stem, the largest ϕ is to be used. However, the product c_1 x c_2 is not to be less than 0.85.

c_3 = as given by the following formula but not less than 1.0.

$$c_3 = 1.2\frac{B}{\Delta^{1/3}}$$

Δ = as specified in **203. 3.** However, it needs not be taken as greater than 80,000 (ton).

c_4 and P_0 = as given in **Table 3.20.4** according to the respective ice class and displacement.

2. Notwithstanding the requirements of preceding 1, for ships of ice classes ISS and IS1 with the keels of which were laid or which were at a similar stage of construction before 1 January 2001, the engine output(P) is not to be less than that obtained from the following formula and in no case less than 740kW for the ice class IS1 nor less than 2600kW for ice class ISS.

$$P = c_1 c_2 c_3 (c_4 \Delta + P_0) \quad (kW)$$

c_1 = following value according to the type of propeller.
For a fixed pitch propeller = 1.0
For a controllable pitch propeller = 0.9

c_2 = following value according to the form of bow but not more than 1.1
For a bulbus bow = 1.1
Others =(ϕ/200 + 0.675)

ϕ = the forward facing angle(°) between the stem and the LWL. If the stem forms a fair curve within the ice belt as specified in 206. 1, it may be presented by a straight line between the points of intersection of the stem and the upper and lower limits of the ice belt. If there are sharp changes in the inclination of the stem, the largest ϕ is to be used. However, the product c_1 x c_2 is not to be less than 0.85.

c_3 = as given by the following formula but not less than 1.0.

$$c_3 = 1.2\frac{B}{\Delta^{1/3}}$$

Δ = as specified in **203. 3**. However, it needs not to be taken as greater than 80,000 (ton).

c_4 and P_0 = as given in **Table 3.20.4** according to the respective ice class and displacement.

3. Even for ships of ice classes ISS and IS1 with the keels of which are laid or which are at a similar stage of construction before 1 January 2001, which comply with the requirements of the preceding 2, the engine output(P) is to comply with the requirement of **Par 1** (1) or the equivalent requirements by 1 January 2005 or 1 January in the year when 20 $years$ has elapsed since the year the ship was delivered, whichever occurs the latest. When, for an existing ship, values for some of the hull parameters required for the calculating method in preceding 1 (1) are difficult to obtain, the following alternative formulae can be used. The dimensions of the ship, defined below, are measured on the load waterline(LWL) as defined in **202. 3.**

$$P = K_e \frac{(R_{CH}/1000)^{3/2}}{D_P}$$

P = engine output (kW)
K_e = as given in **Table 3.20.2**
D_P = diameter of the propeller (m)
R_{CH} = the resistance of the ship in a channel with brash ice and a consolidated layer (N):

$$R_{CH} = C_1 + C_2 + C_3(H_F + H_M)^2(B + 0.658H_F) + C_4LH_F^2 + C_5(LT/B^2)^3(B/4) \quad (N)$$

C_1 and C_2 = coefficients obtained by taking into account a consolidated upper layer of the brash ice

(1) For ships of ice classes IS1

Table 3.20.4 Value of c_4 and P_o

	ISS		IS1	IS2	IS3	IS4	IS1	IS2	IS3	IS4
	Δ < 40000	$\Delta \geq$ 40000	Δ 〈 30000				$\Delta \geq$ 30000			
c_4	0.27	0.15	0.26	0.22	0.18	0.13	0.15	0.13	0.11	0.09
P_o	2200	7000	740	370	0	0	4040	3070	2100	1200

$C_1 = 0$, $C_2 = 0$

(2) For ships of ice classes ISS without a bulbous bow

$$C_1 = f_1 BL/(2T/B+1) + 1.84(f_2 B + f_3 L + f_4 BL)$$

$$C_2 = 3.52(g_1 + g_2 B) + g_3(1+1.2T/B)B^2\sqrt{L}$$

(3) For ships of ice classes ISS with a bulbous bow

$$C_1 = f_1 BL/(2T/B+1) + 2.89(f_2 B + f_3 L + f_4 BL)$$

$$C_2 = 6.67(g_1 + g_2 B) + g_3(1+1.2T/B)B^2\sqrt{L}$$

B = maximum breadth of the ship (m)
L = length of the ship on the waterline (m)
T = maximum ice class draught according to **202. 3** (m)
However, the following shall apply :

$$5 \le (LT/B^2)^3 \le 20$$

H_M = thickness of the brash ice in mid channel (m):

$$H_M = 1.0$$

H_F = thickness of the brash ice layer displaced by the bow(m)

$$H_F = 0.26 + (H_M B)^{0.5}$$

f_1, f_2, f_3, f_4, g_1, g_2, g_3, C_3, C_4 and C_5 = values given in **Table 3.20.5**

Table 3.20.5 Values of f_1, f_2, f_3, f_4, g_1, g_2, g_3, C_3, C_4 and C_5

$f_1(N/m^2)$	10.3	$g_1(N)$	1530	$C_3(kg/(m^2s^2))$	460
$f_2(N/m)$	45.8	$g_2(N/m)$	172	$C_4(kg/(m^2s^2))$	18.7
$f_3(N/m)$	2.94	$g_3(N/m^{1.5})$	400	$C_5(kg/s^2)$	825
$f_4(N/m^2)$	5.8				

4. An engine output less than that required above may be approved if deemed appropriate by the society, the ship has features that can improve the performance of the ship when navigating in ice.

205. Design Ice Pressures

1. Design ice pressure P is not to be less than that obtained from the following formula:

$$P_d = C_d C_1 C_a P_n \quad (MPa)$$

$$C_d = \frac{ak+b}{1000}$$

$$k = \frac{\sqrt{\Delta P}}{1000}$$

Δ = displacement (ton) of the ship specified in **203. 3.**
P = engine output (kW).
a and b = as given in **Table 3.20.6** according to the region under consideration and the value of k

Table 3.20.6 Value of a and b

	Forward region		Midship region and Aft region	
	$k \le 12$	$k > 12$	$k \le 12$	$k > 12$
a	30	6	8	12
b	230	518	214	286

C_1 = as given in **Table 3.20.7** according to the ice class and the region.
P_n = the nominal ice pressure; the value 5.6 MPa is to be used.
C_a = as given by the following formula. Where, however, C_a is less than 0.5, C_a is to be taken as 0.5 and where C_a exceeds 1.0, C_a is to be taken as 1.0.

Table 3.20.7 Coefficient C_1

Ice class	Forward region	Midship region	Aft region
ISS	1.00	1.00	0.75
IS1	1.00	0.85	0.65
IS2	1.00	0.70	0.45
IS3	1.00	0.50	0.25
IS4	1.00		

$$C_a = \frac{47 - 5l_a}{44}$$

l_a = to be taken as specified in **Table 3.20.8** according to the structural member under consideration.

Table 3.20.8 Value of l_a

Structure	Type of framing	$l_a(m)$
Shell and frames	Transverse	Frame spacing
	Longitudinal	Span of frame
Ice stringer		Span of stringer
Web frame		2-spacing of web frames

2. h is the height of the area under the ice pressure P specified in **Par 1** and is to be as given in **Table 3.20.9** according to the ice class.

Table 3.20.9 Value of h

Ice Class	$h(m)$
ISS	0.35
IS1	0.30
IS2	0.25
IS3	0.22
IS4	0.22

206. Shell Plating

1. The vertical extension of ice belt is to be as given in **Table 3.20.10** according to the ice class and is to comply with the following requirements.

Table 3.20.10 Vertical Extension of the Ice belt b

Ice Class	Above LWL	Below BWL
ISS	0.6 m	0.75 m
IS1	0.5 m	0.6 m
IS2	0.4 m	0.5 m
IS3	0.4 m	0.5 m
IS4	0.4 m	0.5 m

(1) Fore foot
For ice class ISS the shell plating below the ice belt from the stem to a position five main frame spaces abaft the point where the bow profile departs from the keel line is to have at least the thickness required in the ice belt in the midship region.

(2) Upper forward ice belt
For ice classes ISS and IS1 on ships with an open water service speed equal to or exceeding 18 kt, the shell plate from the upper limit of the ice belt to 2 m above it and from the stem to a position at least 0.2 L abaft the forward perpendicular, is to have at least the thickness required in the ice belt in the midship region.

(3) Side scuttles are not to be situated in the ice belt.

(4) If the weather deck in any part of the ship is situated below the upper limit of the ice belt, the bulwark is to be given at least the same strength as is required for the shell in the ice belt. Special consideration has to be given to the design of the freeing ports.

2. The thickness of shell plating in the ice belt is not to be less than that obtained from the following formula:

For the transverse framing:

$$t = 667S\sqrt{\frac{f_1 P_{PL}}{\sigma_y}} + 2.0 \quad (mm)$$

For the longitudinal framing:

$$t = 667S\sqrt{\frac{P_{PL}}{f_2 \sigma_y}} + 2.0 \quad (mm)$$

S = frame spacing (m).
h = as specified in **Table 3.20.9.**
P_{PL} = 0.75 P_d (MPa).
P_d = as specified in **205.1**
f_1 = as given in the following formula. Where, however, f_1 is greater than 1.0, f_1 is to be taken as 1.0

$$f_1 = 1.3 - \frac{4.2}{(h/S+1.8)^2}$$

f_2 = as given by the following formula depending on the value of h/S.

Where h/S < 1.0 : $f_2 = 0.6 + \dfrac{0.4}{h/S}$

Where 1.0 ≤ h/S < 1.8 : $f_2 = 1.4 - 0.4\,(h/S)$

σ_y = yield stress of the material of the member considered, which are given as follows (N/mm^2)
235 : for mild steels as specified in **Pt 2, Ch 1**
315 : for high tensile steels $RA32$, $RD32$, $RE32$ or $RF32$ as specified in **Pt 2, Ch 1**
355 : for high tensile steels $RA36$, $RD36$, $RE36$ or $RF36$ as specified in **Pt 2, Ch 1**

207. General Requirements for Frames

1. The vertical extension of ice strengthening of the framing is to be at least as given in **Table 3.20.11** according to the respective ice classes and regions. Where an upper forward ice belt is required in **206. 1**, the ice strengthening of the framing is to be extended above the LWL by 1 m in addition to the table value, within that area.

2. Within the ice strengthened area all frames are to be effectively attached to all supporting structure by brackets. Frames are to be connected to transversing structure on both sides (i.e., a free edge of a cut-out slot is to be connected to the frame by a lug).

3. For ice class ISS in all region, for ice class IS1 in the forward and midship regions and for ice classes IS2, IS3 and IS4 in the forward regions, followings are to apply in the ice strengthening area.

(1) Frames which are at a small angle to the shell,

Tabel 3.20.11 Vertical Extension of the Ice Strengthening of Framing

Ice Class	Region		Above LWL (m)	Below BWL (m)
ISS	forward	from stem to 0.3L abaft it	1.2	to double bottom or below top of floors
		abaft 0.3L from stem	1.2	1.6
	midship		1.2	1.6
	aft		1.2	1.2
IS1 IS2 IS3	forward	from stem to 0.3L abaft it	1.0	1.6
		abaft 0.3L from stem	1.0	1.3
	midship		1.0	1.3
	aft		1.0	1.0
IS4	forward	from stem to 0.3L abaft it	1.0	1.6
		from stem to 0.3L abaft it	1.0	1.3

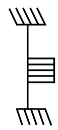
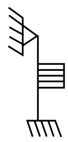
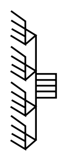
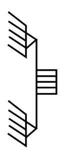
are to be supported against tripping by brackets, intercostals, stringers or similarly at a distance preferably not exceeding 1.3 m.

(2) The frames are to be attached to the shell by double continuous welds. No scalloping is allowed except when crossing shell plate butts.

(3) The web thickness of the frames is to be at least one half of the thickness of the shell plating and at least 9 mm.

(4) Where there is a deck, tanktop or bulkhead in lieu of a frame, the plate thickness of this is to be as per the preceding in (3), to a depth corresponding to the height of adjacent frames.

Table 3.20.12 Value of m_o

Boundary condition	m_o	Example
Both ends fixed 	7.0	Frames in a bulk carrier with top side tnaks
One side fixed and one side simple support 	6.0	Frames extending from the tank top to a single deck
Multi point simple support 	5.7	Continuous frames between several decks or stringers
Both ends simple support 	5.0	Frames extending between two decks only

208. Transverse Frames

1. The section modulus Z of a main or intermediate transverse frame specified in **207. 1** is to be not less than that obtained from the following formula:

$$Z = \frac{P_d Shl}{m_t \sigma_y} \times 10^6 \quad (cm^3)$$

P_d = as specified in **205.1.**
S = frame spacing (m).
h = as specified in **Table 3.20.9.**
l = span of the frame (m).
m_t = as given by the following formula:

$$m_t = \frac{7m_o}{7 - 5h/l}$$

m_o = as specified in **Table 3.20.12.**
σ_y = as specified in **206.2.**

2. The upper of the strengthened part of a main frame and of an intermediate ice frame are to be attached to a deck of an ice stringer specified in **201.** Where an intermediate frame terminates above a deck or an ice stringer which is situated at or above the upper limit of the ice belt, the part above the deck or stringer may be in accordance with the following:

(1) The scantlings are required for an unstrengthened ship and the upper end may be connected to the adjacent main frames by a horizontal member of the same scantlings as the main frame.
(2) The intermediate frame may be extended to the deck above and if this is situated more than 1.8 m above the ice belt, the intermediate frame need not be attached to that deck, except in the forward region.

3. The lower end of the strengthened part of a main frame and of an intermediate ice frame is to be attached to a deck, tanktop or ice stringer specified in **210.** Where an intermediate frame terminates below a deck, tanktop or ice stringer which is situated at or below the lower limit of the ice belt, the lower end may be connected to the adjacent main frames by a horizontal member of the same scantlings as the frames.

209. Longitudinal Frames

1. The spacing of longitudinals in the extension specified in **207.1** is not to exceed 0.35 m for ice classes ISS and IS1, and should in no case exceed 0.45 m for ice classes IS2, IS3 and IS4.

2. The section modulus Z and shear area A of a longitudinal frame in the extension specified in **207. 1** are not to be less than that obtained from the following formula:

$$Z = \frac{f_3 f_4 P_d S l^2}{m_1 \sigma_y} \times 10^6 \quad (cm^3)$$

$$A = \frac{\sqrt{3} f_3 P_d S l}{2\sigma_y} \times 10^4 \quad (cm^2)$$

f_3 = factor which takes account of the load distribution to adjacent frames given by following formula:

$$f_3 = \left(1 - \frac{0.2h}{S}\right)\frac{h}{S}$$

h = as specified in **Table 3.20.9.**
S = frame spacing (m).
f_4 = factor which takes account of the concentration of load to the point of support ; f_4 = 0.6
P = as specified in **205. 1.**
l = span of the longitudinal frame (m).
σ_y = as specified in **206. 2.**
m_1 = boundary condition factor; m_1 = 13.3

210. Ice Stringers

1. The section modulus Z and the shear area A of a stringer situated within the ice belt are to be not less than that obtained from the following formula:

$$Z = \frac{f_5 P_d h l^2}{m_s \sigma_y} \times 10^6 \quad (cm^3)$$

$$A = \frac{\sqrt{3} f_6 P_d h l}{2\sigma_y} \times 10^4 \quad (cm^2)$$

P_d = as specified in **205. 1.**
h = as specified in **Table 3.20.9.** However, the product $P_d h$ is not to be taken as less than 0.3.
l = span of the stringer (m).
m_s = boundary condition factor; m_s = 13.3
f_5 = factor which takes account of the distribution of load to the transverse frames; f_5 = 0.88 may be used for normal constructions, but f_5 may be given by the following formula:

$$f_5 = \frac{1 - d/118}{1 + d/13}$$

$$d = (l/l_f)^3 (l/S_f)\frac{I_f}{I}$$

l = span of the frame (m).
S_f = frame spacing (m).
I = moment of inertia of stringer.
I_f = moment of inertia of frames.
f_6 = factor which takes account of the distribution of load to the transverse frame; f_6 = 0.88 may be used for normal constructions, but f_6 may be given by the following formula:

$$f_6 = \frac{1 + d/(16n)}{1 + d/13}$$

n = number of transverse frames crossing the stringer.
σ_y = as specified in **206. 2.**

2. The section modulus Z and the shear area A of a stringer situated outside the ice belt but supporting ice strengthened frames are not to be less than that obtained from the following formula:

$$Z = \frac{f_7 P_d h l^2}{m_s \sigma_y}\left(l - h_s / l_s\right) \times 10^6 \quad (cm^3)$$

$$A = \frac{\sqrt{3} f_8 P_d h l}{2\sigma_y}\left(l - h_s / l_s\right) \times 10^4 \quad (cm^2)$$

P_d = as specified in **205. 1.**
h = as specified in **Table 3.20.9.** However, the product $P_d h$ is not to be taken as less than 0.3.
l = span of the stringer (m).
m_s = boundary condition factor; m_s = 13.3
l_s = the distance to the adjacent ice stringer (m).
h_s = the shortest distance from the considering stringer to the ice belt (m).

f_7 = factor which takes account the distribution of load to the transverse frames. f_7 is given by the following formula:

$$f_7 = \frac{f_5 + 1}{2}$$

f_5 = as specified in **Par 1.**
f_8 = factor which takes account of the distribution of load to the transverse frames. f_8 is given by the following formula.

$$f_8 = \frac{f_6 + 1}{2}$$

f_6 = as specified in **Par 1.**
σ_y = as specified in **206. 2.**

3. Narrow deck strips abreast of hatches and serving as ice stringers are to comply with the section modulus and shear area requirements in **Par 1** and **2** respectively. In the case of very long hatches, the product $P_d h$ may be taken as less than 0.3 but in no case less than 0.2. egard is to be paid to the deflection of the ship's sides due to ice pressure in way of very long hatch openings, when designing weatherdeck hatchcovers and their fittings.

211. Web Frames

1. The load F transferred to a web frame from an ice stringer or from longitudinal frame may be obtained from the following formula:

$$F = f_6 P_d h S \quad (kN)$$

f_6 = as specified in **210. 1** for ice stringer only and for longitudinals; f_6 =1.0
P_d = ice pressure (MPa) as specified in **205. 1** in calculating C_a however, l_a is to be taken as $2S$.
h = as specified in **Table 3.20.9.** However, the product $P_d h$ is to be more than 0.3.
S = web frame spacing (m).

2. When a web frame can be represented by the structure model shown in **Fig 3.20.3** the section modulus Z and shear area A may be obtained from the following formula:

$$Z = \frac{k_2 F l}{\sigma_y \sqrt{1 - (\gamma A_k / A_a)^2}} \times 10^6 \quad (cm^3)$$

$$A = \frac{\sqrt{3} \alpha k_1 F}{\sigma_y} \times 10^4 \quad (cm^2)$$

l = span of web frame (m).
k_1 = the value is not to be less than that obtained from the following formula, whichever is greater. For the lower part of the web frame the smallest l_F within the ice belt is to be used. For the upper part the biggest l_F within the ice belt is to be used.

$$k_1 = 1 + 0.5(l_F/l)^3 - 1.5(l_F/l)^2$$
$$k_1 = 1.5(l_F/l)^2 - 0.5(l_F/l)^3$$

l_F = distance from the lower support of the web frame to the stringer or longitudinal in question (m).
α and γ = as given in **Table 3.20.13.** For intermediate values of A_f/A_w is to be obtained by linear interpolation.
F = as specified in **Par 1.**
σ_y = as specified in **206. 2.**
k_2 = as given in the following formula:

$$k_2 = 0.5(l_F/l)^3 - 1.5(l_F/l)^2 + (l_F/l)$$

A_k = required shear area (cm^2) obtained by using

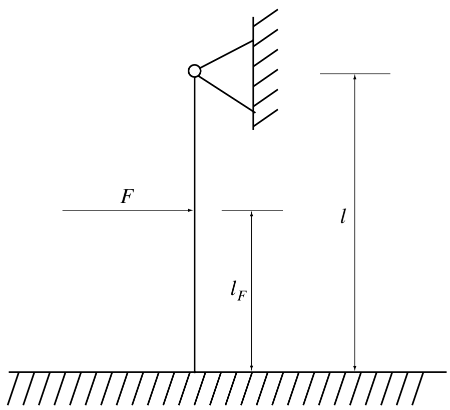


Fig 3.20.3 Structural Model of Web Frame

Table 3.20.13 Value of α and γ

A_f/A_w	0.20	0.40	0.60	0.80	1.00	1.20	1.40	1.60	1.80	2.00
α	1.50	1.23	1.16	1.11	1.09	1.07	1.06	1.05	1.05	1.04
γ	0.44	0.62	0.71	0.76	0.80	0.83	0.85	0.87	0.88	0.89

Note:
A_f = cross section area of free flange (cm^2)
A_w = cross section area of web plate (cm^2)

$k_1 = 1 + 0.5(l_F/l)^3 - 1.5(l_F/l)^2$

A_a = actual cross sectional area of the web frame (cm^2)

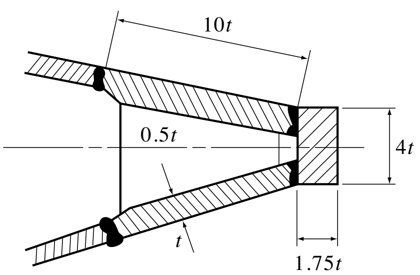
3. For other web frame configurations and boundary conditions specified in **Par 2,** a direct stress calculation is to be carried out. The concentrated load on the web frame is specified in **Par 1.** The point of application is in each case to be chosen in relation to the arrangement of stringers and longitudinal frames so as to obtain the maximum shear forces and bending moments. Allowable stresses are specified in **Table 3.20.14.**

Table 3.20.14 Allowable stresses

Stress	Allowable stress
Shear stress (τ)	$\sigma_y / \sqrt{3}$
Bending stress (σ_b)	σ_y
Equivalent stress $\left(\sigma_e = \sqrt{\sigma_b^2 + 3\tau^2}\right)$	σ_y
Note: σ_y = as specified in **206. 2.**	

212. Stem

1. A sharp edged stem (See **Fig. 3.20.4**) improves the manoeuvability of the ship in ice and is recommended particularly for smaller ships with a length below 150 m.



t = thickness of side plating (mm)

Fig 3.20.4 Sharp Edged Stem

2. The plate thickness of a shaped plate stem and in the case of a blunt bow, any part of the shell which forms an angle of 30 degrees or more to the centre line in a horizontal plane, is to be obtained from the formula in **206. 2.**

where:

S = spacing of elements supporting the plate (m).

P_{PL} = as specified in **205.** (MPa).

l_a = spacing of vertical supporting elements (m).

3. The stem and the part of a blunt bow specified in **Par 2** is to be supported by floors or brackets spaced not more than 0.6 m apart and having a thickness of at least half the plate thickness.

4. The reinforcement of the stem is to be extended from the keel to a point 0.75 m above LWL or, in case an upper forward ice belt is required in **206. 1** to the upper limit of this.

213. Arrangements for Towing

1. A mooring pipe with an opening not less than 250 by 300 mm, a length of at least 150 mm and an inner surface radius of at least 100 mm is to be fitted in the bow bulwark at the centre line.

2. A bitt or other means for securing a towline, dimensioned to stand the breaking force of the towline of the ship is to be fitted.

3. On ships with a displacement not exceeding 30,000 $tons$ the part of the bow which extends to a height of at least 5 m above the LWL and at least 3 m back from the stem, is to be strengthened to take the stresses caused by fork towing. For this purpose intermediate frames are to be fitted and the framing is to be supported by stringers or decks.

214. Stern

1. The clearance between the propeller blade tip and the stern frame is to be sufficient to prevent from occurring high loads on the blade tip.

2. On twin and triple screw ships, the ice strengthening of the shell and framing are to be extended to the double bottom for 1.5 m forward and aft of the side propellers.

3. On twin and triple screw ships, the shafting and stern tubes of side propellers are to be normally enclosed within plated bossings. If detached struts are used, their design, strength and attachment to the hull are to be duly considered.

4. A wide transom stern extending below the LWL will seriously impede the capability of the ship to back in ice. Therefore a transom stern is not to be extended below the LWL, if this can be avoided. If unavoidable, the part of the transom stern below the LWL is to be kept as narrow as possible. The part of a transom stern situated within the ice belt is to be strengthened as for the midship region.

215. Bilge Keel

1. The connection of bilge keels to the hull is to be so designed that the risk of damage to the hull, in case a bilge keel is ripped off, is minimized.

2. It is recommended that bilge keels are cut up into several shorter independent lengths.

216. Rudder and Steering Arrangements

1. The scantlings of rudder post, rudder stock, pintles and steering gear, etc. are to comply with requirements in **Pt 4, Ch 1** and **Pt 5, Ch 7.** In this case, the maximum service speed of ship to be used in these calculations is not to be taken less than that given in the **Table 3.20.15.**

Table 3.20.15 Minimum Speed

Class	Speed (kt)
ISS	20
IS1	18
IS2	16
IS3	14
IS4	14

2. For the ice classes ISS and IS1, the rudder stock and the upper edge of the rudder are to be protected against ice pressure by the ice knife or equivalent means.

3. For ships of ice classes ISS and IS1, the rudders and steering arrangements are to be designed as follows to endure the loads that work on the rudders by the ice when backing into an ice ridge.

(1) Relief valves for hydraulic pressure is to be effective.

(2) The components of the steering gear are to be dimensioned to stand the yield torque of the rudder stock.

(3) Where possible, rudder stoppers working on the blade or rudder head are to be fitted.

217. Ice Torque

1. The dimensions of propellers, shafting and gearing are to be determined taking into account the impact when a propeller blade hits ice.

2. The ice torque M is not to be less than the value determined by the following formula when the ice torque is used for the calculation of propellers in **218.** and the reduction gearing in **220.**

$$M = cD^2 \quad (kN \cdot m)$$

D = diameter of propeller (m).
c = constant given in **Table 3.20.16.**

3. If the propeller is not fully submerged when the ship is in ballast condition, the ice torque for ice class IS1 is to be used for ice classes IS2, IS3 and IS4.

Table 3.20.16 Value of coefficient c

Class	c
ISS	21.09
IS1	15.70
IS2	13.05
IS3	11.97
IS4	11.97

218. Propellers

1. As for the materials of the propellers, the elongation of the materials used is not to be less than 19% for R14A test specimen specified in **Pt 2, Ch 1** and absorbed energy for the Charpy impact test is not to be less than 21J at -10°C for R4 test specimen.

2. Width and thickness of the propeller at each blade section are not to be less than the values determined from following formula. However, the thickness of blade is not to be less than that specified in **Pt 5, Ch 3, 303.**

(1) For solid propellers
At the radius 0.25R:

$$lt^2 = \frac{26490}{T(0.65+0.7p_x/D)}\left[27.2\frac{P}{ZN}+2.24M\right]$$

At the radius 0.60R:

$$lt^2 = \frac{9320}{T(0.65+0.7p_x/D)}\left[27.2\frac{P}{ZN}+2.85M\right]$$

(2) For controllable pitch propellers
At the radius 0.35R:

$$lt^2 = \frac{21090}{T(0.65+0.7p_x/D)}\left[27.2\frac{P}{ZN}+2.34M\right]$$

At the radius 0.6R:

$$lt^2 = \frac{9320}{T(0.65+0.7p_x/D)}\left[27.2\frac{P}{ZN}+2.85M\right]$$

l = length of the expanded cylindrical section of the blade, at the radius in question (cm).
t = the corresponding maximum blade thickness at the radius in question (cm).
p_x = propeller pitch at the radius in question (m). For controllable pitch propeller 70% of the normal pitch is to be used.
D = diameter of propeller (m).
R = radius of propeller (m).
P = engine output per propeller (kW).
M = ice torque specified in 217. ($kN \cdot m$).

Z = number of blades.
N = number of revolution at the maximum continuous engine output of main engine (rpm).
T = specified minimum tensile strength of the propeller blade material. (N/mm^2).

3. The blade tip thickness at the radius $0.5D$ is to be not less than the value determinated by the following formula:

(1) Ice class ISS

$$(20+2D)\sqrt{\frac{490}{T}} \quad (mm)$$

(2) Ice class other than ISS

$$(15+2D)\sqrt{\frac{490}{T}} \quad (mm)$$

D and T = as specified in **Par 2.**

4. The blade thickness of other sections is to conform to a smooth curve connecting the section thickness as determined in **Par 2** and **3.**

5. The thickness of blade edges is not to be less than 50% of the blade tip thickness determined in **Par 3.** For solid propellers, the measured points are the position equal to 1.25 times the required blade tip thickness in **Par 3** from leading and following edges, respectively. For controllable pitch propellers, this applies only to the leading edge.

6. The strength of mechanisms in the boss of a controllable pitch propeller is to be 1.5 times that of the blade when a load is applied at the radius $0.9R$ in the weakest direction of the blade.

219. Shaftings

1. Propeller shaft and Stern tube shaft

(1) The diameter D_p of the propeller shaft at the stern tube shaft is not to be less than obtained from the following formula:

$$D_p = 10.8\sqrt[3]{\frac{Tlt^2}{Y}} \quad (mm)$$

l = actual length of the expanded section of the blade at the radius $0.25R$ (cm).
t = actual maximum blade thickness at the radius $0.25R$ (cm).
T = specified minimum tensile strength of the propeller blade material (N/mm^2).
Y = specified minimum yield strength of the propeller shaft material (N/mm^2)

(2) If the diameter D_p of the propeller boss is greater than $0.25D_p$, the diameter of the propeller shaft at stern tube shaft is not to be less than that obtained from the following formula:

$$D_p = 11.5\sqrt[3]{\frac{Tlt^2}{Y}} \quad (mm)$$

l = actual length of expanded section of the blade at the radius $0.35R$ (cm).
t = actual maximum blade thickness at the radius $0.35R$ (cm).
T and Y = as specified in (1).

(3) The shaft diameter derived from the above (1) or (2) is not to be less than the required diameter specified in **Pt 5, Ch 3, 204.**

2. Intermediate shafts and Thrust shafts

For the ice class Special Class, the diameters of intermediate shafts and thrust shafts in external bearings are not to be less than 1.1 times the required diameter, specified in **Pt 5, Ch 3, 203.**

220. Reduction Gearing

1. Where the reduction gearing is fitted between the main engine and the propeller shafting, the external load magnification coefficient K_1 specified in **Pt 5, Ch 3, 403.** is to be substituted by the value determined by the following formula:

$$\frac{1}{\frac{1}{K_1}+\frac{1}{1+J_1/J_h}\frac{M}{M_o}}$$

K_1 = coefficient specified in **Pt 5, Ch 3, 403.**
M = ice torque specified in **217.** ($kN{\cdot}m$).
M_o = mean torque of the propeller shaft determined by the following formula:

$$M_o = 9.55\ P/N\ (kN{\cdot}m)$$

P, N =as specified in **218. 2**
J_1 = total mass moment of inertia of the output shaft of the reduction gearing, propeller and propulsion shafting, where including propeller with an additional mass of 30% for water.
J_h = total mass moment of inertia the main engine, flywheel and reductions gearing except output shaft. Where the revolution of the engine differ from those of the propeller, the equivalent mass moment of inertia corrected by the gear ratio is to be used.

221. Air compressors

1. The capacity of the compressed air reservoirs is to be sufficient to provide, without being replenished, not less than 12 consecutive starts altering between Ahead and Astern of each main engine of the reversible type, and not less than 6 consecutive starts for installations in which the propeller is reversible without compressed air and for controllable pitch propeller.

2. If the air reservoirs serve any other purposes than starting the propulsion engines, they are to have additional capacity sufficient for these purposes.

3. The capacity of the air compressors is to be sufficient for charging the air reservoirs from atmospheric to full pressure in one hour as specified in **Pt 5, Ch 6, 1001.** For a ship with ice class Special that required its propulsion engines to be reversed for going astern, the compressors are to be able to charge the air reservoirs in half an hour.

222. Sea inlet and cooling water systems

1. The cooling water system is to be designed to ensure a supply of cooling water when navigating in ice.

2. To satisfy in **Par 1,** at least one cooling sea water inlet chest is to be arranged as follows. However, the ship with ice class Class 4 may not comply with the requirements in (2), (3) and (5):

(1) The sea inlet is to be situated near the centerline of the ship and well aft if possible.

(2) As a guidance for design, the volume of sea chest is to be about 1 m^3 for every 750 kW engine output of the ship including the output of auxiliary engines necessary for the ship's service.

(3) The sea chest is to be sufficiently high to allow ice to accumulate above the inlet pipe.

(4) A pipe for discharge cooling water, allowing full capacity discharge, is to be connected to sea chest.

(5) The area through grating holes is not to be less than 4 times the inlet pipe sectional area.

3. Where more than two sea chests are arranged, requirements in **Par 2** (2) and (3) may be suitably considered. In this case, these sea chests are to be arranged for alternating intake and discharge of cooling water. As well, the requirements in **Par 2** (1), (4) and (5) are to be complied with.

4. Heating coils may be installed in the upper part of the chest or chests.

5. At least one of the fire pumps is to be connected to a sea chest which is provided with de-icing arrangement. ⚓

PART H

HULL COMPONENTS

CHAPTER 1
RUDDERS

Section

SECTION 1
General

101. Application

1. The requirements in this Chapter apply to single plate rudders and double plate rudders of stream line section and ordinary shape, being divided into the following types ;

(1) Type A : Rudders with upper and bottom pintles. (*See* **Fig. 4.1.1** Type A)
(2) Type B : Rudders with the neck bearing and the bottom pintle. (*See* **Fig. 4.1.1** Type B)
(3) Type C : Rudders having no bearing below the neck bearing. (*See* **Fig. 4.1.1** Type C)
(4) Type D : Mariner type rudders with neck bearing and pintle, of which lower end is fixed. (*See* **Fig. 4.1.1** Type D)
(5) Type E : Mariner type rudders with two pintles, of which lower ends are fixed. (*See* **Fig. 4.1.1** Type E)

2. The construction of rudders with three or more pintles and of those with special shape or sectional form are to be in accordance with the discretion of this Society.

3. The construction of rudders designed to move more than 35 *degrees* on one side is to be in accordance with the discretion of this Society.

102. Materials

1. Rudders stocks, pintles, coupling bolts, keys and cast parts of rudders are to be made of rolled steel, steel forging or carbon steel casting conforming to the requirements in **Pt 2, Ch 1** of the Rules. For rudder stocks, pintles, coupling bolts and keys, the minimum yield stress is not to be less than 200 (N/mm^2). The requirements in this Chapter are based on a material's yield stress of 235 (N/mm^2). If material is used having a yield stress differing from 235 (N/mm^2) the material factor K is to be determined by **Table 4.1.1**.

Table 4.1.1 Material Factor K
(for steel forging and carbon steel casting)

σ_Y (N/mm^2)	K
$\sigma_Y > 235$	$K = \left(\dfrac{235}{\sigma_Y}\right)^{0.75}$
$\sigma_Y \le 235$	$K = \left(\dfrac{235}{\sigma_Y}\right)^{1.0}$

σ_Y = yield stress (N/mm^2) of material used, and is not to be taken greater than 0.7 σ_T or 450 (N/mm^2), whichever is smaller value.
σ_T = minimum tensile strength of material used (N/mm^2).

2. When the rudder stock diameter is reduced because of the application of steels with yield stresses exceeding 235 (N/mm^2), special consideration is to be given to deformation of the rudder stock to avoid excessive edge pressures at edge of bearings.

3. Welded members of rudders such as rudder plates, rudder frames, rudder main pieces, and edge bars are to be made of rolled steels for hull conforming to the requirements in **Pt 2, Ch 1** of the Rules. The required scantlings may be reduced when high tensile steels are applied. When reducing the scantling, the material factor K is to be as **Table 4.1.2**.

103. Increase in diameter of rudder stocks for special cases

1. The diameters of rudder stocks for ships exclusively

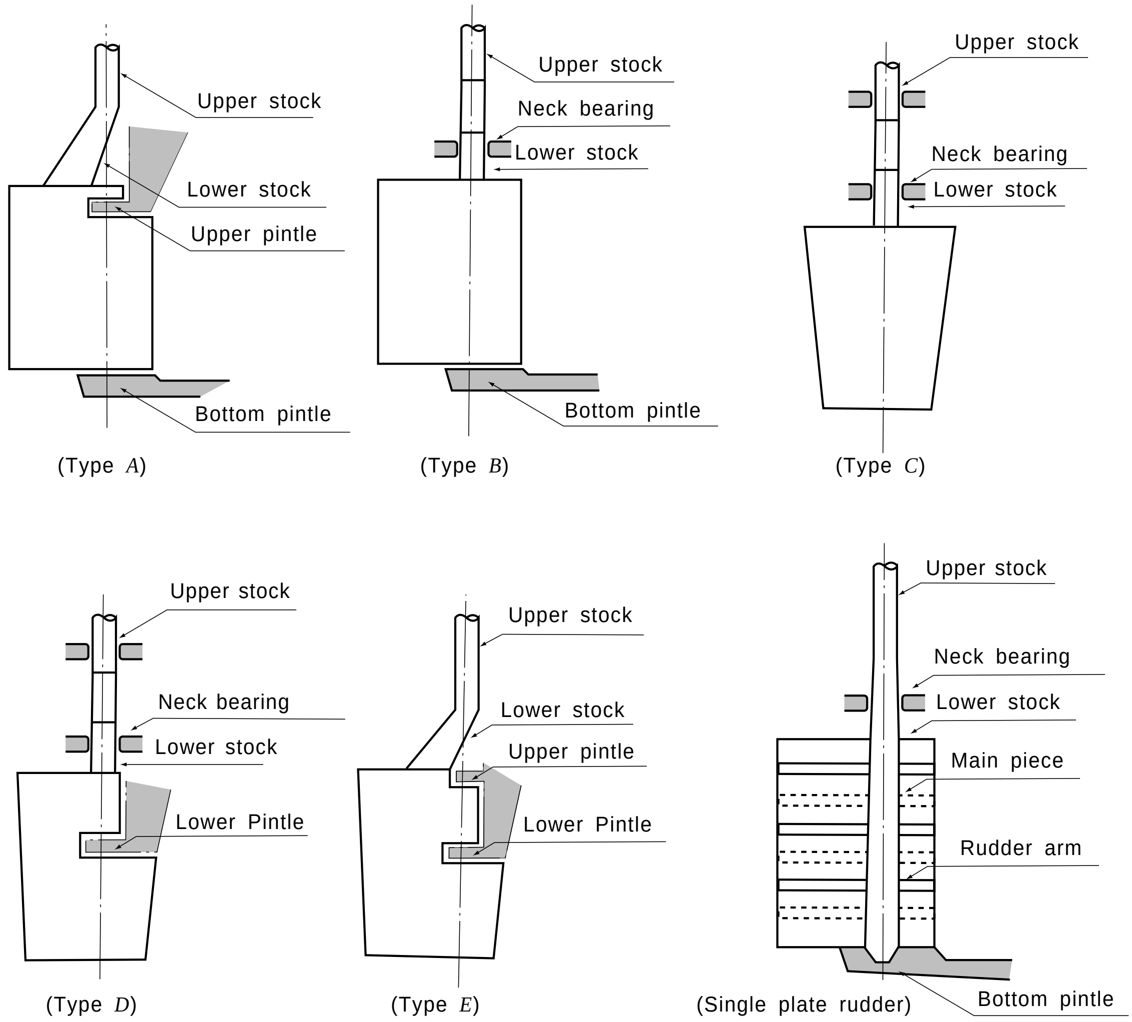


Fig. 4.1.1 Types of Rudders

Table 4.1.2 Material Factor K (for rolled steel)

Material	K
RA, RB, RD or RE	1.0
RA32, RD32 or RE32	0.78
RA36, RD36 or RE36	0.72

engaged in towing services are not to be less than 1.1 *times* those required in this Chapter.

2. In ships which may be frequently steered at a large helm angle when sailing at their maximum speed, such as fishing vessels, the diameters of rudder stocks and pintles, as well as the section modulus of main pieces, are not to be less than 1.1 *times* those required in this Chapter.

3. In ships which might require quick steering, the diameters of rudder stocks are to be properly increased beyond the requirements in this Chapter.

4. The rudders for ships registered for ice strengthening are to be in accordance with the requirements of **Pt 3, Ch 20, 216.** in addition to the requirements of this Chapter.

104. Sleeves and bushes

Bearings located from the bottom of rudder to well above the load line are to be provided with sleeves and bushes.

SECTION 2
Rudder Force

201. Rudder force

The rudder force F_R upon which the rudder scantlings are to be based is to be obtained from the following formula, for each of going ahead or astern. However, when the rudder is arranged behind the propeller that produces an especially great thrust, the rudder force is to be appropriately increased.

$$F_R = 132\,K_1 K_2 K_3 A\,V^2 \quad (N)$$

where :

A = area of rudder plate (m^2).

V = speed of ship(Kt) as defined in **Pt 3, Ch 1** of the Rules. When the speed is less than 10 *knots*, V is to be replaced by $V_{\min}$ obtained from the following formula ;

$$V_{\min} = \frac{V+20}{3} \quad (Kt)$$

For the astern condition, the astern speed V_a is to be obtained from the following formula. However, when the maximum astern speed is designed to exceed V_a, the design maximum astern speed is to be used.

$$V_a = 0.5\,V \quad (Kt)$$

K_1 = factor depending on the aspect ratio Λ of the rudder area, obtained from the following formula.

$$K_1 = \frac{\Lambda + 2}{3}$$

Λ = as obtained from the following formula. However, Λ is not required to be greater than 2.

$$\Lambda = \frac{h^2}{A_t}$$

h = mean height of rudder (m), which is determined according to the coordinate system in **Fig. 4.1.2**.

A_t = sum of rudder plate area A (m^2) and area of rudder post or rudder horn, if any, within the mean height of rudder h.

K_2 = factor depending on the rudder profile (*See* **Table 4.1.3**).

K_3 = factor depending on the location of rudder (*See* **Table 4.1.4**).

SECTION 3
Rudder Torque

301. Rudder torque of Type *B* and Type *C* rudders (Rudder without cut-outs)

The rudder torque T_R of Type B and C rudders is to be obtained for ahead and astern conditions, respectively, according to the following formula.

$$T_R = F_R \cdot r \quad (N \cdot m)$$

where :

F_R = as specified in **201**.

Table 4.1.3 Factor K_2

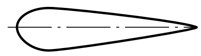
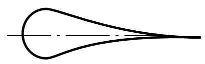
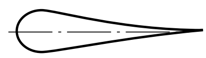
Profile type	K_2	
	Ahead condition	Astern condition
NACA-00 Göttingen profiles 	1.1	0.80
Hollow profiles 	1.35	0.90
Flat side profiles 	1.1	0.90

Table 4.1.4 Factor K_3

Location of rudder	K_3
for rudders outside the propeller jet	0.8
for rudders behind a fixed propeller nozzle	1.15
otherwise	1.0

r = distance from the centre of rudder force on the rudder to the centreline of the rudder stock, determined by the following formula.

$$r = b\,(\alpha - e) \quad (m)$$

For the ahead condition, however, r is not to be less than r_{min} obtained from the following formula.

$$r_{min} = 0.1\,b \quad (m)$$

b = mean breadth (m) of rudder determined by the coordinate system in **Fig. 4.1.2**.

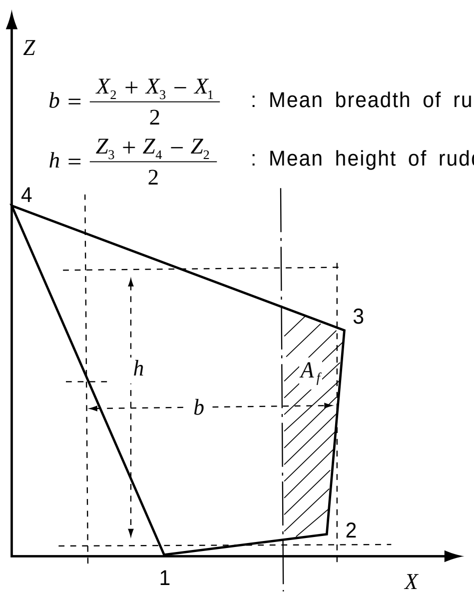


Fig. 4.1.2 Coordinate System of Rudders

α = to be as **Table 4.1.5**.

Table 4.1.5 Factor α

Course of rudder	α
Ahead condition	0.33
Astern condition	0.66

e = balance factor of the rudder obtained from the following formula.

$$e = \frac{A_f}{A}$$

A_f = portion of the rudder plate area situated ahead of the centreline of the rudder stock (m^2).

A = as specified in **201**.

302. Rudder torque of Type A, D and E rudders (Rudder with stepped contours)

The rudder torque T_R of Type A, D and E rudders is to be obtained for the ahead and astern conditions, respectively, according to the following formula :

$$T_R = T_{R1} + T_{R2} \quad (N \cdot m)$$

For the ahead condition, however, T_R is not to be less than T_{Rmin} obtained from the following formula :

$$T_{R\,\min} = 0.1\,F_R \cdot \frac{A_1\,b_1 + A_2\,b_2}{A} \qquad (N \cdot m)$$

where :

T_{R1} and T_{R2} = rudder torque ($N \cdot m$) of portion of A_1 and A_2, respectively, obtained from the following formulae, respectively.

$T_{R1} = F_{R1} \cdot r_1 \; (N \cdot m)$
$T_{R2} = F_{R2} \cdot r_2 \; (N \cdot m)$

A_1 and A_2 = areas of respective rectangulars (m^2) determined by dividing the rudder area into two parts so that $A = A_1 + A_2$ (A_1 and A_2 include A_{1f} and A_{2f} respectively), as specified in **Fig. 4.1.3**.

b_1 and b_2 = mean breadth (m) of portions A_1 and A_2, determined by applying **Fig. 4.1.2** correspondingly.

F_R and A = as specified in **201**.

F_{R1} and F_{R2} = the rudder force of portions A_1 and A_2, obtained from the following formulae, respectively.

$$F_{R1} = F_R \cdot \frac{A_1}{A} \qquad (N)$$

$$F_{R2} = F_R \cdot \frac{A_2}{A} \qquad (N)$$

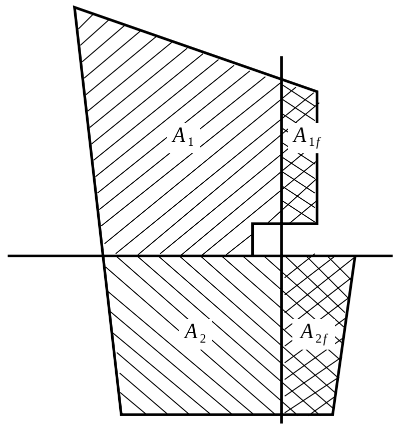


Fig. 4.1.3 Division of Rudder Area

r_1 and r_2 = the distances from each centre of rudder force of portions A_1 and A_2 to the centreline of the rudder stock, determined by the following formulae, respectively.

$r_1 = b_1\,(\alpha - e_1) \quad (m)$
$r_2 = b_2\,(\alpha - e_2) \quad (m)$

e_1 and e_2 = the balance factors of portions A_1 and A_2, obtained from the following formulae, respectively.

$$e_1 = \frac{A_{1f}}{A_1}, \qquad e_2 = \frac{A_{2f}}{A_2}$$

α = to be as **Table 4.1.6**.

Table 4.1.6 Factor α

Locations of rudder parts	α	
For parts of a rudder not behind a fixed structure such as rudder horn	for ahead condition	0.33
	for astern condition	0.66
For parts of a rudder behind a fixed structure such as rudder horn	for ahead condition	0.25
	for astern condition	0.55

SECTION 4
Rudder Strength Calculation

401. Rudder strength calculation

1. The rudder strength is to be sufficient against the rudder force and rudder torque as given in **Sec 2** and **Sec 3**. When the scantling of each part of a rudder is determined, the following moments and forces are to be considered.

For rudder body : bending moment and shear force

For rudder stock : bending moment and torque

For pintle bearing and rudder stock bearing : supporting force

2. The bending moments, shear forces and supporting forces to be considered are to be determined by a direct calculation or an approximate simplified method as deemed appropriate by this Society.

SECTION 5
Rudder Stocks

501. Upper stocks

The upper stock diameter d_u required for the transmission of the rudder torque is to be determined so that the torsional stress not exceed $68/K_s$ (N/mm^2). In dimensioning, the upper stock diameter may be determined by the following formula :

$$d_u = 4.2\sqrt[3]{T_R K_S} \quad (mm)$$

T_R = as specified in **301**. and **302**.
K_s = material factor for rudder stock, as given in **102**.

502. Lower stocks

The diameter d_l of the lower stock subjected to combined forces of torque and bending moment is to be determined so that the equivalent stress in the rudder stock not exceed $118/K_s$ (N/mm^2). The equivalent stress σ_e is to be obtained from the following formula :

$$\sigma_e = \sqrt{\sigma_b{}^2 + 3\tau_t{}^2} \quad (N/mm^2)$$

where :
σ_b and τ_t = the bending stress and torsional stress acting on the lower stock, determined as follows respectively :

$$\sigma_b = \frac{10.2\,M}{d_l{}^3} \times 10^3 \quad (N/mm^2)$$
$$\tau_t = \frac{5.1\,T_R}{d_l{}^3} \times 10^3 \quad (N/mm^2)$$

M = bending moment $(N \cdot m)$ at the section of the rudder stock considered.
T_R = as specified in **301**. and **302**.

When the horizontal section of the lower stock forms a circle, the lower stock diameter d_l may be determined by the following formula :

$$d_l = d_u \sqrt[6]{1 + \frac{4}{3}\left(\frac{M}{T_R}\right)^2} \quad (mm)$$

where :
d_u = upper stock diameter(mm) as given in **501**.

SECTION 6
Rudder Plates, Rudder Frames and Rudder Main Pieces

601. Rudder plate

The rudder plate thickness t is not to be less than that obtained from the following formula :

$$t = 5.5\,S\beta\sqrt{\left(d + \frac{F_R \times 10^{-4}}{A}\right)K_{Pl}} + 2.5 \quad (mm)$$

where :
A and F_R = as specified in **201**.
K_{pl} = material factor for the rudder plate as given in **102**.
d = as specified in **Pt 3, Ch 1, 111**.
β = to be obtained from the following formula :

$$\beta = \sqrt{1.1 - 0.5\left(\frac{S}{a}\right)^2} \qquad \text{max: } 1.0\left(\frac{a}{S} \geq 2.5\right)$$

S = spacing of horizontal or vertical rudder frames, whichever is smaller (m).
a = spacing of horizontal or vertical rudder frames, whichever is greater (m).

602. Rudder frames

1. The rudder body is to be stiffened by horizontal and vertical rudder frames enabling it to act as bending girder.

2. The standard spacing of horizontal rudder frames, S_f is to be obtained from the following formula :

$$S_f = 0.2\left(\frac{L}{100}\right) + 0.4 \quad (m)$$

3. The standard distance from the vertical rudder frame forming the rudder main piece to the adjacent vertical rudder frame is to be 1.5 *times* the spacing of horizontal rudder frames.

4. The thickness of rudder frames is not to be less than 8 *mm* or 70 % of the thickness of the rudder plates as given in **601,** whichever is greater.

603. Rudder main pieces

1. Vertical rudder frames forming the rudder main piece are to be arranged forward and afterward of the centreline of rudder stock at a distance approximately equal to the thickness of the rudder where

the main piece consists of two rudder frames, or at the centreline of the rudder stock where the main piece consists of one rudder frame.

2. The section modulus of the main piece is to be calculated in conjunction with the vertical rudder frames specified in **Par 1** and rudder plates attached thereto. The effective breadth of the rudder plates normally taken into calculation are to be as follows :

(1) Where the main piece consists of two rudder frames, the effective breadth is 0.2 *times* the length of the main piece.
(2) Where the main piece consists of one rudder frame, the effective breadth is 0.16 *times* the length of the main piece.

3. The section modulus and the web area of a horizontal section of the main piece are to be such that bending stress, shear stress and equivalent stress will not exceed the following stress values, respectively.

$$\sigma_b = \frac{110}{K_m} \quad (N/mm^2)$$

$$\tau = \frac{50}{K_m} \quad (N/mm^2)$$

$$\sigma_e = \sqrt{\sigma_b^2 + 3\tau^2} = \frac{120}{K_m} \quad (N/mm^2)$$

In the cases of Type A, D, and E rudders, however, the section modulus and the web area of a horizontal section of the main piece in way of cut-outs are to be such that bending stress, shear stress and equivalent stress not exceed the following stress values, respectively.

$$\sigma_b = \frac{75}{K_m} \quad (N/mm^2)$$

$$\tau = \frac{50}{K_m} \quad (N/mm^2)$$

$$\sigma_e = \sqrt{\sigma_b^2 + 3\tau^2} = \frac{100}{K_m} \quad (N/mm^2)$$

where :

K_m = material factor for the rudder main piece as given in **102**.

4. The upper part of the main piece is to be so constructed as to avoid structural discontinuity.

5. Maintenance openings and cut-outs of rudder plates in Type A, D, and E rudders are to be rounded off properly.

604. Rudder plates, rudder arms and rudder main pieces of single plate rudders

1. The rudder plate thickness t is not to be less than that obtained from the following formula :

$$t = 1.5\,SV\sqrt{K_{pl}} + 2.5 \quad (mm)$$

where :

S = spacing (m) of rudder arms, not to exceed 1 m.
V = speed of ship (Kt) as specified in **201**.
K_{pl} = material factor for rudder plate as given in **102**.

2. Rudder arms are to comply with the following requirements.

(1) The thickness of rudder arms is not to be less than that of rudder plates.
(2) The section modulus of rudder arms is not to be less than the value obtained from the following formula. This section modulus, however, may be reduced gradually toward the edge of the rudder plate.

$$Z = 0.5\,S\,C_1^2\,V^2\,K_a \quad (cm^3)$$

where :

C_1 = horizontal distance (m) from the aft edge of the rudder plate to the centre of the rudder stock.
K_a = material factor for the rudder arm as given in **102**.
S and V = as specified in **Par 1**.

3. The diameters of main pieces are not to be less than those of lower rudder stocks. In rudders having no bearing below the neck bearing, however, the main piece diameter may be reduced gradually within the lower 1/3 area of the rudder, and may be 75% of the specified diameter at the bottom part.

605. Connections

Rudder plates and frames are to be effectively connected and free from defects, cautions being taken to the workmanship.

606. Paintings and drainings

The internal surface of rudder is to be coated with effective paint, and means for draining are to be provided at the bottom of rudder.

SECTION 7
Couplings between Rudder Stocks and Main Pieces

701. Horizontal flange couplings

1. Coupling bolts are to be reamer bolts.

2. Couplings are to comply with the requirements in **Table 4.1.7**.

702. Vertical flange couplings

1. Coupling bolts are to be reamer bolts.

2. Couplings are to comply with the requirements in **Table 4.1.7**.

Table 4.1.7 The Minimum Requirements for Rudder Couplings to Stock

Parameter	Requirement	
	Horizontal flange coupling	Vertical flange coupling
n	6	8
d_b	$0.62\sqrt{\dfrac{d^3 K_b}{n e_m K_s}}$	$\dfrac{0.81\,d}{\sqrt{n}} \times \sqrt{\dfrac{K_b}{K_s}}$
M	-	$0.00043\,d^3$
t_f	$d_b\sqrt{\dfrac{K_f}{K_b}}$ (not less than $0.9\,d_b$)(1)	d_b
w_f	$0.67\,d_b$	$0.67\,d_b$

n = total number of bolts.
d_b = bolt diameter (mm).
d = stock diameter (mm), the greater of the diameters d_u or d_l according to **501.** and **502.**
M = the first moment of area of the bolts about the centreline of the coupling flange (cm^3)
e_m = mean distance (mm) of the bolt axes from the centre of the bolt system.
K_s = material factor for the rudder stock as given in **102.**
K_b = material factor for the bolts as given in **102.**
K_f = material factor for the coupling flange as given in **102.**
t_f = the thickness (mm) of the coupling flanges.
w_f = the width (mm) of the material outside the bolt holes of the coupling flanges.

NOTE :
(1) In way horizontal flange couplings, t_f is to be calculated from d_b determined by a number of bolts not exceeding 8.

703. Cone couplings

1. Cone couplings without hydraulic arrangements (oil injection and hydraulic nut, etc.) for mounting and dismounting the coupling are to comply with the following requirements.

(1) The couplings are to have a taper on diameters of 1 : 8 ~ 1 : 12 and be secured by the slugging nut. (*See* **Fig. 4.1.4**)

(2) The taper length l of rudder stocks fitted into the rudder plate is generally not to be less than 1.5 *times* the rudder stock diameter d_o at the top of the rudder.

(3) For the couplings between stock and rudder, a key is to be provided. And the scantling of the key is to be to the discretion of the Society.

(4) The dimensions of the slugging nut as specified in the preceding (1) are to be as follows (*See* **Fig. 4.1.4**) :

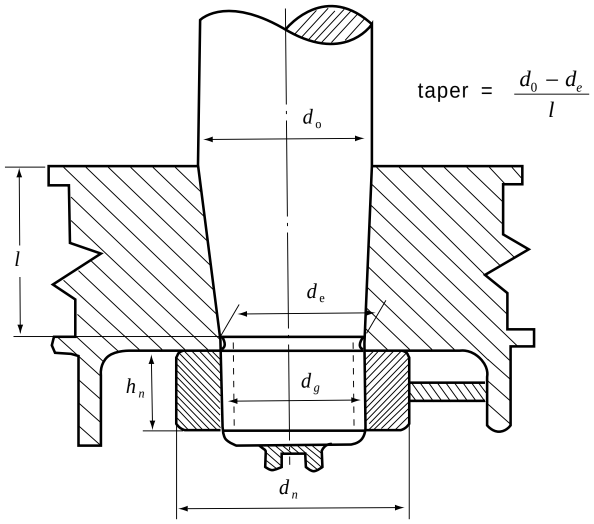


Fig. 4.1.4 Cone Coupling without Hydraulic Arrangements

$d_g \geq 0.65\,d_o$ (mm)
$h_n \geq 0.6\,d_g$ (mm)
$d_n \geq 1.2\,d_e$ or $1.5\,d_g$ (mm), whichever is greater.

where :
d_g = external thread diameter (mm).
h_n = length of nut (mm).
d_n = outer diameter of nut (mm).

(5) The nuts fixing the rudder stocks are to be provided with efficient locking devices such as lock nut, nut stopper, etc.

(6) Couplings of rudder stocks are to be properly protected from corrosion.

2. Cone couplings with hydraulic arrangements (oil injection and hydraulic nut, etc.) for mounting and dismounting the coupling are to comply with the following requirements.

(1) Couplings are to have a taper on diameters of 1 : 12 ~ 1 : 20. The push-up force and push-up length are to be at the discretion of this Society.

(2) The nuts fixing the rudder stocks are to be

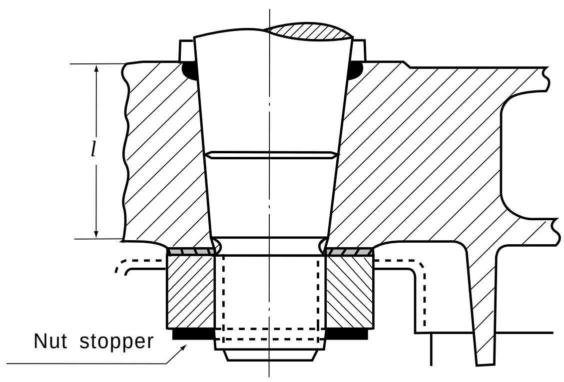


Fig. 4.1.5 Cone Coupling with Hydraulic Arrangements

provided with efficient locking devices. However, a securing plate for securing nut against the rudder body is not to be provided.
(3) Couplings of rudder stocks are to be properly protected from corrosion.
(4) The dimensions of the securing nuts are to be as specified **Par 1,** (4).

SECTION 8
Pintles

801. Diameters of pintles

The diameters of pintles d_p are not to be less than the dimension obtained from the following formula.

$$d_p = 0.35\sqrt{BK_p} \quad (mm)$$

where :

B = reaction force in bearing (N)
K_p = material factor for pintles as given in **102**.

802. Construction of pintles

1. Pintles constructed as taper bolts are to have a taper on the diameter not exceeding the following values, and capable of being fitted to the gudgeons. The nuts fixing the pintles are to be provided with efficient locking devices.

(1) For keyed pintles to be assembled and locked with slugging nuts : 1 : 8 ~ 1 : 12
(2) For pintles mounted with hydraulic arrangements (oil injection and hydraulic nut, etc.) : 1 : 12 ~ 1 : 20

2. The minimum dimensions of the threads and the nuts of pintles are to be determined by applying the requirements in **703. 1** (4) correspondingly.

3. The length of the pintle housing in the gudgeon (*tapered length*) is not to be less than the maximum pintle diameter.

4. Pintles are to be properly protected from corrosion.

SECTION 9
Bearings of Rudder Stocks and Pintles

901. Minimum bearing surface

The bearing surface A_b (defined as the projected area : *Bearing length* × *outside diameter of sleeve*) is not to be less than the value obtained from the following formula.

$$A_b = \frac{B}{q_a} \quad (mm^2)$$

where :

B = as specified in **801**.
q_a = allowable surface pressure (N/mm^2). The allowable surface pressure for the various bearing combination is to be taken from **Table 4.1.8**. When verified by tests, however, different values from those in this Table may be taken.

Table 4.1.8 Allowable Surface Pressure q_a

Bearing material	q_a (N/mm^2)
Lignum vitae	2.5
White metal (oil-lubricated)	5.5
Synthetic materials with hardness between 60 and 70, Shore D (Note 1)	5.5
Steel (Note 2), bronze and hotpressed bronze-graphite materials	7.0

NOTES :
(1) Indentation hardness test at the temperature of 23°C and humidity of 50%, according to a recognized standard. Synthetic bearings are to be of approved type.
(2) Stainless and wear-resistant steel in an approved combination with a stock liner.

902. Length of bearings

The length / diameter ratio of the bearing surface is not to be greater than 1.2.

903. Bearing clearances

With metal bearings clearances are not to be less than $d_{bs}/1000 + 1.0$ (mm) on the diameter.

where :

d_{bs} = the internal diameter of bush (mm).

If non-metallic bearing material is applied, the bearing clearance is to be specially determined considering the material's swelling and thermal expansion properties. This clearance in no way is to be taken less than 1.5 mm on bearing diameter.

904. Thickness of bush and sleeve

The thickness of any bush or sleeve t is not to be less than that obtained from the following formula.

$$t = 0.01\sqrt{B} \quad (mm)$$

where :

B = as specified in **801**.

However, t is not to be less than t_{min} as follows ;

t_{min} = 8 mm for metallic materials and synthetic materials
t_{min} = 22 mm for lignum vitae

SECTION 10
Rudder Accessories

1001. Rudder carriers

Suitable rudder carriers are to be provided for supporting the weight of rudder according to the form and the weight of the rudder, and care is to be taken to provide efficient lubrication at the support.

1002. Jumping stoppers

Suitable arrangements are to be provided to prevent the rudder from jumping due to wave shocks. ⚓

CHAPTER 2
HATCHWAYS AND OTHER DECK OPENINGS

SECTION 1
Hatch Coamings

101. Position of exposed deck openings

For the purpose of this Chapter, two positions of exposed deck openings are defined as follows:

Position I = Upon exposed freeboard and raised quarter decks and exposed superstructure decks situated forward of a point located $0.25L_f$ abaft the fore end of L_f.

Position Ⅱ = Upon exposed superstructure decks situated abaft the forward $0.25L_f$.

102. Height of hatchway coamings

1. The height of coamings above the upper surface of deck is to be at least 600 mm in Position I and 450 mm in Position Ⅱ.

2. For hatchways closed by steel weathertight hatch covers as specified in **301.,** the height of coamings may be reduced from those prescribed in the preceding paragraph or omitted entirely subject to the satisfaction of this Society.

3. The height of hatchway coamings other than those provided in exposed portions of the freeboard or superstructure decks is to be to the satisfaction of the Society having regard to the position of hatchways or the degree of protection provided.

103. Construction of hatchway coamings

1. The thickness of hatchway coamings is not to be less than that obtained from **Table 4.2.1**.

Table 4.2.1 Thickness of Hatch Coamings

Length of Ship (m)	Thickness (mm)
$L \leq 100$	$t = 0.05L + 6$
$L \rangle 100$	$t = 11$

2. Coamings for hatchways in Position I or coamings having a height of 760 mm or more for hatchways in Position Ⅱ are to be stiffened in a suitable position below the upper edge by a horizontal stiffener, the breadth of the horizontal stiffener is not to be less than that obtained from the following formula, but the breadth is not to be less than 180 mm.

$$b = 1.7L + 50 \quad (mm)$$

3. Coamings are to be additionally supported by efficient brackets or stays provided from the horizontal stiffeners to the deck at an interval of approximately 3 $metres$.

4. Coamings for all exposed hatchways are to be stiffened on their upper edges by half round bars or similar moulding bars and their lower parts are to be constructed efficiently by flanging or other suitable means.

5. For the construction and scantlings of coamings of small hatchways, the requirements in the preceding paragraphs may be suitably modified.

6. The construction and scantlings of coamings over 900 mm in height, coamings of hatchways to deep tanks and coamings of hatchways closed by a special type of closing means to which the requirements in this Article are not applicable are to be to the satisfaction of this Society.

SECTION 2
Hatch Openings Closed by Portable Covers and Secured Weathertight by Tarpaulins and Battening Devices

201. Hatch rests

Hatch rests are to be provided with at least 65 mm bearing surface and are to be bevelled, if required, to suit the slope of the hatchways.

202. Wood hatch covers

Wood covers are to comply with the following requirements:

(1) The finished thickness is not to be less than that obtained from the following formulae in association with a span of not more than 1.5 m. Covers intended to carry cargoes on them are to be increased in thickness in direct proportion either where the tween deck height exceeds 2.6 $metres$ or the weight of cargoes to be carried on the hatchway covers exceeds 17.5 kN/m^2, but in no case is the finished thickness to be less than 60 mm.

For 0.15 L_f forward where L_f is not less than 100 m:

$$t = 44\,S \quad (mm)$$

Elsewhere: $t = 40\,S \quad (mm)$

where:
S = spacing of portable beams (m).

(2) The wood for hatchway covers is to be of good quality, straight grained and reasonably free from knots, sap and shakes.

(3) The ends of all wood covers are to be protected by encircling steel band.

203. Steel hatch covers

The section modulus and the moment of inertia of steel hatch covers are not to be less than those obtained from the following formulae:

Section modulus:

$$Z = 0.85\,C_1 b S^2 \quad (cm^3)$$

Moment of inertia:

$$I = 0.78\,C_2 b S^3 \quad (cm^4)$$

where:

b = width of covers (m).
S = spacing of portable beams (m).
C_1, C_2 = as given by **Table 4.2.2**.

204. Hatch beams

1. The scantlings of portable beams are not to be less than those obtained from the following formulae:

Section modulus at mid-span:

$$Z = C_1 K_1 S l^2 \quad (cm^3)$$

Moment of inertia at mid-span:

$$I = C_2 K_2 S l^3 \quad (cm^4)$$

Cross sectional area of web plates at supports: (excluding the reinforcements by **Par 3**)

$$A = C_3 S l \quad (cm^2)$$

where:

S = spacing of portable beams (m).
l = unsupported span of portable beams (m).
C_1, ,C_2, C_3 = coefficients as given in **Table 4.2.2**.
K_1, K_2 = coefficients as given in **Table 4.2.3**.

2. The depth of portable beams and the width of their face plates are to be suitable to ensure lateral stability of the beams. The depth of beams at their ends is not to be less than two-fifth of the depth at mid-span or 150 mm, whichever is the greater.

3. The upper face plates of portable beams are to extend to the extreme ends of the beams. The web plates, for at least 180 mm at each end, are to be increased in thickness to at least twice that at mid-span or to be reinforced with doubling plates.

Table 4.2.2 Coefficients C_1, C_2 and C_3

Line	Hatch way		$(D-d) > F$			$(D-d) \le F$		
			C_1	C_2	C_3	C_1	C_2	C_3
1	In Position I	For 0.15 L_f forward where L_f is larger than 100 m	32	58	2.5	36	64	2.8
2		Elsewhere	27	50	2.2	31	55	2.4
3	In Position II		20	37	1.65	20	37	1.65
4	Carrying cargoes on hatchway cover		27	50	2.2	27	50	2.2

NOTES:
1. F is the value obtained from the following formulae:
   $0.023\,L_f - 1.15$ (m) ············ where L_f is not larger than 250 m.
   4.6 (m) ·························· where L_f is larger than 250 m.
2. Where L_f is 100 m or less, values in Lines 2 and 3 may be reduced to
   100 %···················· where L_f is 100 m,
   57 %···················· where L_f is not larger than 24 m.
   For intermediate L_f, the percentage is to be obtained by interpolation.
3. Values in Line 4 are to be increased in direct proportion either where the tweendeck height exceeds 2.6 m or the weight of cargoes to be carried on the hatchway covers exceeds 17.5 kN/m^2.
4. For exposed hatchways in positions other than Position I or II, value of each coefficient will be specially considered.

Table 4.2.3 Coefficients K_1 and K_2

K_1	$1+\dfrac{3.2\alpha-\gamma-0.8}{7\gamma+0.4}$	K_1 is not to be taken as less than 1.0
K_2	$1+8\alpha^3\dfrac{1-\beta}{0.2+3\sqrt{\beta}}$	$\alpha=\dfrac{l_1}{l}$ $\beta=\dfrac{I_1}{I_0}$ $\gamma=\dfrac{Z_1}{Z_0}$

where:

l = Overall length of portable beam (m).

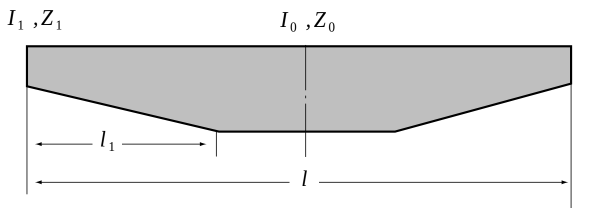
l_1 = Distance from the end of parallel part to the end of portable beam (m).

I_0 = Moment of inertia at mid-span (cm^4).

I_1 = Moment of inertia at ends (cm^4)

Z_0 = Section modulus at mid-span (cm^3)

Z_1 = Section modulus at ends (cm^3)



205. Pontoon covers

Where pontoon covers used in place of portable beams and covers are made of steel, the strength is to comply with the following requirements:

(1) The thickness of top plating is not to be less than 1% of the spacing or stiffeners or 6 mm, whichever is the greater.

(2) The scantlings of stiffeners are not to be less than those obtained from the following formulae:

Section modulus at mid-span:

$$Z = C_1K_1Sl^2 \quad (cm^3)$$

Moment of inertia at mid-span:

$$I = C_2K_2Sl^3 \quad (cm^4)$$

Cross-sectional area of web plates at the ends of stiffeners:

$$A = C_3Sl \quad (cm^2)$$

where:

S = spacing of stiffeners (m).

l = unsupported span (m).

C_1, C_2, C_3 = coefficients as given by **Table 4.2.2**.

K_1, K_2 = coefficients as given by **Table 4.2.3**.

(3) The depth of pontoon covers at supports is not to be less than one-third the depth at mid-span or 150 mm, whichever is the greater.

(4) The width of bearing surface for pontoon covers is not to be less than 75 mm.

206. Special material hatch covers

The strength and stiffness of covers made of materials other than mild steel are to be equivalent to those of mild steel to the satisfaction of this Society.

207. Carriers or sockets

Carriers or sockets for portable beams are to be of substantial construction and means are to be provided for the efficient fitting and securing of the beams. Where rolling types of beams are used, the arrangements shall ensure that the beams remain properly in position when the hatchway is closed.

208. Cleats

Cleats are to be at least 65 mm wide and spaced not more than 600 mm from centre to centre. The cleats along each side are to be arranged not more than 150 mm apart from the hatch corners.

209. Wedges

Wedges are to be of tough wood and to have a taper of not more than one-sixth and not to be less than 13 mm in thickness at the point.

210. Battens

Battens are to be efficient for securing the tarpaulins and not to be less than 65 mm in width and 9 mm in thickness.

211. Tarpaulins

At least two layers of tarpaulines of Grade A complying with the requirements in **Ch 8, Sec 7** are to be provided for each exposed hatchway on the freeboard or superstructure decks and at least one layer of such tarpaulin is to be provided for each exposed hatchway elsewhere.

212. Security of hatch covers

For all hatchways in the exposed freeboard and superstructure decks, steel bars or other equivalent means are to be provided in order to efficiently secure each section of hatchway covers after the tarpaulines are battened down. Hatchway covers of more than 1.5 m in length are to be secured by at least two such securing appliances. At all other hatchways in exposed positions on weather decks, ring bolts or other fittings for lashing are to be provided.

SECTION 3
Hatchways Closed by Weathertight Covers Fitted with Gaskets and Clamping Devices

301. Steel weathertight covers

Steel weathertight covers fitted with gaskets and clamping devices are to comply with the following requirements:

(1) The thickness top of plating is not to be less

than 1 % of the spacing of stiffeners or 6 mm, whichever is the greater.

(2) The scantlings of stiffeners are not to be less than those obtained from the following formulae:

Section modulus at mid-span:

$$Z = 0.85\,C_1K_1Sl^2 \quad (cm^3)$$

Moment of inertia at mid-span:

$$I = 0.78\,C_2K_2Sl^3 \quad (cm^4)$$

Cross-sectional area of web plates at ends of stiffeners:

$$A = C_3Sl \ (cm^2)$$

where:

S = spacing of stiffeners (m).
l = dnsupported span (m).
C_1, C_2, C_3 = coefficients as given by **Table 4.2.2**.
K_1, K_2 = coefficients as given by **Table 4.2.3**.

(3) The depth of steel hatchway covers at supports is not to be less than one-third of the depth at mid-span or 150 mm, whichever is the greater.

(4) The scantlings and constructions of hatchway cover, where the preceding paragraphs are not applicable to small or special types and hatchway coamings is omitted by **102. 2** will be specially considered.

302. Steel hatchway covers for container ships

In case of container ship with unusually large freeboard, gaskets may be omitted and clamping devices for steel hatchway covers may be suitably dispensed with at the discretion of this Society.

303. Steel hatchway covers of deep tanks

Steel hatchway covers of deep tanks are to comply with the following requirements;

(1) The scantlings of covers are to comply with the requirements specified in **301.** and not to be less than required for deep tank top structures.

(2) The means for securing and maintaining oiltightness and watertightness are to be to the satisfaction of this Society .

304. Hatchway covers for sand carrier and dredger

In the case of sand carriers and dredgers, hatchway covers may be omitted at the discretion of this Society.

305. Weathertightness tests

The arrangements for securing weathertightness are to be ensured that the tightness can be maintained in any sea conditions. For this purpose, tests for the tightness of covers are to be required to a water pressure of not less than 0.2 MPa at the initial survey and may also be required at periodical surveys and at annual surveys at the discretion of the Surveyor.

SECTION 4
Miscellaneous Openings

401. Companionways

1. All openings in freeboard decks other than hatchways are to be protected by an enclosed superstructure, or by a deckhouse or companionway of equivalent strength .

2. In Position I the height above the deck of sills at the doorways in companionways is to be at least 600 mm. In Position Ⅱ it is to be at least 380 mm.

402. Protection of machinery space openings

Machinery space openings are to be efficiently enclosed by steel casings of ample strength. Machinery openings provided on freeboard deck are to be placed in superstructures or deckhouses as far as possible. Where the casings are not protected by other structures, the sills of access openings are not to be less than 600 mm in height above the deck in Position I and not to be less than 380 mm in Position Ⅱ. The access openings are to be provided with permanent closures.

403. Closures for access openings or openings

1. Annular spaces around funnels and all other openings in the machinery casings are to be provided with closing means capable of being operated from outside the machinery space in case of fire.

2. Access openings in the machinery spaces are to be provided with steel doors and to be located in enclosed positions as far as possible. Access openings above freeboard deck not within an enclosed superstruture are to be provided with doors capable of being closed and secured from both sides. Doors to exposed access openings on freeboard and sunken poop decks are to be of the outward opening type.

3. Exposed openings on tops of machinery casings are to be provided with covers capable of being readily closed and secured. ⚓

CHAPTER 3
BOW DOORS, SIDE AND STERN DOORS

SECTION 1
Bow doors and inner doors

101. General

1. Application

(1) These requirements apply to the arrangement, strength and securing of bow doors and inner doors leading to a complete or long forward enclosed superstructure.

(2) The bow door and inner door of all existing ro-ro passenger ships constructed before 30 June 1996 are to be deemed appropriate by this Society.

2. Kinds of bow doors

The kinds of bow doors which are applied by this Chapter are generally two types as follows. However, other types of bow doors will be specially considered in association with the applicable requirements of these rules by this Society, except for following (1) and (2).

(1) Visor door
Visor doors opened by rotating upwards and outwards about a horizontal axis through two or more hinges located near the top of the door and connected to the primary structure of the door by longitudinally arranged lifting arms.

(2) Side-opening door
Side-opening doors opened either by rotating outwards about a vertical axis through two or more hinges located near the outboard edges or by horizontal translation by means of linking arms arranged with pivoted attachments to the door and the ship. It is anticipated the side-opening bow doors are arranged in pairs.

3. Arrangement

Arrangements for the bow door and inner door are to comply with the following (1) to (5)

(1) Bow doors are to be situated above the freeboard deck except that where a watertight recess fitted for arrangement of ramps or other related mechanical devices is located forward of the collision bulkhead and above the deepest waterline, the bow doors may be situated above the recess.

(2) An inner door which is to be part of the collision bulkhead is to be fitted. The inner door does not need to be fitted directly above the bulkhead. Where the vehicle ramp is arranged as a part of collision bulkhead, and its position complies with requirements of **Pt 3, Ch 14, 201.,** the vehicle ramp may be regarded as an inner door. If this is not possible, a separate inner weather door is to be installed.

(3) Bow doors and inner doors are to be arranged so as to preclude the possibility of the bow door causing structural damage to the inner door or to the collision bulkhead in the case of damage to or detachment of the bow door. If this is not possible, a separate inner weathertight door is to be installed, as indicated in **Pt 3, Ch 14, 201.**

(4) Bow doors are to be so fitted as to ensure tightness consistent with operational conditions and to give effective protection to inner doors. Inner doors forming part of the collision bulkhead are to be weathertight over the full height of the cargo space and arranged with fixed sealing supports on the aft side of the doors.

(5) The requirements for inner doors are based on the assumption that vehicle are effectively lashed and secured against movement in stowed position.

4. Definitions

The definitions which are used in this Chapter are as follows.

(1) Securing device
A device used to keep the door closed by preventing it from rotating about its hinges or its pivoted attachments to the ship.

(2) Supporting device
A device used to transmit external or internal loads from the door to a securing device and from the securing device to the ship's structure, or a device other than a securing device, such as a hinge, stopper or other fixed devices, that transmits loads from the door to the ship's structure.

(3) Locking device
A device that locks a securing device in the closed position.

102. Strength criteria

1. Primary structure and securing and supporting devices

Scantlings of the primary members, securing and supporting devices of bow doors and inner doors are to be determined to withstand the design loads defined in **103**., using the following permissible stresses of **Table 4.3.1.**

Table 4.3.1 Permissible stress for primary members, securing and supporting devices

Stress	Permissible stress
Shear stress (τ)	$\tau = 80/K$
Bending stress(σ)	$\sigma = 120/K$
Equivalent stress $\left(\sigma_e = \sqrt{\sigma^2 + 3\tau^2}\right)$	$\sigma_e = 150/K$
K = material factor as specified in **Table 4.3.2**	

2. The buckling strength of primary members is to be verified as being adequate.

3. Stress of steel bearings in securing and supporting devices

For steel to steel bearings in securing and supporting devices, the nominal bearing pressure calculated by dividing the design force by the projected bearing area is not to exceed $0.8\sigma_y$.

σ_y = the yield stress of the bearing material

4. Tensile stress on threaded bolts

The arrangement of securing and supporting devices is to be such that threaded bolts do not carry support forces. The maximum tension in way of bolts not carrying support forces is not to exceed $125/K (N/mm^2)$.

K = material factor as specified in **Table 4.3.2.**

Table 4.3.2 Material Factor K

Material	K
RA, RB, RD or RE	1.0
$RA32$, $RD32$ or $RE32$	0.78
$RA36$, $RD36$ or $RE36$	0.72

103. Design loads

1. Bow doors

(1) External pressure
Design external pressure P_e, to be considered for the scantlings of primary members, securing and supporting devices of bow doors is to be taken as indicated by the following formula.

$$P_e = 2.75\,\lambda C_H\,(0.22 + 0.15\tan\alpha)\,(0.4\,V\sin\beta + 0.6\sqrt{L})^2 \quad (kN/m^2)$$

where :
V = contractual ship's speed, in knots
L = ship's length, in m, as specified in **Pt 3, Ch 1, 102.,** but need not be taken greater than 200 m.
λ = coefficient depending on the area where the ship is intended to be operated :
for sea going ships λ = 1.0
for ships operated in coastal waters λ = 0.8
for ships operated in sheltered waters λ = 0.5
C_H = coefficient that obtained from ship length as specified in **Table 4.3.3.**

Table 4.3.3 Coefficient C_H

L	C_H
L < 80 m	L/80
L ≥ 80 m	1.0

α = flare angle at the point to be considered, defined as the angle between a vertical line and the tangent to the side shell plating measured in a vertical plane normal to the horizontal tangent to the shell plating (See **Fig. 4.3.1**).

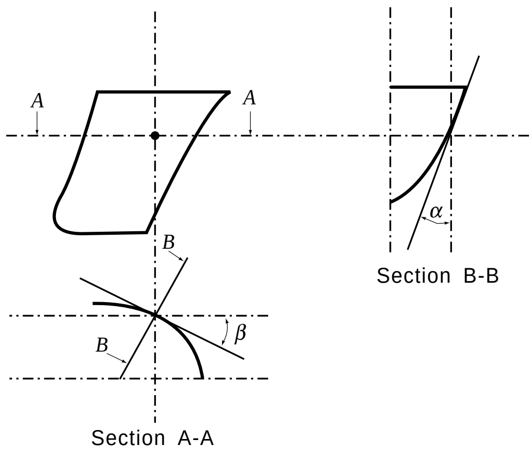


Fig. 4.3.1 Entry and flare angle

β = entry angle at the point to be considered, defined as the angle between a longitudinal line parallel to the centerline and the tangent to the shell plating in a horizontal plane (See **Fig. 4.3.1**).

(2) External forces
The design external forces considered in determining scantlings of securing and supporting devices of bow doors are not to be taken less

than those given by the following formulae.

$$F_x = P_{em} A_x$$
$$F_y = P_{em} A_y$$
$$F_z = P_{em} A_z$$

F_x = the design external force(kN) in the longitudinal direction.
F_y = the design external force(kN) in the horizontal direction.
F_z = the design external force(kN) in the vertical direction.
A_x = area(m^2) of the transverse projection of the door between the levels of the bottom of the door and the upper deck, or between the bottom of the door and the top of the door, whichever is lesser (See **Fig. 4.3.2**).

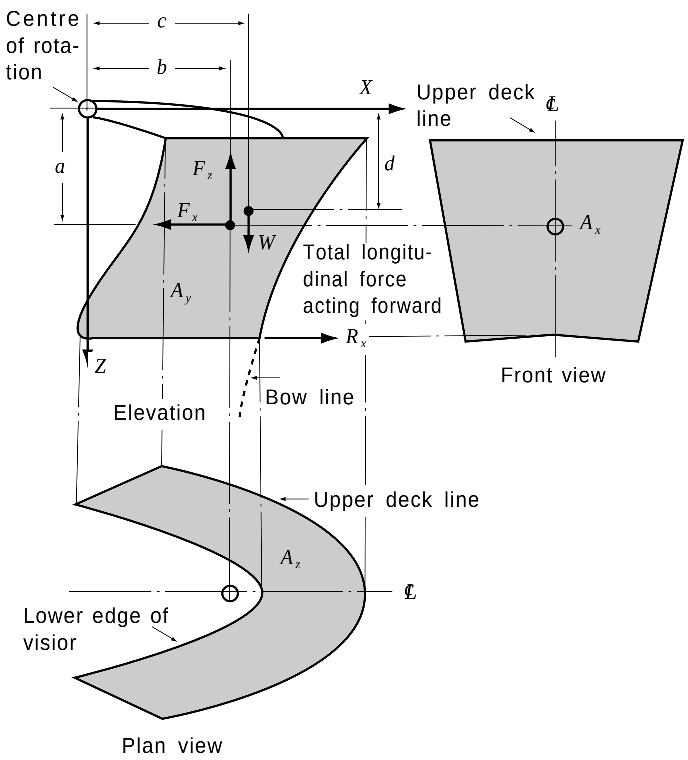


Fig. 4.3.2 Visor type Bow Door

A_y = area(m^2) of the longitudinal projection of the door between the levels of the bottom of the door and upper deck, or between the bottom of the door and the top of the door, whichever is lesser (see **Fig. 4.3.2**).
A_z = area(m^2) of the horizontal projection of the door between the levels of the bottom of the door and the upper deck, or between the bottom of the door and the top of the door, whichever is lesser (See **Fig. 4.3.2**).
h = height(m) of the door between the levels of the bottom of the door and the upper deck, or between the bottom of the door and the top of the door, whichever is lesser.
l = fore and aft length(m) of the door at a height $h/2$ above the bottom of the door.
P_{em} = external pressure, in kN/m^2, as given in **103.1** (1) with angles α_m and β_m defined as follows :
α_m = flare angle measured at a point on the bow door $l/2$ aft of the stem line on a plane $h/2$ above the bottom of the door (See **Fig. 4.3.3**).
β_m = entry angle measured at a point on the bow door $l/2$ aft of the stem line on a plane $h/2$ above the bottom of the door (See **Fig. 4.3.3**).

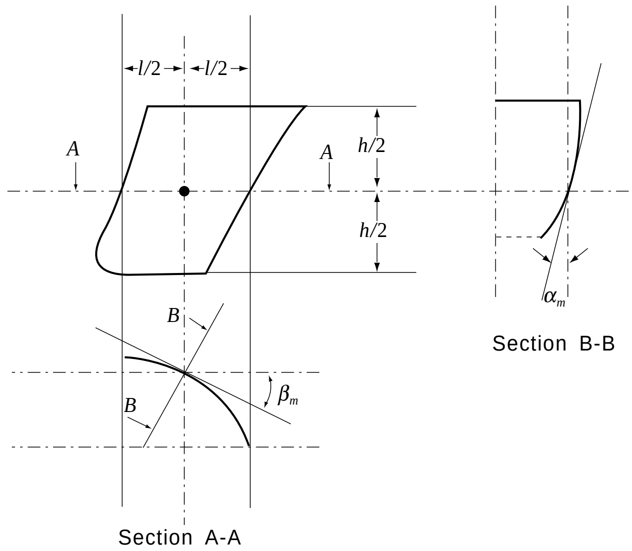


Fig. 4.3.3 α_m and β_m

For doors, including bulwark, of unusual form or proportions, e.g. ships with a rounded nose and large stem angles, the area and angles used for determination of the design values of external forces may require to be specially considered.

(3) For visor doors the closing moment M_y under external loads, in $kN \cdot m$, is to be taken as the following formula.

$$M_y = F_x a + 10 W_C - F_z b \quad (kN \cdot m)$$

F_x and F_z = as specified in above (2).
W = mass of the visor door (ton)
a = vertical distance from visor pivot to the centroid of the transverse vertical projected area of the visor door (m)
b = horizontal distance from visor pivot to the centroid of the horizontal projected area of the visor door.(m)
c = horizontal distance from the visor pivot to the center of gravity of the visor mass (m)

(4) Moreover, the lifting arms of a visor door and its supports are to be dimensioned for the static and dynamic forces applied during the lifting and lowering operations, and a minimum wind pressure of 1.5kN/m^2 is to be taken into account.

2. Inner door

(1) External pressure
The design external pressure, in kN/m^2, considered for the scantlings of primary members, securing and supporting devices and surrounding structure of inner doors is to be taken as the greater of P_{e1} or P_{e2} as given by the following formulae.

$$P_{e1} = 0.45\,L \qquad (kN/m^2)$$
$$P_{e2} = 10\,h \qquad (kN/m^2)$$

h = the distance from the load point to the top of the cargo space (m).
L = ship's ength, as defined in **Pt 3, Ch 1, 102.** (m). But need not be taken greater than 200 m.

(2) Internal pressure
The design internal pressure, P_i, considered for the scantlings of securing devices of inner doors is not to be less than 25 kN/m^2.

104. Scantlings of bow doors

1. General

(1) The strength of bow doors is to be commensurate with that of the surrounding structure.
(2) Bow doors are to be adequately stiffened and means are to be provided to prevent lateral or vertical movement of the doors when closed. For visor doors adequate strength for the opening and closing operations is to be provided in the connections of the lifting arms to the door structure and to the ship structure.

2. Primary structure

Scantlings of the primary members are generally to be supported by direct calculations in association with the external pressure given in **103. 1** (1) and permissible stresses given in **Table 4.3.1.** Normally, formulae for simple beam theory may be applied.

3. Secondary stiffeners

Secondary stiffeners are to be supported by primary members constituting the main stiffening of the door. The section modulus of secondary stiffeners is not to be less than that required for end framing. Consideration is to be given, where necessary, to differences in fixity between ship's frames and bow doors stiffeners. In addition, stiffener webs are to have a net sectional area, A, not less than that obtained from the following formula.

$$A = \frac{QK}{10} \qquad (cm^2)$$

Q = shear force (kN) in the stiffener calculated by using uniformly distributed external pressure Pe
P_e = as specified in **103. 1** (1)
K = material factor as specified in **Table 4.3.2**

4. Plating

The thickness of bow door plating is to be not less than that required for the side shell plating, using bow door stiffener spacing, but in no case less than the minimum required thickness of fore end shell plating.

105. Scantlings of inner doors

1. General

(1) Scantlings of the primary members are generally to be supported by direct calculations in association with the external pressure given in **103. 2** (1) and permissible stresses given in **Table 4.3.1.** Normally, formulate for simple beam theory may be applied.
(2) Where inner doors also serve as a vehicle ramps, the scantlings are not to be less than those required for vehicle decks.

106. Securing and supporting of bow doors

1. General

(1) Bow doors are to be fitted with adeqate means of securing and supporting so as to be commensurate with the strength and stiffness of the surrounding structure.
(2) The hull supporting structure in way of the bow doors is to be suitable for the same design loads and design stresses as the securing and supporting devices.
(3) Where packing is required, the packing material is to be of a comparatively soft type, and the supporting forces are to be carried by the steel structure only. Other types of packing may be considered.
(4) Maximum design clearance between securing and supporting devices is not generally to exceed 3mm.
(5) A means is to be provided for mechanically fixing the door in the open position.
(6) Only the active supporting and securing devices having an effective stiffness in the relevant direction are to be included and considered to calculate the reaction forces acting on the devices.
(7) Small and/or flexible devices such as cleats intended to provide load compression of the packing material are not generally to be included in the calculations.
(8) The number of securing and supporting devices are generally to be the minimum practical whilst

taking into account the requirements for redundant provision given in **Par 2** (6), (7) and the available space for adequate support in the hull structure.

(9) For opening outwards visor doors, the pivot arrangement is generally to be such that the visor is self closing under external loads, that M_y>0. Moreover, the closing moment M_y as given in **103. 1,** (3) (A) is to be not less than:

$$M_{yo} = 10\,Wc + 0.1\sqrt{a^2+b^2}\cdot\sqrt{F_x^2+F_z^2} \quad (kN\cdot m)$$

W, a, b, c, F_x and F_z = as specified in **103.**

2. Scantlings

(1) Securing and supporting devices are to be adequately designed so that they can withstand the reaction forces within the permissible stresses given in **Table 4.3.1.**

(2) For visor doors the reaction forces applied on the effective securing and supporting devices assuming the door as a rigid body are determined for the following combination of external loads acting simultaneously together with the self weight of the door :

(A) Case 1 F_x and F_z

(B) Case 2 0.7F_y acting on each side separately together with 0.7F_x and 0.7F_z where F_x, F_y and F_z are determined as indicated in **103. 1** (2) and applied at the centroid of projected areas.

(3) For side-opening doors the reaction forces applied on the effective securing and supporting devices assuming the door as a rigid body are determined for the following combination of external loads acting simultaneously together with the self weight of the door:

(A) Case 1 F_x, F_y and F_z

(B) Case 2 0.7F_x and 0.7F_z acting on both doors and 0.7F_y acting on each door separately. where F_x, F_y and F_z are determined as indicated in **103. 1** (2) and applied at the centroid of projected areas.

(4) The support forces as determined according to above (2) (A) and (3) (A) shall generally give rise to a zero moment about the transverse axis through the centroid of the area A_x. For visor doors, longitudinal reaction forces of pin and/or wedge supports at the door base contributing to this moment are not to be of the forward direction.

(5) The distribution of the reaction forces acting on the securing and supporting devices may require to be supported by direct calculations taking into account the flexibility of the hull structure and the actual position and stiffness of the supports.

(6) The arrangement of securing and supporting devices in way of these securing devices is to be designed with redundancy so that in the event of failure of any single securing or supporting device the remaining devices are capable to withstand the reaction forces without exceeding by more than 20 per cent the permissible stresses as given in **Table 4.3.1.**

(7) For visor doors, two securing devices are to be provided at the lower part of the door, each capable of providing the full reaction force required to prevent opening of the door within the permissible stresses given in **Table 4.3.1.** The opening moment M_0, in $kN\cdot m$, to be balanced by this reaction force, is not to be taken less than:

$$M_o = 10Wd + 5A_x a \quad (kN\cdot m)$$

where :

A_x = as specified in **103.1** (2)
a = as specified in **103. 1** (3)
d = vertical distance from the hinge axis to centre of gravity of the door(m)
W = as specified in **103. 1** (3)

(8) For visor doors, the securing and supporting devices excluding the hinges should be capable of resisting the vertical design force (F_z – 10W), in kN, within the permissible stresses given in **Table 4.3.1.**

(9) All load transmitting elements in the design load path, from door through securing and supporting devices into the ship structure, including welded connections, are to be to the same strength standard as required for the securing and supporting devices.

(10) For side-opening doors, thrust bearing has to be provided in way of girder ends at the closing of the two leaves to prevent on leaf to shift towards the other one under effect of unsymmetrical pressure (See **Fig 4.3.4**). Each part of the thrust bearing has to be kept secured on the other part by means of securing devices.

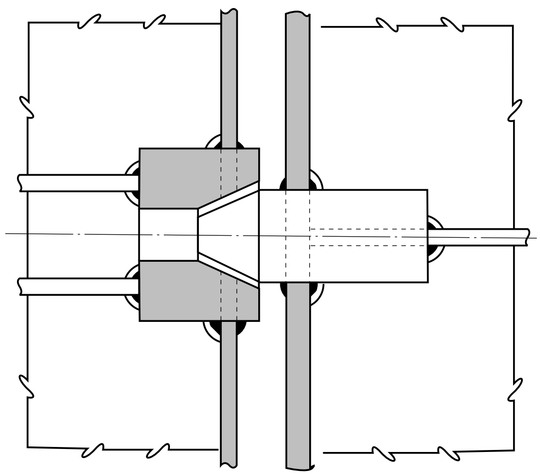


Fig. 4.3.4 Example of thrust bearing

107. Securing and locking arrangement

Securing devices are to be equipped with mechanical locking arrangement (self locking or separate arrangement), or to be of the gravity type. Those devices are to comply with the requirements of the following **Par 1.** and **2.**

1. Operation

Securing devices are to be simple to operate and easily accessible. The opening and closing systems as well as securing and locking devices are to be interlocked in such a way that they can only operate in the proper sequence.

(1) Hydraulic securing devices
Where hydraulic securing devices are applied, the system is to be mechanically lockable in closed position. This means that, in the event of loss of the hydrulic fluid, the securing devies remain locked. The hydraulic system for securing and locking devices is to be isolated from other hydrulic circuits, when in closed position.

(2) Bow doors and inner doors giving access to vehicle decks are to be provided with an arrangement for remote control, from a position above the freeboard deck, of
(A) the closing and opening of the doors, and
(B) associate securing and locking devices for every door.

(3) Remote control
Indication of the open/closed position of every door and every securing and locking device is to be provided at the remote control stations. The operating panels for operation of doors are to be inaccessible to unauthorized persons. A notice plate, giving instructions to the effect that all securing devices are to be closed and locked before leaving harbour, is to be placed at each operating panel and is to be supplemented by warning indicator lights.

2. Indication and monitoring

(1) Indicator
The indicator system is to be designed on the fail safe principle and in accordance with the following (A) to (D).
(A) Location and type
Separate indicator lights and audible alarms are to be provided on the navigation bridge and on the operating panel to show that the door and inner door are closed and that their securing and locking devices are properly positioned. The indication panel on the navigation bridge is to be equipped with mode a section function “harbour/sea voyage”, so arraged that audible alarm is given if vessel leaves harbor with a door or inner door not closed and with any of the securing devices not in the correct position. Indication of the open/closed position of every door and every securing and locking device is to be provided on the operating panels.
(B) Indicator lights
Indicator lights are to be designed so that they cannot be manually turned off. The indication panel is to be provided with a lamp test-function.
(C) Power supply
The power supply for the indicator system is to be independent of the power supply for operating and closing the doors.
(D) Protection of sensors
Sensors are to be protected from water, ice formation and mechanical damage.

(2) Water leakage protection
A drainage system is to be arranged in the area between bow door and ramp, as well as in the area between the ramp and inner door where fitted. The system is to be equipped with an audible alarm function to the navigation bridge for water level in these areas exceeding 0.5m above the car deck level. A water leakage detection system with audible alarm and television surveillance are to be arranged to provide an indication to the navigation bridge and to the engine control room of leakage through the inner door.

(3) Door surveillance
Between the bow door and the inner door a television surveillance system is to be fitted with a monitor on the navigation bridge and in the engine control room. The system must monitor the position of doors and a sufficient number of their securing devies.

108. Operating and maintenance manual

1. An operating and maintenance manual for the bow door and inner door must be submitted for the approval of this Society before providing it on board and contain the following (1) through (4).

(1) Main particulars and design drawings.
(2) Service conditions (service area restrictions, acceptable clearances for supports).
(3) Maintenance and function testing.
(4) Register of inspections and repairs.

2. Documented operating procedures for closing and securing the bow door and inner door are to be kept on board and posted in appropriate place.

Section 2
Side and stern doors

201. General

1. Application

(1) These rules give requirements for the arrangement, strength and securing of side shell doors, abaft the collision bulkhead, and stern doors leading into enclosed spaces.

(2) The side shell door and stern door of all existing ro-ro passenger ships constructed before 1 July 1997 are to be as deemed appropriate by this Society.

2. Arrangement

(1) Stern doors for passenger vessels are to be situated above the freeboard deck. Stern doors for ro-ro cargo ships and side shell doors may be either below or above the freeboard deck.
(2) The side and stern doors are to be so fitted as to ensure tightness and structural integrity commensurate with their location and the surrounding structure.
(3) In general, the lower edge of door openings is not to be below a line drawn parallel to the freeboard deck at side, which has at its lowest point the upper edge of the uppermost load line.
(4) Where side door and stern door are unavoidably provided below the line as stipulated in above (2), the following conditions are to be satisfied.
  (A) Compartment being equivalent to watertight-bulkhead in strength and watertightness is to be provided and the second door is to be fitted for the compartment.
  (B) Detecting device for sea water leakage is to be provided in the compartment and drainage means of the compartment with a screw-down stop valve capable of being controlled from easily accessible position is to be provided.
(5) Doors are generally to be arranged to open outwards.

3. Definitions

The definitions specified in this Section are to be in accordance with **101.4.**

202. Strength Criteria

1. Primary structure and securing and supporting devices

Scantlings of the primary members, securing and supporting devices of doors are to be determined to withstand the design loads defined in **203.,** using the following permissible stresses of **Table 4.3.1.**

2. The bucking strength of primary members is to be verified as being adequate.

3. Steel of steel bearings in securing and supporting devices

For steel to steel bearings in securing and supporting devices, the nominal bearing pressure calculated by dividing the design force by the projected bearing area is not to exceed $0.8\sigma_y$.

σ_y = the yield stress of the bearing material.

4. Tensile stress on threaded bolts

The arrangements of securing and supporting devices is to be such that threaded bolts do not carry support forces. The maximum tension in way of threads bolts not carrying support forces is not to exceed $125/K(N/mm^2)$.

K = material factor as specified in **Table 4.3.2.**

203. Design Loads

The design forces considered for the scantlings of primary members, securing and supporting devices are not to be less than the following **Par 1** to **3.**

1. Design forces for securing or supporting devices of doors opening inwards :

External force : $F_e = AP_e + F_p \quad (kN)$

Internal force : $F_i = F_0 + 10W \quad (kN)$

2. Design forces for securing or supporting devices of doors opening outwards :

External force : $F_e = AP_e \quad (kN)$

Internal force : $F_i = F_0 + 10W + F_p \quad (kN)$

3. Design forces for primary members is to be taken as the greater of the following two formulae :

External force : $F_e = AP_e \quad (kN)$

Internal force : $F_i = F_0 + 10W \quad (kN)$

where :

A = area, in m^2, of the door opening
W = mass of the door(ton)
F_p = total paking force in kN, packing line pressure is normally not to be taken less than $5N/mm$.
F_0 = the greater of F_c and $5A$ (kN)
F_c = accidental force, in kN, due to loose of cargo etc., to be uniformly distributed over the area A and not to be taken less than $300kN$. For small doors such as bunker doors and pilot doors, the value of F_c may be appropriately reduced. However, the value of F_c may be taken as zero, provided an additional structure such as an inner ramp is fitted, which is capable of protecting the door from accidental forces due to loose cargoes.
Pe = external design pressure, in kN/m^2, determined at the centre of gravity of the door opening and not taken less than the value obtained from the following formulae.

for $Z_G < T \quad 10(T - Z_G) + 25$
for $Z_G \geq T \quad 25$

However, for stern doors of ships fitted with bow doors, P_e is not to be taken less than:

$$P_e = 0.6\lambda C_H(0.8 + 0.6\sqrt{L})^2$$

where :

C_H = coefficient that obtained from ship's length as specified in **Table 4.3.3.**

L = ship's length, in m, as specified in **Pt 3, Ch 1, 102.** but need not be taken greater than 200 m.

Z_G = height of the center of area of the door, in m, above the baseline

λ = coefficient depending on the area where the ship is intended to be operated :

for sea going ships $\lambda = 1$
for ships operated in coastal waters $\lambda = 0.8$
for ships operated in sheltered waters $\lambda = 0.5$

T = draught, in m, at the highest subdivision load line

204. Scantlings

1. General

(1) In general the strength of side and stern doors is to be equivalent to the strength of the surrounding structure.

(2) Side and stern door openings in the side shell are to have well rounded corners and adequate compensation is to be arranged with web frames at sides and stringers or equivalent above and below.

(3) Side and stern doors are to be adequately stiffened, and means are to be provided to prevent movement of the doors when closed. Adequate strength is to be provided in the connections of the lifting/maneuvering arms and hinges to the door structure and to the ship structure.

(4) Where side and stern doors also serve as vehicle ramps, the design of the hinges should take into account the ship angle of trim which may result in uneven loading on the hinges.

2. Plating

(1) The thickness of the side and stern door plating is not to be less than the side shell plating calculated with the door stiffener spacing, and in no case to be less than the minimum shell plate thickness.

(2) Where side and stern doors also serve as vehicle ramps, the plating is not to be less than required for vehicle decks.

3. Stiffeners

(1) The section modulus of horizontal or vertical stiffeners is not to be less than required for side framing. Consideration is to be given, where necessary, to differences in fixity between ship's frame and door stiffeners.

(2) Where side and stern doors also serve as vehicle ramps, the stiffener scantlings are not to be less than required for vehicle decks.

(3) Where necessary, side and stern door stiffeners are to be supported by girders or stringers.

4. Primary members

(1) Scantlings of primary members are generally to be supported by direct calculations in association with the design forces given in **203. 3** and permissible stresses given in **Table 4.3.1.**

(2) The webs of girders and stringers are to be adequately stiffened, preferably in a direction perpendicular to the shell plating.

(3) The girder system is to be given sufficient stiffness to ensure integrity of the boundary support of the door.

(4) Edge stiffeners/girders should be adequately stiffened against rotation and are to have a moment of inertia, I, not less than that obtained from following formula.

$$I = 8 P_I d^4 \quad (cm^4)$$

d = distance(m) between closing devices.

P_I = packing line pressure along edges, not to be taken less than 5 N/mm

(5) For edge girders supporting main door girders between securing devices, the moment of inertia is to be increased in relation to the additional force.

205. Securing and supporting

1. General

(1) Side shell doors and stern doors are to be fitted with adequate means of securing and supporting so as to be commensurate with the strength and stiffness of the surrounding structure.

(2) A means is to be provided for mechanically fixing the door in the open position.

(3) The hull supporting structure in way of the doors is to be suitable for the same design loads and design stresses as the securing and supporting devices.

(4) Where packing is required, the packing material is to be of a comparatively soft type, and the supporting forces are to be carried by the steel structure only. Other types of packing may be considered.

(5) Maximum design clearance between securing and supporting devices is not generally to exceed 3mm.

(6) Only the active supporting and securing devices having an effective stiffness in the relevant direction are to be included and considered to calculate the reaction forces acting on the devices.

(7) Small and/or flexible devices such as cleats intended to provide local compression of the packing material are not generally to be included in the calculations.

(8) The number of securing and supporting devices are generally to be the minimum practical whilst taking into account the requirement for redun-

dant provision given in **Par 2,** (3) and the available space for adequate support in the hull structure.

2. Scantlings

(1) Securing and supporting devices are to be adequately designed so that they can withstand the reaction forces within the permissible stresses given in **Table 4.3.1.**

(2) The distribution of the reaction forces action on the securing devices and supporting devices may require to be supported by direct calculations taking into account the flexibility of the jull structure and the actual position of the supports.

(3) The arrangement of securing devices and supporting devices in way of these securing devices is to be designed with redundancy so that in the event of failure of any single securing or supporting device the remaining devices are capable to withstand the reaction forces without exceeding by more than 20 per cent the permissible stresses as given in Table 4.3.1.

(4) All load transmitting elements in the design load path, from the door through securing and supporting devices into the ship's structure, including welded connections, are to be to the same strength standard as required for the securing and supporting devices.

206. Securing and locking arrangement

Securing devices are to be equipped with mechanical locking arrangement (self locking or separate arrangement), or to be of the gravity type. Those devices are to comply with the requirements of the following **Par 1** and **2.**

1. Operation

Securing devices are to be simple to operate and easily accessible. The opening and closing systems as well as securing and locking devices are to be interlocked in such a way that they can only operate in the proper sequence.

(1) Doors which are located partly or totally below the free board deck with a clear opening area greater than $6m^2$ are to be provided with an arrangement for remote control, from a position above the freeboard deck, of
(A) the closing and opening of the doors,
(B) associated securing and locking devices.

(2) Romote control
For doors which are required to be equipped with a remote control arrangement, indication of the open/closed position of the door and the securing and locking device is to be provided at the remote control stations. The operating panels for operation of doors are to be inaccessible to unauthorized persons. A notice plate, giving instructions to the effect that all securing devices are to be closed and locked before leaving habour, is to be placed at each operating panel and is to be supplemented by warning indicator lights.

(3) Hydraulic securing devices
Where hydrulic securing devices are applied, the system is to be mechanically lockable in closed position. This means that, in the event of loss of the hydrulic fluid, the securing devices remain locked. The hydraulic system for securing and locking devices is to be isolated from other hydrulic circuits, when closed position.

2. Systems for indication/monitoring

The following requirements apply to doors in the boundary of special category spaces or ro-ro spaces. For cargo ships, where no part of the door is below the uppermost waterline and the area of the door opening is not greater than $6m^2$, then the requirements of this section need not be applied.

(1) Indicators
The indicator system is to be designed on the fail safe principle and in accordance with the following (A) to (D).
(A) Location and type
Separate indicator lights and audible alarms are to be provided on the navigation bridge and on each operating panel to indicate that the doors are closed and that their securing and locking devices are properly positioned. The indication panel on the navigation bridge is to be equipped with mode a section function "harbour/sea voyage", so arraged that audible alarm is given if vessel leaves harbor with side shell or stern doors not closed or with any of the securing devices not in the correct position.
(B) Indicator lights
Indicator lights are to be designed so that they cannot be manually turned off. The indication panel is to be provided with a lamp test-function
(C) Power supply
Tehe power supply for the indicator system is to be independent of the power supply for operating and closing the doors and is to be provided with a backup power supply.
(D) Protection of sensors
The sensors of the indicator system are to be protected from water, ice formation and mechanical damage.

(2) Water leakage protection
A water leakage detection system with audible alarm and television surveillance are to be arranged to provide an indication to the navigation bridge and to the engine control room of leakage through the side shell and stern door.

207. Operating and Maintenance Manual

1. An Operating and Maintenance Manual for the side shell and stern doors is to be submitted for the approval of the Society before providing it on board and contain the following (1) through (4).

(1) main particulars and design drawings,
(2) service conditions(e.g. service restrictions, emergency operations, acceptable clearances for supports)
(3) maintenance and function testing,
(4) register of inspections and repairs.

2. Documented operating procedures for closing and securing side shell and stern doors are to be kept on board and posted at the appropriate places. ⚓

CHAPTER 4
BULWARKS, FREEING PORTS, SIDE SCUTTLES, VENTILATORS AND PERMANENT GANGWAYS

Section

SECTION 1
Bulwarks

101. Arrangements

Bulwarks or guardrails are to be provided on all exposed parts of the freeboard and superstructure decks and on top of all other exposed deck houses. The height of bulwarks and guardrails is to be at least 1 *metre* from the top of deck. Where this height is considered to interfere with the normal operation of the ship and where deemed necessary by the Society, a lesser height may be permitted subject to this Society's approval.

102. Strength of bulwarks

1. The bulwarks are to be strongly constructed and effectively stiffened on their upper edge.
2. The thickness of bulwarks on the freeboard decks is not to be less than 6 *mm*.
3. Bulwarks are to be supported by strong stays attached to deck in way of the beams and spaced not more than 1.8 *metres* apart on freeboard deck.
4. Stays are to be made of bulb plates or flanged plates and effectively attached to deck and bulwark.

103. Bulwarks of timber carriers

Decks which are designed to carry timber deck cargoes are to be provided with bulwarks more than 1 *metre* in height or with specially strong guardrails. The upper edges of the bulwarks are to be well stiffened and supported by specially strong stays spaced not more than 1.5 *metres* and attached to deck in way of the beams. Necessary freeing ports are to be provided in the bulwarks.

104. Reinforcement of bulwarks

1. Gangways and other openings in bulwarks are to be well clear of the breaks of superstructures.
2. Where bulwarks are cut to form gangways or other openings, stays of increased strength are to be provided at the ends of the openings.
3. The plating of bulwarks in way of mooring pipes or eye plates for cargo handling is to be doubled or increased in thickness.
4. At the ends of superstructures, the bulwark rails are to be bracketed either to the superstructure end bulkheads or to the stringer plates of the superstructure decks, or other equivalent arrangements are to be made so that the abrupt change of strength is avoided.

105. Expansion joint

Long bulwarks are to be so arranged that they are not affected as far as possible by the stress of the main hull structures and expansion joints are to be provided all suitable locations.

106. Guardrails

1. The opening below the lowest course of the quardrails shall not exceed 230 *mm*. The other courses shall be not more than 380 *mm* apart.
2. In ships with rounded sheer strakes, the stays of guardrails are to be placed on the flat part of deck.

SECTION 2
Freeing Ports

201. General

1. Where bulwarks on the weather portions of freeboard or superstructure decks form wells, ample provision is to be made for rapidly freeing the decks of water and for draining them.
2. Ample freeing ports are to be provided for clearing any space other than wells, where water is liable to be shipped and to remain.

3. In ships having a reduced freeboard, guardrails are to be provided for at least a half of the length of the exposed parts of weather deck or other effective freeing arrangements are to be considered, as required by this Society.

202. Freeing port area

1. The freeing port area on each side of the ship for each well on the freeboard and raised quarter decks is not to be less than that obtained from **Table 4.4.1**.

Table 4.4.1 Total Area of Freeing Port

Length of bulwarks	Total area of freeing ports (m^2)	
	Freeboard and raised quarter decks	Superstructure decks
$l \le 20m$	$A = 0.035\,l + 0.7 + a$	$A = \frac{0.035\,l + 0.7 + a}{2}$
$l > 20m$	$A = 0.07\,l + a$	$A = \frac{0.07\,l + a}{2}$

l = length of bulwark (m), but need not be taken as greater than $0.7\,L_f$.
a = as obtained from the following table.

Height of bulwarks (m)	Correction value (m^2)
$h < 0.9$	$a = -0.04\,l\,(0.9 - h)$
$0.9 \le h \le 1.2$	$a = 0$
$1.2 < h$	$a = 0.04\,l\,(h - 1.2)$

h = average height of bulwalks above the deck (m).

2. In ships either without sheer or with less sheer than the standard, the minimum freeing port area obtained from the formulae in **Par 1** is to be increased by multiplying the factor obtained from the following formula :

$$a_0 = 1.5 - \frac{S}{2\,S_0}$$

where:

S = average height of actual sheer (mm).
S_0 = average height of the standard sheer given by the International Convention on Load Lines, 1966 (mm).

3. Where a ship is provided with a trunk or a hatch side coaming which is continuous or substantially continuous between detached superstructures, the area of freeing port opening is not to be less than that given by **Table 4.4.2**.

4. Notwithstanding the requirements in **Pars 1** to **3,** where deemed necessary by the Society in ships having trunks on the freeboard deck, guardrails are to be provided instead of bulwarks on the freeboard deck in way of trunks for more than half of the length of trunk.

Table 4.4.2 Area of Freeing Ports

Breadth of hach way of trunk	Area of freeing ports in relation to the total area of bulwark
$0.4\,B_f$ or less	0.2
$0.75B_f$ or more	0.1

NOTE :
The area of freeing ports at intermediate breath is to be obtained by interpolation.

203. Open superstructures

In ships having superstructures which are open at either or both ends, adequate provision for freeing the space within such superstructures is to be provided subject to this Society's approval.

204. Arrangement of freeing ports

The lower edges of the freeing ports are to be as near the deck as possible and two-thirds of the freeing ports area required by **202.** is to be provided in the half of the well near the lowest point of the sheer curve.

205. Construction of freeing ports

1. Where both the length and the height of freeing ports exceed 230 mm respectively, freeing ports are to be protected by rails spaced approximately 230 mm apart.

2. Where shutters are provided to freeing ports,ample clearance is to be provided to prevent jamming. Hinge pins or bearings of the shutters are to be of non-corrodible material. Where shutters are provided with securing appliances, these appliances are to be of approved construction.

SECTION 3
Side Scuttles

301. General

1. No side scuttle is to be provided in such a position that its sill is below a line drawn parallel to the freeboard deck at side and having its lowest point $0.025\,B_f$ or 500 mm, above the uppermost load line, whichever is the greater.

2. No side scuttle is to be provided to any space solely engaged in carriage of cargoes.

302. Application

1. Side scuttles to spaces below the freeboard deck and those in the side or front walls of sunken poop are not to be less efficient than *B* class side scuttles complying with the requirements in **Ch 8, Sec 8**.

2. Side scuttles to spaces within enclosed superstructures or within deckhouses on the upper deck which have an unprotected deck opening inside leading to a space below the freeboard deck, and those exposed to direct blow of seas are not to less efficient than *C* class side scuttles with hinged dead-light complying with the requirements in **Ch 8, Sec 8**.

3. Side scuttles fitted in spaces which give direct access to an openstairway and provided in deckhouse and companion which protect the openings specified in below, are to be *C* class side scuttles with hinged dead light complying with the requirements in **Ch 8, Sec 8** or equivalent thereto.

(1) The opening in the superstructure deck which gives access to the spaces below the freeboard deck or within an enclosed superstructure.
(2) The opening in the top of deckhouse on the freeboard deck which gives access to spaces below the freeboard deck.

303. Protection of side scuttles

All side scuttles in way of the anchor housing and other similar places where they are liable to be damaged are to be protected by strong gratings.

SECTION 4
Ventilators

401. Construction of coamings

1. Ventilators placed in Position I or II, for spaces below the freeboard deck or decks of enclosed superstructures are to have coamings of steel or other equivalent material and be efficiently connected to the deck. All ventilator coamings exceeding 900 *mm* in height are to be specially strengthened at the support.

2. Ventilators passing through superstructures other than enclosed superstructure are to have substantially constructed coamings of steel or equivalent at the freeboard deck.

402. Height of coamings

The height of ventilator coamings above the upper surface of the deck is to be at least 900 *mm* in Position I, and 760 *mm* in Position II. Where the ship has an unusually large freeboard or where the ventilator serves spaces within unenclosed superstructures, the height of ventilator coamings may be suitably reduced.

403. Thickness of coamings

1. The thickness of ventilator coamings in Position I and II leading to spaces below the freeboard deck or within enclosed superstructures is not to be less than given by Line 1 in **Table 4.4.3**. Where the height of the coamings is reduced by the provisions in **402.** the thickness may be suitably reduced.

2. Where ventilators pass through superstructures other than enclosed superstructures, the thickness of ventilator coamings in the superstructures is not to be less than that given by Line 2 in **Table 4.4.3**.

Table 4.4.3 Thickness of Ventilator Coamings

Outside diameter of ventilator (*mm*)		80 and under	160	230 and over but less than 330
Thickness of coaming plate (*mm*)	Line 1	6	8.5	8.5
	Line 2	4.5	4.5	6

NOTES:
1. For intermediate values of outside diameter of ventilator, the thickness of coaming plate is to be obtained by linear interpolation.
2. Where the outside diameter of ventilator is over 330 *mm*, the thickness of coaming plate is to be in accordance with the discretion of the Society.

404. Connection

Where no steel deck exists, a steel plate is to be fitted in way of the coaming and efficiently stiffened between the beams as may be required

405. Length of cowlhead housing

Ventilator cowls are to be fitted up closely to the outer surface of the coamings and are to have housing not less than 380 *mm* in length, except that a less housing may be permitted for ventilators not greater than 200 *mm* in diameter.

406. Closing appliances

1. Ventilators to machinery and cargo spaces are to be provided with means for closing openings capable of being operated from outside the spaces in case of a fire.

2. All ventilator openings in exposed positions on thefreeboard and superstructure decks are to be provided with efficient weathertight closing appliances Where the height of coaming of any ventilator exceeds 4.5 *metres* in Position I or 2.3 *metres* in Position II, such closing appliances may be omitted unless required in **Par 1**.

3. In ships not more than 100 *metres* in length for freeboard, the closing appliances mentioned in **Par 2** are to be permanently provided; where not so provided in other ships, they are to be conveniently stowed near the ventilators to which they are to be fitted up.

407. Ventilators for deckhouses

The ventilators for the deckhouses which protect the companionways leading to spaces below the freeboard deck are to be equivalent to those for the enclosed superstructures.

SECTION 5
Permanent Gangways

501. General

Satisfactory means (in the form of guardrails, life lines, gangways or under deck passages, etc.) are to be provided for the protection of the crew in getting to and from their quarters, the machinery space and all other parts used in the necessary work of the ship.

502. Ships having reduced freeboard

In ships having a reduced freeboard, a fore and after permanent gangway is to be provided at the level of the Superstructure deck between the poop or after deckhouse and the midship bridge or deckhouse, or equivalent means of access is to be provided to carry out the purpose of gangway, such as a passage below deck. Safe and satisfactory access from the gangway level is to be available between separate crew accommodations and the machinery space.

503. Construction of gangways

The gangway specified in **502.** is to be efficiently constructed and situated as near the centre line of ship as practicable. The gangways are to be in general at least 600 *mm* wide and to be provided on their both sides with guardrails which are at least 1 *metre* high and comply with the requirements in **106. 1**. ⚓

CHAPTER 5
MASTS AND DERRICK POSTS

SECTION 1
Masts without Cargo Gear

101. Outside diameter

The outside diameter of steel masts which are not equipped with cargo derricks and are stayed with shrouds as specified in **104.** is not to be less than those obtained from the following formulae:

Outside diameter at the uppermost deck at which the mast is supported (hereinafter referred to as "**base**"):......................................$3.3H$ (cm)

Outside diameter at the outrigger or at the part to which the upper end of shrouds is connected (hereinafter referred to as "**top**"):....$2.5H$ (cm)

where:

H = height of mast from the base to the top (m).

102. Thickness of plating

The thickness of plating of masts at each part is not to be less than that obtained from the following formula or $5\,mm$, whichever is the greater:

$$t = 0.1D_m + 2.5 \ (mm)$$

where:

D_m = outside diameter of masts at each part (cm).

103. Reinforcement

The base and top of masts are to be properly strengthened.

104. Rigging

The rigging for masts is not to be less effective than would be obtained from two steel wire shrouds on each side of the ship, of the sizes given in **Table 4.5.1**, so placed that each distance from the forward and after chain plates to the base is not less than one-fourth of the height of mast from base to top or $B/4$, whichever is the greater.

Table 4.5.1 Diameter of Steel Wire for Shrouds

Height of masts from base to top (m)	9	12	15	18
Diameter of steel wire (mm)	20	22	24	26
NOTE: The wire rope is to be No.1 or No. 3 wire rope specified in **Ch 8, Sec 5**.				

SECTION 2
Derrick Posts

201. Application

The materials, construction and scantlings of masts, derrick posts and stays used for cargo handling will be considered in accordance with the requirements in **Pt 9, Ch 2.** ⚓

CHAPTER 6
CEILINGS AND SPARRINGS

SECTION 1
Bottom Ceilings

101. Ships with single bottoms

1. In ships with single bottoms, close ceilings are to be provided on the floors up to the upper turn of bilge.

2. The thickness of ceilings is to be as **Table 4.6.1**.

3. The ceilings on the flat on the floors are to be laid in portable sections, or other convenient arrangements are to be made for easy removal where required for cleaning, painting or inspection of the bottom.

Table 4.6.1 Thickness of ceiling

L	Thickness of ceiling (mm)
$L < 61\ m$	50
$61\ m \leq L \leq 76\ m$	57
$L > 76\ m$	63

102. Ships with double bottoms

1. In ships with double bottoms, close ceilings are to be laid from the margin plate to the upper turn of bilge so arranged as to be readily removable for inspection of the limbers.

2. Ceilings are to be laid on the inner bottoms under hatchways, unless the requirements in **Pt 3, Ch 7, 501. 3** or **Pt 7, Ch 3, 204. 2** are applied.

3. Ceilings on the top of double bottom are to be laid on battens not less than 13 mm in thickness, or to be bedded on the covering required in **Ch 7, 104**.

4. The thickness of ceilings is to be as required in **101. 2**.

SECTION 2
Sparrings

201. Arrangements

In all cargo spaces where it is intended to carry general cargo, sparrings not less than 50 mm in thickness and 150 mm in breadth are to be provided not more than 230 mm apart above the bilge ceiling, or equivalent arrangements are to be provided for the protection of framing.

202. Special protections.

Where it is intended normally to carry such cargoes as timbers which are liable to cause damage to the hull, special protection arrangements are to be provided.

203. Exemptions.

1. Sparring may be omitted in cargo holds of ships such as coal carriers, bulk carriers, ore carriers and similar ships.

2. General cargo ships may omit sparring only subject to the approval of the Society at the request of Owner, in which case the ship is distinguished with the notation “*n.s.*” in the Register Book. ⚓

CHAPTER 7
CEMENTING AND PAINTING

SECTION 1
Cementing

101. General

The bottom in ships with single bottoms, the bilges in all ships and the double bottoms in the boiler spaces of all ships are to be efficiently protected by Portland cement or other equivalent materials which cover the plates and frames as far as the upper turn of bilge. However, cement protection may be dispensed with in the bottom of the space solely used for carriage of oil.

102. Portland cement

Portland cement is to be mixed with fresh water and sand or other satisfactory substances, in the proportion of about one part of cement to two of sand.

103. Thickness of cement

The thickness of cement is not to be less than 20 mm at the edges.

104. Special consideration

The top plating of tanks, where ceiled directly, is to be covered with good tar put on hot and well sprinkled with cement powder, or with other equally effective coatings.

SECTION 2
Painting

201. General

1. All steel works are to be coated with a suitable paint. Special requirements may be additionally made by this Society in accordance with the kind of ships, purpose of spaces, etc.

2. Notwithstanding the requirements in **Par 1,** where it is recognized by the Society that the spaces are effectively protected against corrosion of steel works by the means other than painting or due to quality of cargoes, etc., painting may be omitted.

202. Wash cement

Steelworks in tanks intended for water may be coated with wash cement in lieu of paint.

203. Cleaning before painting

The surface of steelworks is to be thoroughly cleaned and loose rust, oil and other injurious adhesives are to be removed before being painted. At least the outer surface of shell plating below the load line is to be sufficiently free from rust and mill scale before painting. ⚓

CHAPTER 8
EQUIPMENT NUMBER AND EQUIPMENT

Section

SECTION 1
General

101. General and application

1. All ships, according to their equipment number of provisions in **Sec 2,** are to be provided with anchors, chain cables, ropes, etc. which are not less than given in **Table 4.8.1**.

2. Anchors, chain cables, ropes, etc. for ships having equipment number not more than 205 or more than 16,000 are to be as determined by this Society.

3. The bower anchors given in **Table 4.8.1** are to be connected to their cables and stored on board ready for use. A spare anchor in addition to the requirements given in **Table 4.8.1** may be required for the ships such as cable layer, observation, research, patrol and fishing vessels in consideration of purpose of ships, condition in service area, etc. Also, a spare anchor may be required for the ships intended for the similar purpose as the above mentioned ships, where considered necessary by this Society.

4. The anchors, chain cables and ropes (hereinafter referred to as "**equipment**") which are required to be tested and inspected to be used for ships classed with this Society are to comply with the requirements of this Chapter.

5. The equipment other than those prescribed in this Chapter may be used where specially approved in connection with the design and use. In such case,the detailed data relating to the process of manufacture of the equipment are to be submitted for approval.

6. All ships are to be provided with suitable appliances for handling of anchors

7. The inboard end of chain cable is to be secured to the hull through a strong eye plate by means of shackle or by other equivalent means.

102. Materials

1. The materials for equipment specified in this Chapter are to comply with the requirements in each Section and **Pt 2, Ch 1.**

2. The test pieces and testing procedures for materials of equipment are to comply with the requirements in each Section and **Pt 2, Ch 1.**

103. Process of manufacture

The process of manufactures for equipment specified in this Chapter is to comply with the requirements in each Section.

104. Tests and inspections

1. All equipment prescribed in this Chapter are to be tested and inspected in the presence of this Society's Surveyor in accordance with the requirements of this Chapter and are to comply with the requirements for the tests and inspections.

2. Where equipment having characteristics differing from those prescribed in this Chapter are to be tested and inspected according to the approved specification othe testing.

3. The tests and inspections for equipment may be dispensed with, where these equipment have appro priate certificates accepted by this Society.

105. Execution of tests and inspections

1. The manufacturers shall afford the Surveyor all necessary facilities and access to all relevant parts of the works to enable him to verify that the approved process is adhered to.

2. All tests and inspections of equipment are to be carried out at the place of manufacturer prior to delivery.

106. Marking for accepted equipments

Equipment which have satisfactory complied with the required in this Chapter are to be stamped in accordance with the provisions in each Section.

SECTION 2 Equipment Number

201. Equipment number

Equipment number is the value obtained from the following formula:

$$E = \Delta^{\frac{2}{3}} + 2.0\,Bh + 0.1\,A$$

where:

Δ = molded displacement in tonnes to the summer load waterline.

h, A =values specified in the following (1), (2) and (3).

(1) h is the value obtained from the following formula:

$$h = f + h' \ (m)$$

where:

f = vertical distance, at the midship, from the load line to the top of uppermost continuous deck beam at side (m).

h' = height from the uppermost continuous deck to the top of uppermost superstructures or deckhouses having a breadth greater than $B/4$ (m), In the calculation of h', sheer and trim may be ignored. Where a deckhouse having a breadth greater than $B/4$ is located above a deckhouse with a breadth of $B/4$ or less, the narrow deckhouse may be ignored.

(2) A is the value obtained from the following formula:

$$A = fL + \sum h''l \quad (m^2)$$

where:

f = value specified in (1)

$\sum h''l$ =summing up of the products of the height h'' (m) and length l (m) of superstructures, deckhouses or trunks which are located above the uppermost continuous deck within the length of ship and also have a breadth greater than $B/4$ and a height greater than 1.5 *metres*.

(3) In the application of (1) and (2), screens and bulwarks more than 1.5 *metres* in height are to be regarded as parts of superstructure or deckhouses.

202. Mass of anchors

1. The mass of individual bower anchors may vary by ±7 % of the mass given in **Table 4.8.1** provided that the total mass of stipulated number of bower anchors is not less than obtained from multiplying the mass per anchor by the number given in **Table 4.8.1**. Where, however, an approval by the Society is obtained, the anchors which are increased in mass by more than 7 % may be used.

2. Where stock anchors are used, the mass excluding the stock, is not to be less than 0.80 times the mass specified in **Table 4.8.1** for ordinary stockless bower anchors.

3. Where high holding power anchors are used, the mass of each anchor may be 0.75 times the mass specified in **Table 4.8.1**.

4. Where super high holding power anchors are used, the mass of each anchor may be 0.5 times the mass specified in **Table 4.8.1**. However, the mass of super high holding anchor is generally not to exceed 1,500 *kg*.

203. Chain cables and stream lines

1. Chain cables for bower anchors are to be stud link chains of Grade 1, 2 or 3 specified in **Sec 4**. However, Grade 1 chains made of Class 1 chain bars (*RSBC* 31) are not to be used in association with high holding power anchors.

2. As for chain cables or wire ropes for stream lines, the breaking test load specified in **Sec 4** or **5** is not to be less than the breaking load given in **Table 4.8.1** respectively.

204. Tow lines and mooring lines

1. As for wire ropes and hemp ropes used as tow lines and mooring lines, the breaking test load specified in **Sec 5** or **6** is not to be less than the breaking load given **Table 4.8.1** respectively.

2. For ships having the ratio A/E above 0.9, the following number of ropes should be added to the number required by **Table 4.8.1** for mooring lines.

$\frac{A}{E}$	Number of mooring line
$0.9 < \frac{A}{E} \le 1.1$	1
$1.1 < \frac{A}{E} \le 1.2$	2
$\frac{A}{E} > 1.2$	3

NOTES:
A = value specified in **201.** (2)
E = equipment number.

Table 4.8.1 Bower Anchors, Chain Cables and Ropes

Equipment letter	Equipment number		Stockless bower anchors		Stud link chain cables for bower anchors				Tow line			Mooring line			
	Exceeding	Not exceeding	Number	Mass per anchor (kg)	Total length (m)	Diameter (mm) Grade 1	Grade 2	Grade 3	Length (m)	Breaking load (kN)	(kg)	Number	Length (m)	Breaking load (kN)	(kg)
B3	205	240	2	660	302.5	26	22	20.5	180	● 129	13200	4	120	↑ 64	6500
B4	240	280	2	780	330	28	24	22	180	150	15300	4	120	69	7000
B5	280	320	2	900	357.5	30	26	24	180	174	17700	4	140	74	7500
C1	320	360	2	1020	357.5	32	28	24	180	↓ 207	21100	4	140	● 78	8000
C2	360	400	2	1140	385	34	30	26	180	↑ 224	22800	4	140	88	9000
C3	400	450	2	1290	385	36	32	28	180	250	25500	4	140	98	10000
C4	450	500	2	1440	412.5	38	34	30	180	277	28200	4	140	108	11000
C5	500	550	2	1590	412.5	40	34	30	190	306	31200	4	160	123	12500
D1	550	600	2	1740	440	42	36	32	190	⊕ 338	34500	4	160	132	13500
D2	600	660	2	1920	440	44	38	34	190	371	37800	4	160	147	15000
D3	660	720	2	2100	440	46	40	36	190	406	41400	4	160	157	16000
D4	720	780	2	2280	467.5	48	42	36	190	441	45000	4	170	172	17500
D5	780	840	2	2460	467.5	50	44	38	190	↓ 480	48900	4	170	186	19000
E1	840	910	2	2640	467.5	52	46	40	190	↑ 518	52800	4	170	201	20500
E2	910	980	2	2850	495	54	48	42	190	559	57000	4	170	↓ 216	22000
E3	980	1060	2	3060	495	56	50	44	200	603	61500	4	180	↑ 230	23550
E4	1060	1140	2	3300	495	58	50	46	200	647	66000	4	180	250	25500
E5	1140	1220	2	3540	522.5	60	52	46	200	691	70500	4	180	270	27500
F1	1220	1300	2	3780	522.5	62	54	48	200	738	75300	4	180	284	29000
F2	1300	1390	2	4050	522.5	64	56	50	200	786	80100	4	180	309	31500
F3	1390	1480	2	4320	550	66	58	50	200	836	85200	4	180	324	33000
F4	1480	1570	2	4590	550	68	60	52	220	⊡ 888	90600	5	190	324	33000
F5	1570	1670	2	4890	550	70	62	54	220	941	96000	5	190	333	34000
G1	1670	1790	2	5250	577.5	73	64	56	220	1024	104400	5	190	⊕ 353	36000
G2	1790	1930	2	5610	577.5	76	66	58	220	1190	113100	5	190	378	38500
G3	1930	2080	2	6000	577.5	78	68	60	220	1168	119100	5	190	402	41000
G4	2080	2230	2	6450	605	81	70	62	240	1259	128400	5	200	422	43000
G5	2230	2380	2	6900	605	84	73	64	240	1356	138300	5	200	451	46000
H1	2380	2530	2	7350	605	87	76	66	240	1453	148200	5	200	480	49000
H2	2530	2700	2	7800	632.5	90	78	68	260	1471	150000	6	200	↓ 480	49000
H3	2700	2870	2	8300	632.5	92	81	70	260	1471	150000	6	200	↑ 490	50000
H4	2870	3040	2	8700	632.5	95	84	73	260	1471	150000	6	200	500	51000
H5	3040	3210	2	9300	660	97	84	76	280	1471	150000	6	200	520	53000
J1	3210	3400	2	9900	660	100	87	78	280	1471	150000	6	200	554	56500
J2	3400	3600	2	10500	660	102	90	78	280	1471	150000	6	200	588	60000
J3	3600	3800	2	11100	687.5	105	92	81	300	1471	150000	6	200	618	63000
J4	3800	4000	2	11700	687.5	107	95	84	300	1471	150000	6	200	647	66000
J5	4000	4200	2	12300	687.5	111	97	87	300	1471	150000	7	200	647	66000
K1	4200	4400	2	12900	715	114	100	87	300	1471	150000	7	200	657	67000
K2	4400	4600	2	13500	715	117	102	90	300	1471	150000	7	200	667	68000
K3	4600	4800	2	14100	715	120	105	92	300	1471	150000	7	200	677	69000
K4	4800	5000	2	14700	742.5	122	107	95	300	1471	150000	7	200	⊡ 686	70000
K5	5000	5200	2	15400	742.5	124	111	97	300	1471	150000	8	200	686	70000
L1	5200	5500	2	16100	742.5	127	111	97	300	1471	150000	8	200	696	71000
L2	5500	5800	2	16900	742.5	130	114	100	300	1471	150000	8	200	706	72000
L3	5800	6100	2	17800	742.5	132	117	102	300	↓ 1471	150000	9	200	706	72000
L4	6100	6500	2	18800	742.5		120	107				9	200	716	73000
L5	6500	6900	2	20000	770		124	111				9	200	726	74000

Table 4.8.1 Bower Anchors, Chain Cables and Ropes (Continued)

Equipment letter	Equipment number		Stockless bower anchors		Stud link chain cables for bower anchors				Tow line			Mooring line			
	Exceeding	Not exceeding	Number	Mass per anchor (kg)	Total length (m)	Diameter (mm) Grade 1	Grade 2	Grade 3	Length (m)	Breaking load (kN)	(kg)	Number	Length (m)	Breaking load (kN)	(kg)
M1	6900	7400	2	21500	770		127	114				10	200	726	74000
M2	7400	7900	2	23000	770		132	117				11	200	726	74000
M3	7900	8400	2	24500	770		137	122				11	200	735	75000
M4	8400	8900	2	26000	770		142	127				12	200	735	75000
M5	8900	9400	2	27500	770		147	132				13	200	735	75000
N1	9400	10000	2	29000	770		152	132				14	200	735	75000
N2	10000	10700	2	31000	770			137				15	200	735	75000
N3	10700	11500	2	33000	770			142				16	200	735	75000
N4	11500	12400	2	35500	770			147				17	200	735	75000
N5	12400	13400	2	38500	770			152				18	200	735	75000
O1	13400	14600	2	42000	770			157				19	200	735	75000
O2	14600	16000	2	46000	770			162				21	200	735	75000

NOTES :
1. Where steel wire ropes are used, the following wire ropes corresponding to the marks shown in the Table, ● (6 × 12), ⊕ (6 × 24), ⧈ (6 × 37), are to be provided.
2. Length of chain cables may be that including shackles for connection
3. Tow line is not a condition of Classification, but is listed in this table only for guidance.

3. For individual mooring lines with required breaking load above 490 kN according to **Table 4.8.1** the required strength may be reduced by the corresponding increase of the number of mooring lines and vice versa, provided that the total breaking load of all mooring lines aboard the ship is not less than the value obtained from multiplying the required breaking load in **Table 4.8.1** by the sum of number required in **Table 4.8.1** and **Par 1,** irrespective of the requirements in **Par 1**. However, the number of mooring lines is not to be less than 6 in any case, and any one of the lines is not to have a breaking load less than 490 kN.

4. The requirements for synthetic fibre ropes used as tow lines or mooring lines are to be as stipulated elsewhere.

5. The length of individual mooring lines may be reduced up to 7 % of the length given in **Table 4.8.1** provided that total length of the stipulated number of mooring lines is not less than obtained from multiplying the length by the number given in **Table 4.8.1**.

6. For mooring lines connected with powered winches where the rope is stored on the drum, steel cored wire ropes of suitable flexible construction may be used instead of fibre cored wire ropes subject to the approval by this Society.

205. Emergency towing arrangements on tankers

1. For tankers which operate in international service area, emergency towing arrangements shall be fitted at both ends on board every tanker of not less than 20,000 tonnes deadweight.

2. Tankers constructed on or after 1 July 2002 are to be in accordance with the requirements in the following Sub-paragraphs.

(1) The arrangements shall, at all times, be capable of rapid deployment in the absence of main power on the ship to be towed and easy connection to the towing ship. At least one of the emergency towing arrangements shall be pre-rigged ready for rapid deployment.

(2) Emergency towing arrangements at both ends shall be of adequate strength taking into account the size and deadweight of the ship, and the expected forces during bad weather conditions. The design, construction and prototype testing of emergency towing arrangement are to be in accordance with **Ch 3, Sec 25.** in **"Guidances for Approval of Manufacturing Process and Type Approval, etc"**.

3. For tankers constructed before 1 July 2002, the design, construction and prototype testing of emergency towing arrangements are to be in accordance with **Ch 3, Sec 25.** in **"Guidances for Approval of Manufacturing Process and Type Approval, etc"**.

SECTION 3
Anchors

301. Application

Anchors to be equipped on ships in accordance with the provisions in this Chapter are to be in compliance with the requirements in this Section or to be of equivalent quality.

302. Kinds

The Kinds of anchors are as follows:

Stock anchor
Stockless anchor

303. Materials

1. Materials used for anchors are to be cast steel, forged steel or rolled steels specified in **Pt 2, Ch 1.** Cast steel, however, is not to be used for the pins connecting the shank to the head and anchor rings of small anchors.

2. Cast steels for super high holding power anchor are to be subjected to the impact test according to the followings.

(1) One set of three V notch impact test specimens specified in **Pt 2, Ch 1** are to be taken.
(2) The average absorbed energy is not to be less than 27 J at 0C°. However, when the average absorbed energy of two or more test specimens among a set of test specimens is less than 27 J or when the average absorbed energy of a single test specimen is less than 19 J, the test is to be considered to have failed.
(3) Anchor rings of super high holding power anchor are to comply with the requirements of impact test for Grade 3 chain in **Ch 8, Table 4.8.8.**

304. Constructions and dimensions

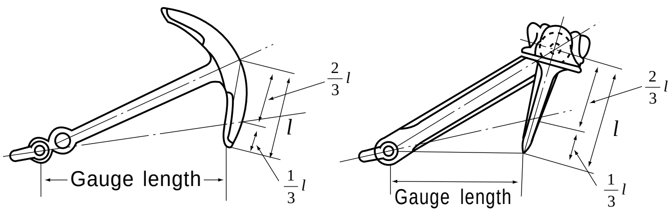
1. The construction and form of anchors are to comply with the *KS V* 3311 (*Anchors*) and the special forms of anchors are to be approved by this Society.

2. The high holding power anchors and super high holding anchors, except in accordance with the provision in the above **Par 1,** are to be tested by the holding power indicated by the Society and are to comply with the test requirements.

3. The welding for rolled steel fabricated anchors is generally to be in accordance with the requirement in **Pt 2, Ch 2.**

305. Length of arm

1. Length of the arm is the distance from the centre of the pin in case of anchors having the head pin and from the top of the crown in case of anchors of other types to the tip of the flukes. (*See* **Fig.4.8.1**)



Stock Anchor   Stockless Anchor

Fig. 4.8.1 Anchors

2. Where the crown is of concave form, the intersection of the centre line of the shank with the plane in contact with the tops of the arms is considered as the top of the crown.

306. Mass

1. The mass of the stock of a stock anchor is not to be less than one-fourth of the mass of anchor excluding stock.

2. The mass of stockless anchor excluding shank is not to be less than three-fifths of the total mass of the anchor.

3. The mass of an anchor is to be measured before executing proof test.

4. In case of stock anchors, the mass of the anchor excluding stock and the mass of the stock are to be measured separately. In case of stockless anchors the total mass of anchor and the mass of shank are to be measured.

307 Drop and hammering tests

Cast steel anchors are to be subjected to the following tests prior to the execution of the proof tests and are to comply with the test requirements.

(1) *Drop tests*
(a) Each piece of the cast steel anchor is to be lifted to 4 *metres* in height and dropped on an steel slab on the hard ground without any crack or other defects.
(b) Where shank and arms are cast in one piece in stock anchors, the anchor is first to be lifted to the specified height with its shank and arms in a horizontal position and then dropped on the steel slab, and to be lifted once more to the specified height with the crown downwards and dropped on two steel blocks on the slab arranged to enable the anchor to give shock at the middle of each arm without making the crown touch the slab, and are to be found free from cracks, deformation or other defects.
(c) Where the slab is broken by the impact, the anchor is to be retested with a new slab.
(2) *Hammering tests*
After the drop test specified in (1), the anchor

Table 4.8.2 Proof Test Load for Anchors

Mass of anchor (kg)	Proof test load (kN)	Mass of anchor (kg)	Proof test load (kN)	Mass of anchor (kg)	Proof test load (kN)	Mass of anchor (kg)	Proof test load (kN)
25	12.6	1000	199	4500	622	10000	1010
30	14.5	1050	208	4600	631	10500	1040
35	16.9	1100	216	4700	638	11000	1070
40	19.1	1150	224	4800	645	11500	1090
45	21.2	1200	231	4900	653	12000	1110
50	23.2	1250	239	5000	661	12500	1130
55	25.2	1300	247	5100	669	13000	1160
60	27.1	1350	255	5200	677	13500	1180
65	28.9	1400	262	5300	685	14000	1210
70	30.7	1450	270	5400	691	14500	1230
75	32.4	1500	278	5500	699	15000	1260
80	33.9	1600	292	5600	706	15500	1270
90	36.3	1700	307	5700	713	16000	1300
100	39.1	1800	321	5800	721	16500	1330
120	44.3	1900	335	5900	728	17000	1360
140	49.0	2000	349	6000	735	17500	1390
160	53.3	2100	362	6100	740	18000	1410
180	57.4	2200	376	6200	747	18500	1440
200	61.3	2300	388	6300	754	19000	1470
225	65.8	2400	401	6400	760	19500	1490
250	70.4	2500	414	6500	767	20000	1520
275	74.9	2600	427	6600	773	21000	1570
300	79.5	2700	438	6700	779	22000	1620
325	84.1	2800	450	6800	786	23000	1670
350	88.8	2900	462	6900	794	24000	1720
375	93.4	3000	474	7000	804	25000	1770
400	97.9	3100	484	7200	818	26000	1800
425	103	3200	495	7400	832	27000	1850
450	107	3300	506	7600	845	28000	1900
475	112	3400	517	7800	861	29000	1940
500	116	3500	528	8000	877	30000	1990
550	124	3600	537	8200	892	31000	2030
600	132	3700	547	8400	908	32000	2070
650	140	3800	557	8600	922	34000	2160
700	149	3900	567	8800	936	36000	2250
750	158	4000	577	9000	949	38000	2330
800	166	4100	586	9200	961	40000	2410
850	175	4200	595	9400	975	42000	2490
900	182	4300	604	9600	987	44000	2570
950	191	4400	613	9800	998	46000	2650

NOTE ;
Where mass of anchor is intermediate in this Table, proof test load is to be determined by linear interpolation

is to be slung clear of the ground and thoroughly hammered with a hammer which the mass is 3 kg to 7 kg and is to be found free from cracks or other defects.

308. Proof tests

1. Anchors are to be tested in accordance with the requirements in **Table 4.8.2,** applying the required load corresponding to the mass of anchor (excluding the mass of stock for stock anchor) at the position of one-third of the length of the arm from the tip of the fluke, for every arm or for both arms simultaneously or for each position in case of the anchor having the head pin, and to be found free from cracks, deformation or other defects. In every test, the difference between the gauge lengths, where one-tenth of the required load was applied first and where the load has been released to one-tenth of the required load from the full load, may be permitted not to exceed 1% of the gauge length. (*See* **Fig.4.8.1**)

2. The proof test load, however, for high holding power anchors is to be the load specified for an ordinary anchor of which mass is equal to 4/3 times the actual total mass of high holding power anchor.

3. The proof test load for super high holding power anchors is to be the load specified for an ordinary anchor of which the mass is 2 times the actual mass of super high holding power anchor.

309. Non-destructive test

1. After the proof load test, cast steel anchors and cast steel high holding power anchors are to be visually inspected and the following areas are to be examined by the dye penetrant testing, the magnetic particle testing or the ultrasonic testing.

(1) in way of areas where feeder heads and risers have been removed.
(2) in way of areas where weld repairs have been carried out.
(3) in way of high load areas (e.g. : the flukes etc.)

2. After the proof load test, super high holding power anchors are to be visually inspected and are to be examined by non-destructive test as specified below (1) through (3).

(1) dye penetrant testing or magnetic particle testing at all surfaces for cast steel anchors and at the welds for rolled steel fabricated anchors
(2) ultrasonic testing in way of area where weld repairs have been carried out and where feeder heads and risers have been removed for cast steel anchors.
(3) ultrasonic testing or radiographic testing may be required in way of high load areas and suspect areas, in addition to the inspection specified in the above (1) and (2).

310. Marking

1. Where anchors have satisfactorily passed the tests and inspections, they are to be stamped with the mass of anchor (excluding the mass of stock in stock anchors), at the middle position of the shank and the Society's brand and the test number at the position two-thirds of the length of arm from the tip of the fluke on the same side. Where the anchor is formed with separate shank and arms, the Society's brand and the test number are also to be stamped on the shank in the neighbourhood of the head pin, and in case of stock anchor, the mass of stock, this Society's brand and the test number are also to be stamped on the stock.

2. In case of high holding power anchors, alphabet H is to be stamped in front of this Society's brand in addition to the stamps specified in the above **Par 1.**

3. In case of super high holding power anchors, alphabet SH is to be stamped before this Society's brand in addition to the stamps specified in the above **Par 1.**

311. Painting

Anchors are not to be painted until the tests and inspections are finished.

SECTION 4
Chains

401. Applications

1. Anchor chains to be equipped on ships, steering chains (hereinafter referred to as "**chain**"), shackles and swivels (hereinafter referred to as "**accessories**") are to comply with the requirements in this Section or to be of equivalent quality.

2. Offshore mooring chains are to be as deemed appropriate by this Society.

402. Kinds of chains

The kinds of chains are as follows:

(1) Studless chain

(2) Stud link chain

(A) Grade 1 chain

(B) Grade 2 chain

(C) Grade 3 chain

403. Materials

1. Chains are to be made of the materials given in **Tables 4.8.3** and **4.8.4** according to their grades and manufacturing processes, respectively.

2. Notwithstanding **Par 1** above, the rolled steel round bars may be used for chain round bars, provided they satisfactorily comply with this Society and comply with the requirements **Pt 2, Ch 1, 306. 4.**

404. Processes of manufacture

1. Chains are to be made by pressure butt welding, flash butt welding or casting. Their manufactures are to obtain approval by this Society in advance concerning their manufacturing methods.

2. Studless short link chains more than 26mm in diameter and stud link chains are not to be made by pressure butt welding.

3. Inserted studs are to be pressed completely to the centre position of the link and at right angles to the sides of the link.

4. Accessories are to be made by casting or forging. Their manufacturers are to obtain approval by this Society in advance concerning their manufacturing methods.

Table 4.8.3 Materials for Chain Links

Process / Kind	Manufacturing Process		
	Pressure butt welded	Flash butt welded	Cast
studless chain	Grade 1 chain bar (*RSBC* 31)	Grade 1 chain bar (*RSBC* 31)	—
Grade 1 chain	—	Grade 1 chain bar (*RSBC* 31)	—
Grade 2 chain	—	Grade 2 chain bar (*RSBC* 50)	Grade 2 cast steel for chain(*RSCC* 50)
Grade 3 chain	—	Grade 3 chain bar (*RSBC* 70)	Grade 3 cast steel for chain(*RSCC* 70)

NOTE :
Materials for Grade 2 chains may be used for Grade 1 chains.

Table 4.8.4 Materials for Accessories

Process / Kind	Materials for Accessories	
	Casting	Forging
studless chain Grade 1 chain Grade 2 chain	Grade 2 steel casting for chain (*RSCC* 50)	Grade 2 steel forging for chain (*RSFC* 50)
Grade 3 chain	Grade 2 steel casting for chain (*RSCC* 70)	Grade 3 steel forging for chain (*RSFC* 70)

NOTE:
Materials for Grade 2 chains may be used for accessories for Grade 2 chains.

405. Heat treatment

1. The heat treatment of chains is to comply with the requirements given in **Table 4.8.5**

2. Notwithstanding **Par 1** above, Grade 2 flash butt welded chains subjected to sufficient preheating may not be required heat treatment on the approval by this Society.

Table 4.8.5 Heat treatment

Kind of chain	Heat treatment
Studless chain Grade 1 chain	As welded or Normalized
Grade 2 chain	Normalized, in principle
Grade 3 chain	Normalized, Normalized and tempered, Quenched and tempered

406. Quality and repair of defects

1. Chains and accessories are to be free from cracks, notches, inclusions and other defects impairing the performance of the products.

2. Minor surface defects other than preceding **Par 1,** can be partly removed by grinder. In this case the grinding is so as to leave gentle transition to the surrounding surface and, in principle, local grinding up to 5% of the nominal link diameter may be permitted.

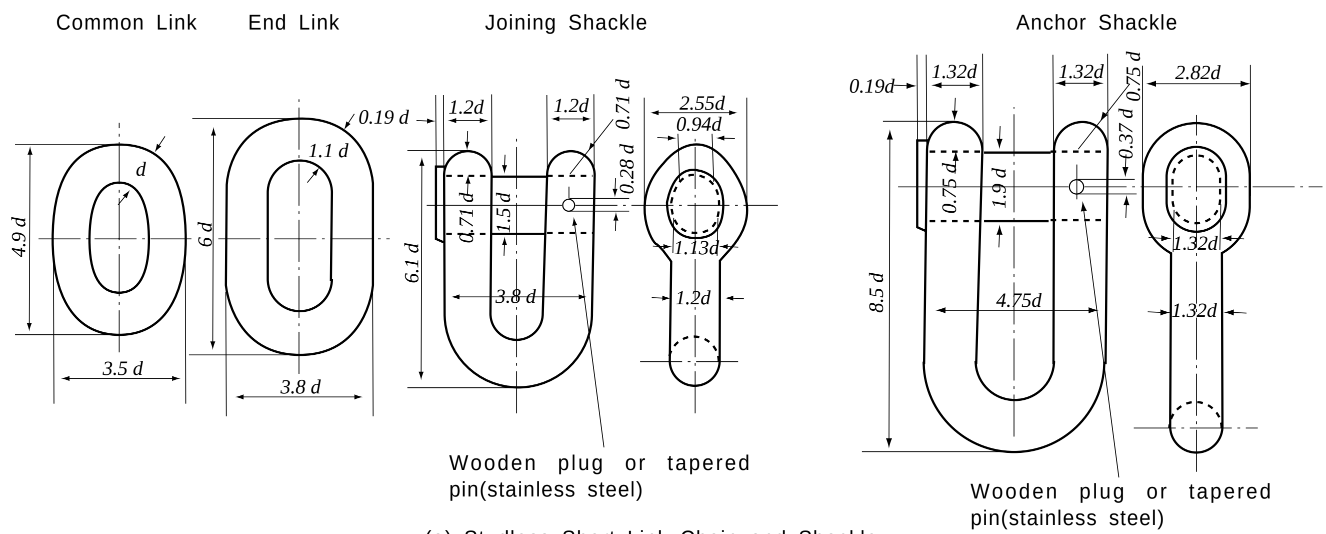
407. Dimensions and form

1. The standard dimensions and forms of each kind of link and accessory are to be as given in **Fig. 4.8.2.**

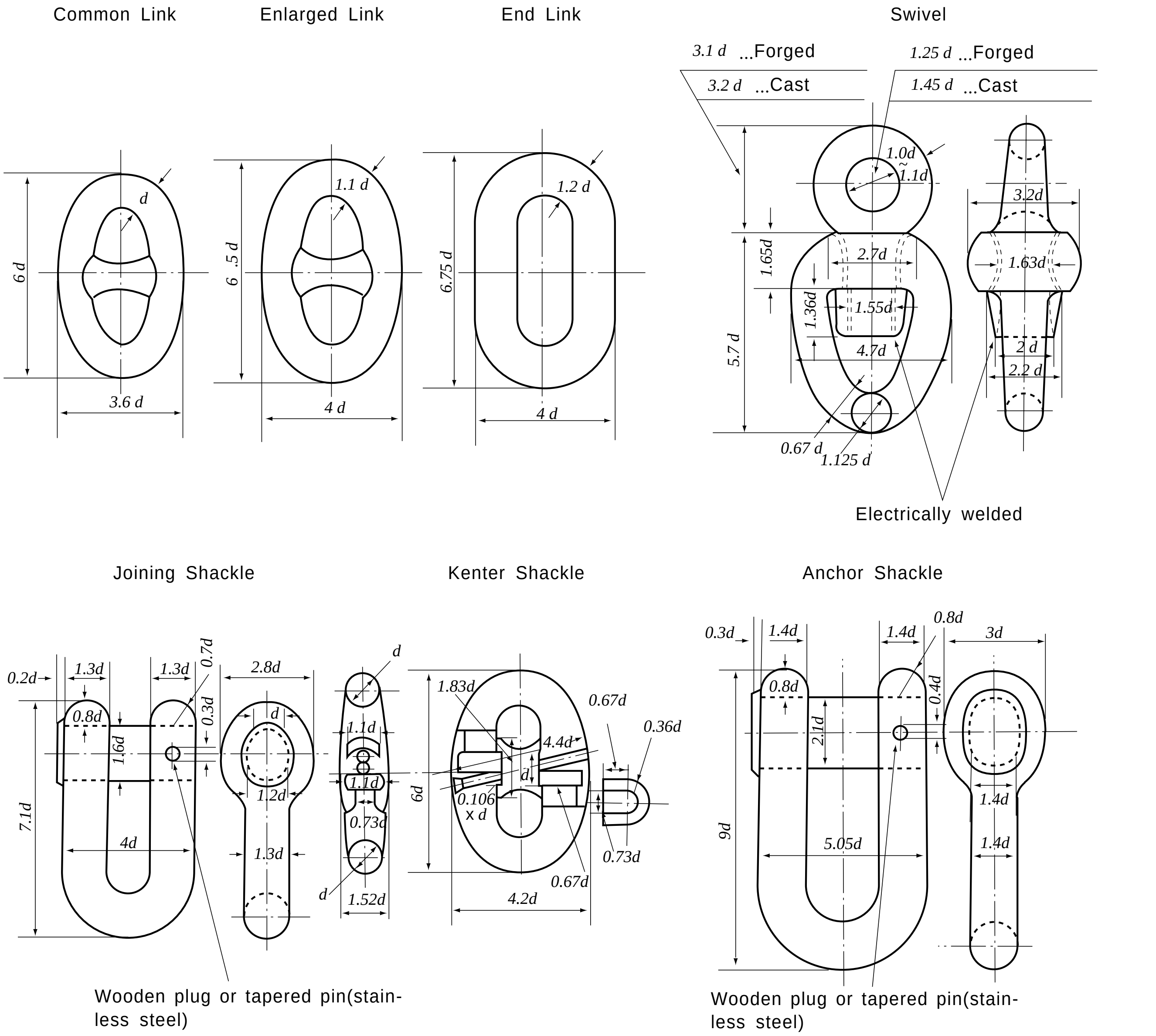
2. The nominal diameter of chains is to be denoted by the diameter of the common link.

3. One length of chains is the distance from the outer end of the internal bent portion of the link at one end of the chain to that at the other end of the chain. The standard length of anchor chains is 27.5 m.

4. There is to be an odd number of links in each



(a) Studless Short Link Chain and Shackle



(b) Stud Link Chain and Shackle

Fig. 4.8.2 Dimensions and Forms of Link Chain, Shackle and Swivel

length of chains, except where swivels are fitted.

5. Links of every kind, shackles and swivels are to be of uniform shape and their bent portions are to be sufficient to allow each link to work smoothly.

408. Dimension tolerances

The tolerances for chains and accessories are to comply with the following requirements in **Par 1** and **2** and the dimensions thereof are to be measured after the execution of a proof test.

1. Chain

(1) The negative tolerance at the crown part of each kind of link is to comply with the requirements in accordance with its nominal diameter as given in **Table 4.8.6** and the plus tolerance may be up to 5% of its nominal diameter. However, no negative tolerance of the cross sectional area of the crown part of the link is permitted.

Table 4.8.6 Nagative Tolerances of Diameters

Nominal Diameter (mm)	over		40	84	122
	up to	40	84	122	
Negative Tolerances (mm)		1	2	3	4

(2) The tolerances other than the crown part of each kind of link are to be up to +5%, but are not to be negative.

(3) Notwithstanding the requirements in (1) and (2) above, no negative tolerance of the diameter at the welded part is permitted. The positive tolerances thereof are left to the discretion of this Society.

(4) The tolerances for a length of 5 links are to be 2.5%, but may not be negative.

(5) The tolerances except for the requirements specified in (1) to (4) above are to be $\pm$2.5%.

2. Accessories

(1) The tolerance of the diameter at the bent portions of kenter shackles are to be equal +5%, but may not be negative.

(2) All other dimensions are subjected to manufacturing tolerances of $\pm$2.5%.

409. Mass

The mass of chains is to comply with the standard mass given in **Table 4.8.7** in accordance with their kind, and to be measured after the execution of proof tests.

410. Breaking tests of chains

1. The breaking tests are to be carried out for test specimens consisting of at least three links taken from the chains at random. The test is to be carried out after the chains were heat treated where necessary.

2. One tspecimen is to be taken from each four length in the presence of a surveyor. However, where one length of chain is short and the total length of two lengths of chain is less than 27.5 *metres*, such two lengths may be regarded as one length.

3. The test specimens are to withstand satisfactorily the breaking test loads specified in **Table 4.8.7** according to their grades.

4. Where the capacity of the testing machine does not reach the breaking test loads specified in **Table 4.8.7,** the breaking test may be substituted by a method approved by this Society.

5. Where the test is not satisfactory, the chain may be retested by taking out another set of test specimens from the same length of chain, and where the test specimens comply with the requirements, the remaining three lengths of chain may be accepted. Where the retest fails, the length of chain from which the test specimen have been taken is rejected, and the remaining three chains are to be subjected to the breaking tests individually. If one of such test fails to meet the requirements, all the remaining three lengths of the chain are rejected.

6. Where the missing chain links due to the preparation of the retest of **Par 5** above are replaced by new chain links, the test specimens manufactured by the same procedure are to be subjected to the breaking test, and are to comply with the requirements.

411. Breaking tests of accessories

1. From each manufacturing lot, which have the same grade, size and heat treatment, of 25 units or less of shackles, swivel shackles, large links and end links made by casting and from each manufacturing lot of 50 units or less of kenter shackles, one unit is to withstand satisfactorily the breaking test loads specified in **Table 4.8.7** according to the grades of chain to be connected.

2. Where the test of **Par 1** above is not satisfactory, the accessories may be retested by taking out two units from the same lot. If one such test fails to meet the requirements, the entire unit test quantity is rejected.

3. Accessories used for the breaking load test must not be put into further use. However, the accessories, which have been successfully tested in accordance with **Par 1** of the above, may be used in service at the discretion of this Society.

4. When the accessories are in accordance with the following requirements in (1) to (3), no impact testing is required subject to the approval by this Society.

(1) The breaking load test has been demonstrat-

Table 4.8.7 Breaking and Proof Test Loads for Chains

Nominal dia. d (mm)	Stud link chain							Studless chain		
	Grade 1 chain		Grade 2 chain		Grade 3 chain		Mass of chain per metre (kg)	Breaking test load(kN)	Proof test load(kN)	Mass of chain per metre (kg)
	Breaking test load(kN)	Proof test load(kN)	Breaking test load(kN)	Proof test load(kN)	Breaking test load(kN)	Proof test load(kN)				
12.5	66	46	92	66	132	92	3.422	58	29	3.40
14	82	58	116	82	165	116	4.292	72	36	4.26
16	107	76	150	107	216	150	5.606	95	47	5.56
17.5	127	89	179	127	256	179	6.707	113	57	6.66
19	150	105	211	150	301	211	7.906	133	67	7.84
20.5	175	123	244	175	349	244	9.203	155	78	9.14
22	200	140	280	200	401	280	10.60	178	89	10.52
24	237	167	332	237	476	332	12.61	213	107	12.52
26	278	194	389	278	556	389	14.80	250	125	14.72
28	321	225	449	321	642	449	17.17	290	145	17.08
30	368	257	514	368	735	514	19.71	332	174	19.60
32	417	291	583	417	833	583	22.43	379	189	22.28
34	468	328	655	468	973	655	25.32	428	214	25.16
36	523	366	732	523	1050	732	28.38	480	239	28.20
38	581	406	812	581	1160	812	31.62	533	267	31.44
40	640	448	896	640	1280	896	35.04	591	296	34.80
42	703	492	981	703	1400	981	38.63	652	327	38.40
44	769	538	1080	769	1540	1080	42.40	716	358	42.00
46	837	585	1170	837	1680	1170	46.34	783	391	46.00
48	908	635	1270	908	1810	1270	50.46	852	426	50.00
50	981	686	1370	981	1960	1370	54.75	925	462	54.40
52	1060	739	1480	1060	2110	1480	59.22			
54	1140	794	1590	1140	2270	1590	63.86			
56	1220	851	1710	1220	2430	1710	68.68			
58	1290	909	1810	1290	2600	1810	73.67			
60	1380	969	1940	1380	2770	1940	78.84			
62	1470	1030	2060	1470	2940	2060	84.18			
64	1560	1100	2190	1560	3130	2190	89.70			
66	1660	1160	2310	1660	3300	2310	95.40			
68	1750	1230	2450	1750	3500	2450	101.3			
70	1840	1290	2580	1840	3690	2580	107.3			
73	1990	1390	2790	1990	3990	2790	116.7			
76	2150	1500	3010	2150	4300	3010	126.5			
78	2260	1580	3160	2260	4500	3160	133.2			
81	2410	1690	3380	2410	4820	3380	143.7			
84	2580	1800	3610	2580	5160	3610	154.5			
87	2750	1920	3850	2750	5500	3850	165.8			
90	2920	2050	4090	2920	5840	4090	177.4			
92	3040	2130	4260	3040	6080	4260	185.4			
95	3230	2260	4510	3230	6440	4510	197.6			
97	3340	2340	4680	3340	6690	4680	206.1			
98	3400	2380	4770	3400	6820	4770	210.3			
100	3530	2470	4940	3530	7060	4940	219.0			
102	3660	2560	5120	3660	7320	5120	227.8			
105	3850	2700	5390	3850	7700	5390	241.4			
107	3980	2790	5570	3980	7960	5570	250.7			
108	4040	2830	5660	4050	8090	5660	255.4			
111	4250	2970	5940	4250	8480	5940	269.8			
114	4440	3110	6230	4440	8890	6230	284.6			
117	4650	3260	6510	4650	9300	6510	299.8			
120	4850	3400	6810	4850	9720	6810	315.4			
122	5000	3500	7000	5000	9990	7000	326.0			

Table 4.8.7 Breaking and Proof Test Loads for Chains (continued)

Nominal dia. d (mm)	Stud link chain							Unstudded chain		
	Grade 1 chain		Grade 2 chain		Grade 3 chain		Mass of chain per metre (kg)	Breaking test load(kN)	Proof test load(kN)	Mass of chain per metre (kg)
	Breaking test load(kN)	Proof test load(kN)	Breaking test load(kN)	Proof test load(kN)	Breaking test load(kN)	Proof test load(kN)				
124	5140	3600	7200	5140	10280	7200	336.7			
127	5350	3750	7490	5350	10710	7490	353.2			
130	5570	3900	7800	5570	11140	7800	370.1			
132	5720	4000	8000	5720	11420	8000	381.6			
137	6080	4260	8510	6080	12160	8510	411.0			
142	6450	4520	9030	6450	12910	9030	441.6			
147	6840	4790	9560	6840	13660	9560	473.2			
152	7220	5050	10100	7220	14430	10100	506.0			
157	7600	5320	10640	7600	15200	10640	539.8			
162	7990	5590	11170	7990	15970	11170	574.7			

NOTE :
Where nominal diameter is less than 12.5 mm or intermediate in this Table, breaking test loads, proof test loads and mass of chain per metre are to be determinated by the following table :

Kind	Breaking test load (N)	Proof test load (N)	Mass (kg)
Unstudded chain	$370\ d^2$	$184\ d^2$	$0.0217\ d^2$
Grade 1 chain	$9.81\ d^2 (44 - 0.08\ d)$	$6.87\ d^2 (44 - 0.08\ d)$	$0.0219\ d^2$
Grade 2 chain	$13.7\ d^2 (44 - 0.08\ d)$	$9.81\ d^2 (44 - 0.08\ d)$	$0.0219\ d^2$
Grade 3 chain	$19.6\ d^2 (44 - 0.08\ d)$	$13.7\ d^2 (44 - 0.08\ d)$	$0.0219\ d^2$

where :
d = Nominal diameter (mm)

ed on the occasion of the approval testing of parts of the same design.
(2) The tensile test and impact test have been demonstrated by each manufacturing lot.
(3) Non-destructive testing has been demonstrated before forwarding the products.

412. Proof tests

1. The proof tests are to be carried out for each length of the chains which satisfactorily complied with the breaking tests, and the chains are to withstand the proof test loads specified in **Table 4.8.7** without cracking, breakage or any other defects. The test is to be carried out after the chains were heat treated where necessary.

2. Where the test of **Par 1** abs not satisfactory, the chain may be retested only once more by link of same manufacturing process after replacing the defective link. Where, however, more than 5% of the total links are found defective, the retest is not permitted.

3. Each kind of accessory is to be tested to the proof test loads specified in **Table 4.8.7**, in accordance with the kinds and diameters of the chains to be connected therewith, and they are to withstand the test without crack, breakage or any other defect. This test may be carried out simultaneously with the proof test for the chains or together with any chains of the same diameter with which shackles and swivels are connected.

413. Mechanical tests of grade 2 and grade 3 chain links

1. Grade 2 and grade 3 flash butt welded chain links are to be subjected to the mechanical tests, and are to comply with the requirements.

2. Notwithstanding **Par 1,** for grade 2 flash butt welded chains no mechanical tests are required subject to the approval by this Society.

3. Mechanical properties of chain links are to comply with requirements given in **Table 4.8.8.**

4. One tensile test specimen and one set of three impact test specimens are to be taken from the parts other than the welded joint links (except heat treated grade 2 chains) ; in addition for grade 3 chains, one set of three impact test specimens are to be taken from the welded joint for which the centre of notch of the specimens is to be located at the welded joint. These specimens are to be

Table 4.8.8 Mechanical Properties

Kind of chain	Except welded part						Welded part	
	Tensile test				Impact test(1)(2)		Impact test(1)	
	Yield point or proof stress (N/mm^2)	Tensile strength (N/mm^2)	Elongation (L=5d)(%)	Reduction of area (%)	Testing temperature(°C)	Minimum mean absorbed energy(J)	Testing temperature(°C)	Minimum mean absorbed energy(J)
Grade 2	295 min.	490~690	22 min.	-	0	27	-	-
Grade 3	410 min.	690 min.	17 min.	40 min.	0	60	0	50

(Note)
(1) When the absorbed energy of two or more test specimens among a set of test specimens is less in value than the specified minimum mean absorbed energy or when the absorbed energy of a single test specimen is less in value than 70% of the specified minimum mean absorbed energy, the test is considered to have failed.
(2) For Grade 2 chain heat treated, no impact testing is required.

taken at random among four lengths of chain but not from the chain subjected to breaking test.

5. Test procedure and forms of test specimens are to comply with the requirements in **Pt 2, Ch 1, Sec 2.**

6. Where the test results of mechanical properties of chain links do not conform to the requirements, additional tests are to be carried out in accordance with the requirements specified in **Pt 2, Ch 1, 306. 9.**

414. Marking

Where chains and accessories have satisfactorily passed the tests and inspections, they are to be stamped with this Society's brand, kind of chain and certificated numbers.

415. Painting

Chains and accessories are not to be painted until the tests and inspections are finished.

SECTION 5
Steel Wire Ropes

501. Application

1. The steel wire ropes used for steering ropes, mast riggings, stream wires, tow lines or mooring lines (hereinafter referred to as "**steel wire rope**") to be equipped on ships in accordance with the provisions in **Sec 2** are to comply with the requirements in this Section or to be of equivalent quality.

2. The provisions in this Section are applicable to the wire ropes constructed with fibre rope core and from individual wires having the tensile strength level of 1470 N/mm^2 [150 kgf/mm^2]. However, wire ropes constructed from other individual wires than those described above or steel wire ropes constructed with an independent wire rope core may be used where specially approved in connection with their manufacture.

502. Grades

1. Steel wire ropes are classified into seven grades according to their composition specified in **Table 4.8.9.** The classification may be indicated by grade number or composition mark.

2. Steel wire ropes No. 1 are used for standing riggings, No. 3 for standing and running riggings and Nos. 2, 4, 5, 6 and 21 for running riggings.

503. Processes of manufacture

1. The individual wires composing the strands of steel wire ropes are to consist of wires of *KS D* 3559 (Hard Steel Wires) or equivalent thereto.

2. The individual wires are to have no joint for the whole length of a steel wire rope. However, in an unavoidable case in the manufacturing process, they may be jointed by welding, brazing or twisting at only one position for each 10 *metre* length of strand.

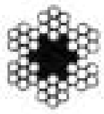
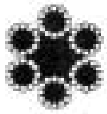
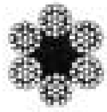
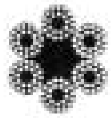
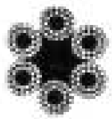
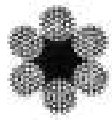
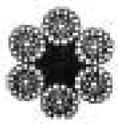
3. The individual wires are to be galvanized or to be drawn after being galvanized, and they are to be applied with oil to the extent necessary for maintenance unless otherwise specified. The galvanizing is to be performed effectively to the satisfaction of the Society. The oil is to be free from harmful acid or heavy alkali.

4. Fibre of good quality which suitably contains oil is to be used for core of steel wire rope and strand. The oil is to be free from acid or heavy alkali.

5. Steel wire ropes are to be left-hand lay and the strands are to be right-hand lay (called as "*Z* twisting").

6. Diameter, degree of twist, etc. are to be finished uniformly for the whole length of the steel wire ropes.

Table 4.8.9 Grades of Steel Wire Ropes

Grade		No.1	No.2	No.3	No.4	No.5	No.6	No.21
Sectional view								
Composition	Number of wires	7	12	19	24	30	37	36
	Number of strands	6	6	6	6	6	6	6
	Fibre core	Centre	Centre and centres of strand	Centre	Centre and centres of strand	Centre and centres of strand	Centre	Centre
Composition mark		(6×7)	(6×12)	(6×19)	(6×24)	(6×30)	(6×37)	$(6 \times WS\ (36))$

504. Diameter of individual wires and steel wire ropes

1. The difference between the maximum and minimum diameters of the individual wires composing the strand of steel wire ropes is not to exceed the limits given in **Table 4.8.10**.

2. The diameter of steel wire ropes is the diameter of the circumscribed circle of ropes and it is taken as an average diameter measured at any two or more positions except within 1.5 *metres* from the ends of ropes. In this case, the tolerance for the diameter of ropes is to be within +7 % and –0 %.

Table 4.8.10 Permissible Variation in Diameter of Individual Wires

Diameter of individual wire (mm)	Difference between maximum and minimum diameters (mm)
$0.26 < d \le 1.00$	0.06
$1.00 < d \le 2.30$	0.09
$2.30 < d \le 3.70$	0.12
$3.70 < d \le 4.50$	0.14

505. Mass

The standard mass of steel wire ropes is as given in **Table 4.8.11** according to the grade and diameter.

506. Breaking tests

1. Steel wire ropes are to be subjected to the breaking tests for each one length.

2. Where steel wire ropes are continuously manufactured by the same machine with the same wires and divided into several lengths, the test may be carried out on one length selected by the Surveyor at random. Where this test is satisfactory, the tests for the other lengths may be dispensed with.

3. The breaking tests for steel wire ropes are to be carried out in accordance with the following requirements:

(1) The test piece of which both ends are either loosened and solidified to cone with suitable metal alloy or gripped by other suitable methods, is to be set to the testing machine and gradually pulled until breaks down.
(2) One test piece is to be taken from each length of steel wire ropes.
(3) The distance between the grips is not to be less than 40 times the diameter of ropes. However, it need not exceed 2 *metres*.
(4) The test pieces are to withstand the breaking test loads specified in **Table 4.8.11** according to the grade and diameter of steel wire rope.
(5) Where the test piece has broken down at the parts of the grips before reaching the required breaking load, one more test piece taken from the steel wire rope may be retested.

507. Individual wire tests

1. Individual wire tests are to be carried out each one length.

2. Where steel wire ropes are continuously manufactured by the same machine with the same wires and divided into selected lengths, the test may be carried out on one length selected by the Surveyor at random. Where this test is satisfactory, the tests for the other lengths may be dispensed with.

3. For tests on the individual wires, a suitable length of a strand is to be cut off the rope and unstranded. The number of wires to be taken therefrom for tests is to be as specified in **Table 4.8.12**. Any straightening of test pieces which may be needed is to be done at the room temperature by a suitable method without injuring the test pieces.

4. The individual wire tests are to be carried out in accordance with the following requirements:

Table 4.8.11 Masses and Breaking Test Loads for Steel Wire Ropes

Grade	No.1		No.2		No.3		No.4		No.5		No.6		No.21	
Composition mark	(6 × 7)		(6 × 12)		(6 × 19)		(6 × 24)		(6 × 30)		(6 × 37)		(6 × WS(36))	
Diameter of steel wire rope (mm)	Breaking test load (kN)	Mass per metre in length (kg)	Breaking test load (kN)	Mass per metre in length (kg)	Breaking test load (kN)	Mass per metre in length (kg)	Breaking test load (kN)	Mass per metre in length (kg)	Breaking test load (kN)	Mass per metre in length (kg)	Breaking test load (kN)	Mass per metre in length (kg)	Breaking test load (kN)	Mass per metre in length (kg)
10	52.4	0.371	32.7	0.273	47.9	0.364	45.5	0.332	41.1	0.310	48.9	0.359	50.5	0.396
12	75.4	0.534	47.1	0.393	71.6	0.524	65.5	0.478	59.1	0.446	70.5	0.517	72.8	0.570
14	103	0.727	64.0	0.535	97.4	0.713	89.1	0.651	80.5	0.607	96.2	0.704	99.0	0.776
16	134	0.950	83.6	0.699	127	0.932	117	0.850	105	0.793	126	0.920	129	1.01
18	170	1.20	106	0.885	161	1.18	147	1.08	133	1.00	159	1.16	164	1.28
20	210	1.48	130	1.09	199	1.46	181	1.33	164	1.24	195	1.44	202	1.58
22	253	1.80	158	1.32	240	1.77	221	1.61	199	1.50	237	1.74	244	1.92
24	302	2.14	188	1.57	286	2.10	262	1.91	236	1.79	281	2.07	291	2.28
26	354	2.51	221	1.85	336	2.47	308	2.24	278	2.10	330	2.43	341	2.68
28	411	2.91	256	2.14	389	2.85	357	2.60	322	2.43	382	2.82	396	3.10
30	472	3.34	294	2.46	447	3.28	410	2.99	369	2.79	439	3.23	454	3.56
32	536	3.80	334	2.80	509	3.73	466	3.40	421	3.17	501	3.68	517	4.06
34	605	4.29	378	3.16	575	4.21	526	3.84	475	3.58	566	4.16	583	4.58
36	679	4.81	424	3.54	644	4.72	589	4.30	533	4.02	634	4.66	654	5.13
38	756	5.36	472	3.94	718	5.26	657	4.79	593	4.48	707	5.19	730	5.72
40	838	5.93	523	4.37	795	5.82	728	5.31	657	4.95	782	5.75	808	6.34
42					877	6.42	802	5.86	725	5.47	863	6.34	890	6.99
44					963	7.05	881	6.43	794	6.00	947	6.96	978	7.67
46					1050	7.70	963	7.03	869	6.56	1040	7.61	1070	8.38
48					1150	8.39	1050	7.65	945	7.14	1130	8.28	1140	9.12
50					1250	9.10	1150	8.30	1020	7.74	1230	8.98	1260	9.90
52							1230	8.98	1110	8.38	1320	9.73	1360	10.7
54							1320	9.68	1200	9.04	1420	10.5	1470	11.5
56							1420	10.4	1280	9.71	1530	11.3	1590	12.4
58							1530	11.2	1380	10.4	1650	12.1	1700	13.3
60							1640	12.0	1470	11.1	1760	12.9	1810	14.3
62							1750	12.8	1580	11.9	1880	13.8	1940	15.2
65							1920	14.0	1740	13.1	2070	15.2	2140	16.7

(1) *Wrapping Tests*

(A) In wrapping tests, the test pieces are to be wrapped at least eight times around the wire with the same diameter as the test piece. Where they are unwrapped, the number of broken test pieces is not to exceed the number given in **Table 4.8.13** except for the core of the strand.

(B) Where the test is not satisfactory, new test pieces of the required number may be prepared and retested. In this case, the number of broken test pieces including those of the first test is not to exceed the number given in **Table 4.8.13** except for the core of the strand.

Table 4.8.12 Number of Test Pieces for Individual Wires Tests

Grade	Composition mark	Number of test Pieces
No. 1	(6 × 7)	6
No. 2	(6 × 12)	12
No. 3	(6 × 19)	18
No. 4	(6 × 24)	12
No. 5	(6 × 30)	15
No. 6	(6 × 37)	18
No. 21	(6 × WS(36))	35

Table 4.8.13 Permissible Number of Failed Test Pieces in Individual Wire Test

Grade	Composition mark	Number	
		First test	Retest
No. 1	(6 × 7)	0	2
No. 2	(6 × 12)	1	3
No. 3	(6 × 19)	1	4
No. 4	(6 × 24)	1	3
No. 5	(6 × 30)	1	4
No. 6	(6 × 37)	1	4
No. 21	(6 × *WS* (36))	3	9

Table 4.8.14 Number of Twisting in Twisting Tests

Diameter of individual wire (*mm*)	Number of twisting
$0.26 \leq d \leq 1.0$	21
$1.0 < d \leq 2.3$	20
$2.3 < d \leq 3.7$	18
$3.7 < d \leq 4.5$	17

NOTES:
1. The figures in the Table are based on the twisting speed of 60 *r.p.m.*
2. Where it is necessary to modify the interval of the grips, the number of times of twisting is to be increased or decreased in direct proportion to the interval of the grips.

(2) *Twisting Tests*
(A) In twisting tests, the test piece with the length 100 times the diameter of the test piece is to be gripped hard at the ends, and then one end is to be revolved until the test piece is broken down. The tests are to show that no test piece has been broken down with the number of times of twisting not more than one-half of that specified in **Table 4.8.14** and the number of the test pieces which have been broken down with the number of times of twisting less than that specified in **Table 4.8.14** is not to be more than that given in **Table 4.8.13** except for the core of the strand.
(B) Where the test is not satisfactory, new test pieces of the required number may be taken and retested. Where, however, there is any test piece which has been broken down with the number of times of twisting not more than one-half of the specified number, the retest is not allowed. The retest is to show that no test piece has been broken down with the number of times of twisting not more than one-half of the specified number and the number of the test pieces including those of the first test which have been broken down with the number of times of twisting not less than the specified number is not to exceed the number given in **Table 4.8.13** except for the core of the strand.
(C) Where the test piece has been broken down at the parts of the grips, and the results of the test do not comply with the requirements, a retest may be allowed.

(3) *Inspection of Diameter*
(A) The diameters of individual wires are to be inspected at the time of other tests. The number of test pieces which fail to meet the requirements in **504. 1** are not to be more than given in **Table 4.8.13.** except for the core of the strand.
(B) Where any test piece fails to pass the inspection specified in (A), further inspection may be carried out on test pieces of the specified number. In this case, the total number of test pieces which fail to meet the requirements in **504. 1** in both inspections are not to be more than the number given in **Table 4.8.13**.

508. Inspection

Steel wire ropes will be accepted, where the results of the breaking and individual wire tests and the inspection of the dimensions and appearance of each length are satisfactory.

509. Marking

The steel wire ropes which have satisfactorily passed the tests and inspections are to be sealed with lead and affixed with this Society's brand, the test number and grade number on the lead.

SECTION 6
Fibre Ropes

601. Application

1. Hemp ropes and synthetic fibre ropes used for tow lines and mooring lines to be equipped on ships in accordance with the provisions in **Section 2** (hereinafter referred to as "**fibre rope**") are to comply with the requirements in this Section.

2. Filaments and fibre ropes having characteristics differing from those specified in this Section are to comply with the requirements in **101. 4**.

602. Kinds of fibre ropes

Fibre ropes are classified into 9 kinds as shown in **Table 4.8.15**.

603. Processes of manufacture

Synthetic fibre ropes are to be manufactured by approved processes at approved works.

Table 4.8.15 Kinds of Fibre Rope

Kind of fibre rope			Pilament (material)
Hemp rope			Manila hemp
Synthetic fibre rope	Vinylon rope	Grade 1 Grade 2	Vinylon
	Polyethylene rope	Grade 1 Grade 2	Polyethylene
	Polyester rope		Polyester
	Polypropylene rope	Grade 1 Grade 2	Polypropylene
	Polyamide rope		Polyamide

604. Materials

1. Hemp ropes are to be made of pure manila hemp not containing any other similar fibre.

2. Synthetic fibre ropes are to be made of pure filaments not containing any other filaments, which are not to be restored

605. Construction of fibre ropes and others

1. Hemp ropes are, in general, to be composed of three strands and synthetic fibre ropes are to be composed of three or eight strands.

2. Three strand ropes are, in general, to be made of strands twisted together with a Z lay, these strands themselves being made with an S lay. Eight strand ropes are, in general, to be formed of four pairs of strands, the pairs being constituted successively of two strands twisted in the S direction and than of two strands twisted in the Z direction.

3. The number of the yarns of a strand is to be same, and the dimensions and laying of the yarns composing ropes are to be uniform for the whole length of the rope.

4. The lead for the strand is, in general, to be below 3.2 times the nominal diameter for three strand rope and below 3.5 times the nominal diameter for eight strand rope.

5. Polyamide ropes are to be suitably heat treated by induction furnace or others to set the lay and obtain dimensional stability. Vinylon and polypropylene ropes may be subjected to suitable heat treatment,if necessary.

6. Synthetic fibre ropes may be subjected to resin treatment and dye treatment subject to the approval by the Society.

7. Oil of good quality is to be used in manufacturing hemp ropes. Ropes are not to contain excessive quantity of oil.

606. Diameter

The diameter of fibre ropes is to be measured on circumscribed circle of the ropes under the load equal to 5 % of the breaking test load specified in **Table 4.8.16** Its tolerance is to be ±3 % of its nominal diameter.

607. Breaking tests

Breaking tests for fibre ropes are to be carried out in accordance with the following requirements:

(1) One specimen is to be taken from each coil of the fibre ropes. Where fibre ropes are continuously manufactured by the same machine with the yarns of the same type and divided into several coils, one specimen may be taken from one coil of the ropes selected by the Surveyor at random.

(2) The length of the specimen is not to be less than 30 times the diameter of the hemp rope, but need not exceed one *metre*.

(3) Specimens for polyethylene and polypropylene ropes are to be subjected to breaking tests in as wet condition immediately after having been immersed in warm water at $35 \pm 2\,^{\circ}C$ for more than 30 *minutes*. For other fibre ropes than the above ropes, specimens are to be subjected to breaking tests in as dry condition at room temperature.

(4) The load at the time of breaking is not to be less than given in **Table 4.8.16**.

608. Inspection of appearance and dimensions

Fibre ropes are to be inspected on the appearance and dimensions and they are to be in good order.

609. Marking

The fibre rope which has satisfactorily passed the tests and inspections is to be sealed with lead and affixed with this Society's brand indicating compliance with the Rule requirements and the test number. Furthermore, diameter, mass, kind of ropes, coil length, manufacturing number and manufacturer are to be marked in proper way.

Table 4.8.16 Braking Test Loads for Fibre Ropes (kN)

Dismeter of rope (mm)	Hemp rope(1)	Synthetic fibre rope							Polyamide(1)
		Vinylon(1)		Polyethylene(2)		Poly-ester(1)	Polypropylene(2)		
		Grade 1	Grade 2	Grade 1	Grade 2		Grade 1	Grade 2	
10	7.06	9.32	15.7	9.71	12.7	15.6	10.8	12.7	18.1
12	9.90	13.4	21.8	13.9	17.7	22.0	15.7	17.7	27.5
14	13.1	17.9	28.4	18.6	23.5	29.2	20.6	23.5	36.6
16	16.9	22.9	36.3	23.8	29.4	37.5	26.5	29.4	46.9
18	21.0	28.6	45.1	29.7	37.3	46.7	32.4	37.3	58.3
20	25.6	34.8	54.9	36.1	44.1	56.8	39.2	44.1	70.9
22	30.5	41.6	65.7	43.1	54.9	67.8	47.1	54.9	84.6
24	35.9	48.8	77.5	50.7	63.7	79.6	54.9	63.7	100
26	41.6	56.7	89.2	58.8	73.5	92.4	63.7	73.5	116
28	47.8	65.1	103	67.5	83.4	106	73.5	83.4	132
30	54.3	74.0	117	76.3	97.1	121	83.4	97.1	151
32	61.2	83.5	131	86.5	108	136	94.1	108	170
35	72.3	99.0	155	102	127	161	111	127	201
40	95.4	127	198	131	164	206	142	164	258
45	119	157	247	163	203	260	177	203	321
50	144	191	300	198	250	312	214	250	390
55	173	228	358	237	294	373	255	294	466
60	203	269	421	279	348	438	300	348	547
65	235	312	487	324	402	508	348	402	635
70	271	358	559	371	461	583	399	461	729
75	307	407	635	422	525	663	453	525	829
80	346	459	716	476	593	747	511	593	935
85	387	514	801	533	667	837	572	667	1050
90	431	571	895	592	735	931	635	735	1170
95	477	632	981	655	814	1030	702	814	1280
100	525	694	1080	721	897	1140	772	897	1410

(Note)
(1) Breaking load at room temperature in dried condition.
(2) Breaking load at room temperature after having been immersed in warm water at 35 ± 2°C for more than 30 minutes.

SECTION 7
Hatch Tarpaulins

701. Application

1. Hatch tarpaulins to be equipped on ships in accordance with the provisions in **Ch 2** are to comply with the requirements in this Section or to be of equivalent quality.
2. The tests and inspections for hatch tarpaulins made of synthetic materials are to be to the discretion of this Society.

702. Grades

The grades of tarpaulins are as follows:

Grade A tarpaulins (Mark, *TA*)
Grade B tarpaulins (Mark, *TB*)

703. Materials

Tarpaulins are to be made from cloths woven with flax yarn or cotton yarn of good quality.

704. Sewing

The overlapping, sewing threads and method of sewing for the purpose of joining the cloths used for tarpaulins are to be to the satisfaction of the Surveyor.

705. Mass

The mass of cloths used for tarpaulins before waterproof treatment is not to be less than $650\,g/m^2$ for Grade A tarpaulins and $490\,g/m^2$ for Grade B tarpaulins. Where, however, the waterproof mediums other than tar are used, the minimum mass may be reduced to 85% of the above mass according to the characteristics of the mediums.

706. Tensile Tests

The strength of cloths used for tarpaulins before the waterproof treatment is not to be less than 80 kg for Grade A tarpaulins and 60 kg for Grade B tarpaulins in warp and woof, being tested with test pieces 30 mm wide and 200 mm long. Where, however, the waterproof mediums other than tar are used, the minimum strength may be reduced to 85% of the above value according to the characteristics of the mediums.

707. Waterproof treatments

1. Waterproof mediums are to be made of suitable tar, grease or chemicals.

2. Tarpaulins are to pass the waterproofness tests which the Surveyor considers appropriate.

3. The waterproof medium applied to the tarpaulin is to prove free from adhesion, cracking or any other defect on its surface where it is folded at the temperature which the Surveyor considers appropriate.

708. Making

For the hatch tarpaulins which have been satisfactorily tested and inspected, the Society's brand, manufacturer, test number and grade identification of the hatch tarpaulins are to be marked on suitable places of the hatch tarpaulins.

SECTION 8
Side Scuttles

801. Application

The side scuttles to be fitted up on ships according to the requirements in **Ch 4** (hereinafter referred to as "**side scuttle**") are to comply with the requirements in this Section or to be of equivalent quality.

802. Grades

Side scuttles are classified into the following three grades and divided into "**fixed type**" and "**hinged type**" according to the types of glass holders of the scuttles:

Grade A scuttle (Mark, *RPA*)
Grade B scuttle (Mark, *RPB*)
Grade C scuttle (Mark, *RPC*)

803. Construction and dimensions

The construction and dimensions of the main parts of the side scuttles are to be in accordance with the requirements in the following Sub-paragraphs and **Tables 4.8.17** to **4.8.20,** according to their nominal diameters and grades, and those of other parts are to be determined at the discretion of the Surveyor.

(1) *Construction of deadlights*
(A) Side scuttles are to be provided with deadlights of the types specified in **Table 4.8.21,** according to the grade of side scuttles.
(B) Deadlights are to be strongly ribbed on back surface and fitted up to the frames by strong hinges and provided with the means capable of being secured by bolts. They are also to be so constructed as to be kept watertight where closed, by means of antivulcanizing rubber packings of good quality fitted up on the grooves which are provided on the rims.
(C) Portable deadlights are to be so arranged as to be quickly closed and secured, and to be kept sufficiently watertight where closed.

Table 4.8.17 Grade A Side Scuttles (Fixed Type and Hinged Type)

Main parts of side scuttle				Nominal diameter of scuttle (mm)		
				200	250	300
Thickness of shell flange of scuttle frame (mm)				13	14	14
Glass holder and deadlight	Hinge	Outer diameter of hinge (mm)		36	40	40
		Diameter of hinge pin (mm)		18	20	20
	Pivot bolt	Nominal diameter of bolt (mm)		M 22	M 24	M 24
		No. of bolts	Glass holder	-	2	2
			Deadlight	2	3	3
		Outer diameter of hinge (mm)		32	38	38
		Diameter of hinge pin (mm)		16	19	19
	Thickness of deadlight (mm)			9	10	10
Strengthened glass		Diameter (mm)		212	262	312
		Thickness (mm)		12	15	15
Plug		Outer diameter (mm)		-	288	338
		Thickness (mm)		-	16	16

Table 4.8.18 Grade B Side Scuttles (Fixed Type and Hinged Type)

<table>
<tr><td colspan="5" rowspan="2">Main parts of side scuttle</td><td colspan="5">Nominal diameter of scuttle (mm)</td></tr>
<tr><td>200</td><td>250</td><td>300</td><td>350</td><td>400</td></tr>
<tr><td colspan="5">Thickness of shell flange of scuttle frame (mm)</td><td>10</td><td>11</td><td>11</td><td>12</td><td>13</td></tr>
<tr><td rowspan="8">Glass holder and deadlight</td><td rowspan="2">Hinge</td><td colspan="3">Outer diameter of hinge (mm)</td><td>32</td><td>36</td><td>36</td><td>36</td><td>40</td></tr>
<tr><td colspan="3">Diameter of hinge pin (mm)</td><td>16</td><td>18</td><td>18</td><td>18</td><td>20</td></tr>
<tr><td rowspan="6">Pivot bolt</td><td colspan="3">Nominal diameter of bolt (mm)</td><td>M 20</td><td>M 22</td><td>M 22</td><td>M 22</td><td>M 24</td></tr>
<tr><td rowspan="3">No. of bolts</td><td colspan="2">Glass holder</td><td>2</td><td>2</td><td>2</td><td>2</td><td>2</td></tr>
<tr><td rowspan="2">Dead-light</td><td>Fixed type</td><td>2</td><td>2</td><td>2</td><td>-</td><td>-</td></tr>
<tr><td>Hinged type</td><td>1</td><td>1</td><td>1</td><td>2</td><td>2</td></tr>
<tr><td colspan="3">Outer diameter of hinge (mm)</td><td>28</td><td>32</td><td>32</td><td>32</td><td>38</td></tr>
<tr><td colspan="3">Diameter of hinge pin (mm)</td><td>14</td><td>16</td><td>16</td><td>16</td><td>19</td></tr>
<tr><td colspan="5">Thickness of deadlight (mm)</td><td>6</td><td>7</td><td>7</td><td>7</td><td>8</td></tr>
<tr><td colspan="2" rowspan="2">Strengthened glass</td><td colspan="3">Diameter (mm)</td><td>212</td><td>262</td><td>312</td><td>362</td><td>412</td></tr>
<tr><td colspan="3">Thickness (mm)</td><td>10</td><td>12</td><td>12</td><td>15</td><td>15</td></tr>
<tr><td colspan="2" rowspan="2">Plug</td><td colspan="3">Outer diameter (mm)</td><td>234</td><td>286</td><td>336</td><td>386</td><td>438</td></tr>
<tr><td colspan="3">Thickness (mm)</td><td>5</td><td>6</td><td>6</td><td>6</td><td>7</td></tr>
</table>

Table 4.8.19 Grade C Bronze Side Scuttles (Fixed Type and Hinged Type)

<table>
<tr><td colspan="4" rowspan="2">Main parts of side scuttle</td><td colspan="5">Nominal diameter of scuttle (mm)</td></tr>
<tr><td>200</td><td>250</td><td>300</td><td>350</td><td>400</td></tr>
<tr><td colspan="4">Thickness of shell flange of scuttle frame (mm)</td><td>9</td><td>10</td><td>10</td><td>11</td><td>12</td></tr>
<tr><td rowspan="8">Glass holder and deadlight</td><td rowspan="2">Hinge</td><td colspan="2">Outer diameter of hinge (mm)</td><td>28</td><td>32</td><td>32</td><td>36</td><td>36</td></tr>
<tr><td colspan="2">Diameter of hinge pin (mm)</td><td>14</td><td>16</td><td>16</td><td>18</td><td>18</td></tr>
<tr><td rowspan="5">Pivot bolt</td><td colspan="2">Nominal diameter of bolt (mm)</td><td>M 16</td><td>M 20</td><td>M 20</td><td>M 22</td><td>M 22</td></tr>
<tr><td rowspan="2">No. of bolts</td><td>Glass holder</td><td>2</td><td>2</td><td>2</td><td>2</td><td>3</td></tr>
<tr><td>Deadlight</td><td>1</td><td>1</td><td>1</td><td>2</td><td>2</td></tr>
<tr><td colspan="2">Outer diameter of hinge (mm)</td><td>24</td><td>28</td><td>28</td><td>32</td><td>32</td></tr>
<tr><td colspan="2">Diameter of hinge pin (mm)</td><td>12</td><td>14</td><td>14</td><td>16</td><td>16</td></tr>
<tr><td colspan="3">Thickness of deadlight (mm)</td><td>5</td><td>6</td><td>6</td><td>7</td><td>7</td></tr>
<tr><td colspan="2" rowspan="2">Strengthened glass</td><td colspan="2">Diameter (mm)</td><td>212</td><td>262</td><td>312</td><td>362</td><td>412</td></tr>
<tr><td colspan="2">Thickness (mm)</td><td>10</td><td>10</td><td>10</td><td>12</td><td>12</td></tr>
<tr><td colspan="2" rowspan="2">Plug</td><td colspan="2">Outer diameter (mm)</td><td>232</td><td>284</td><td>334</td><td>386</td><td>436</td></tr>
<tr><td colspan="2">Thickness (mm)</td><td>4.5</td><td>4.5</td><td>4.5</td><td>6</td><td>6</td></tr>
</table>

(2) *Construction of plugs*

(A) In Grade A and Grade B scuttles of hinged type, plugs are to be provided.

(B) In Grade C scuttles, plugs are to be provided where considered necessary.

(C) Plugs are to have a good fit in their proper position from the inside of the ship, by means of the shoulder or other suitable appliances provided in the side scuttle frames. They are to be so fitted up that their outer surface is kept at least 3 mm inside from the outer surface of the scuttle frames.

Table 4.8.20 Grade *C* Aluminium Alloy Side Scuttles (Fixed Type and Hinged Type)

Main parts of side scuttle				Nominal diameter of scuttle (mm)			
				250	300	350	400
Thickness of shell flange of scuttle frame (mm)				15	15	16	17
Glass holder and deadlight	Hinge	Outer diameter of hinge (mm)		32	32	36	36
		Diameter of hinge pin (mm)		16	16	18	18
	Pivot bolt	Nominal diameter of bolt (mm)		TW 20	TW 20	TW 22	TW 22
		No. of bolts	Glass holder	2	3	3	3
			Deadlight	1	1	2	2
		Outer diameter of hinge (mm)		28	28	32	32
		Diameter of hinge pin (mm)		14	14	16	16
	Thickness of deadlight (mm)			8	8	8	8
Strengthened glass		Diameter (mm)		262	312	362	412
		Thickness (mm)		10	10	12	12
Plug		Outer diameter (mm)		284	334	386	436
		Thickness (mm)		4.5	4.5	6	6

(3) *Packing grooves*
The grooves which are provided on the rims of the glass holders and the deadlights are to be of 9 mm in surface breadth, 12 mm in bottom breadth and 6 mm in depth as far as possible.

(4) *Glass holders*
Glass holders of hinged type are to be fitted up to the frames by strong hinges and provided with the means capable of being secured by bolts. They are also to be so constructed as to be kept watertight where closed, by means of anti-vulcanizing rubber packings of good quality fitted up on the grooves which are provided on the frames.

(5) *Pivot bolts*
(A) The pivot bolts for glass holders and deadlights are to be secured to the frames by strong hinges.
(B) The lock nuts for Grade *A* scuttles are to be of such form that the deadlight and the glass holder can not be locked or unlocked without using spanners of square, hexagonal or other box type.
(C) The number of bolt and the diameters of bolts and bolt holes to fit the scuttles up to the ship's sides are to be as specified in **Table 4.8.21**.

804. Materials

1. The materials used for the construction of side scuttles are to comply with the requirements in **Table 4.8.22** according to the grades of side scuttles.

2. Where steel or iron is used, the side scuttles are to be galvanized.

3. The parts of aluminium alloy scuttles are to receive surface treatment according to *KS D* 8301 (*Anode Treated Coating*) or equivalent thereto. The surface treatment specified above is, in general, to comply with *0–9. K1 or S-14. K2* of *KS D* 8301 or equivalent thereto.

4. The materials specified in **Table 4.8.22** are to be tested in accordance with the following requirements. However, the steel plates used for the plugs of Grades *B* and *C* scuttles may be of the quality accepted by the Surveyor, provided that they are free from crack or any other defect.

(1) *Tensile tests*
For scuttle frames, glass holders and deadlights, one test piece is to be taken from each cast. Where the number of castings from one cast exceeds 50, an additional test pieces to be taken from each 50 castings or fraction thereof. For hinge pins, pivot bolts and plugs of Grade *A* scuttles, one test piece is to be taken from each 50 pieces or fraction thereof. The test pieces are to comply with the test requirements given in **Table 4.8.23**.

(2) *Bend tests*
For deadlights of cast steel or malleable cast iron, one test piece is to be taken from each cast. Where the number of castings from one cast exceeds 50, an additional test piece is to be taken from each 50 castings or fraction thereof. The test piece is to stand being bent cold to the angle specified in **Table 4.8.24**, without crack or any other defect on the out-

Table 4.1.21 Types of Deadlight and Demensions of Bolts

Nominal diameter of scuttle (*mm*)		200			250			300			350			400			Type of glass holder	Type of dead-light
Grade of scuttle	Bolt	Nominal dia. of bolt (*mm*)	Dia. of bolt hole (*mm*)	No.	Nominal dia. of bolt (*mm*)	Dia. of bolt hole (*mm*)	No.	Nominal dia. of bolt (*mm*)	Dia. of bolt hole (*mm*)	No.	Nominal dia. of bolt (*mm*)	Dia. of bolt hole (*mm*)	No.	Nominal dia. of bolt (*mm*)	Dia. of bolt hole (*mm*)	No.		
Bronze scuttle	Grade *A*	M20	22	9	M20	22	12	M20	22	12	–	–	–	–	–	–	Fixed	Hinged
		–	–	–	M20	22	11	M20	22	11	–	–	–	–	–	–	Hinged	
	Grade *B*	M16	18	9	M20	22	9	M20	22	9	–	–	–	–	–	–	Fixed	
		M16	18	8	M20	22	8	M20	22	8	M20	22	12	M22	24	12	Hinged	
	Grade *C*	M12	13	8	M16	18	8	M16	18	8	M20	22	12	M20	22	12	Fixed or Hinged	Hinged or Portable
Aluminium alloy scuttle	Grade *C*	–	–	–	M16	18	8	M16	18	8	M20	22	12	M20	22	12	Fixed or Hinged	

Table 4.8.22 Materials for Side Scuttle

Item	Grade of side scuttles			
	Bronze scuttle			Aluminium alloy scuttle
	Grade *A*	Grade *B*	Grade *C*	Grade *C*
Scuttle frame and glass holder	Gun-metal casting	Gun-metal casting	Gun-metal casting	Aluminium alloy casting
Deadlight	Gun-metal casting or steel casting	Malleable cast iron	Malleable cast iron	Aluminium alloy casting
Plug	Steel plate	Steel plate	Steel plate	Steel plate
Hinge pin and pivot bolt	Naval brass bar	Brass bar for forging	Brass bar for forging	Anticorrosive aluminium alloy bar
Nut and hook	Gun-metal casting	Gun-metal casting	Gun-metal casting	Aluminium alloy casting

Table 4.8.23 Mechanical Properties

Material	Tensile strength N/mm^2 [kgf/mm^2]	Elongation (%)	Test specimen
Gun-metal casting	245[25] min.	15 min.	R 14 A or R 14 B
Aluminium alloy casting	215[22] min.	10 min.	
Cast steel	410[42] min.	21 min.	
Malleable cast iron	275[28] min.	4 min.	
Naval brass bar	345[35] min.	20 min.	
Brass bar for forging	315[32] min.	15 min.	
Anticorrosive aluminium alloy bar	225[23] min.	-	
Steel plate	400[41] min.	18 min.(*)	R1

NOTE :
* Elongation of steel plate shows that in case of using test specimen R1

Table 4.8.24 Bending Tests

Item	Bend angle	Inside radius (*mm*)	Test piece (*mm*)		
			Breadth	Thickness	Length
Deadlight of cast steel	120°	25	25	20(Bend test piece R1)	220 or more
Deadlight of malleable cast iron	90°	40	16	10	220 or more

Table 4.8.25 Chemical Composition

<table>
<tr><th colspan="2">Chemical composition(%) / Material</th><th>Cu</th><th>Si</th><th>Fe</th><th>Mn</th><th>Mg</th><th>Zn</th><th>Ti</th><th>Cr</th><th>Al</th></tr>
<tr><td rowspan="2">Aluminium Alloycasting</td><td>①</td><td rowspan="2">0.10 max.</td><td rowspan="2">0.30 max.</td><td rowspan="2">0.40 max.</td><td>0.60 max.</td><td>3.5~5.5</td><td rowspan="2">0.10 max.</td><td rowspan="2">0.20 max.</td><td rowspan="2">—</td><td rowspan="4">Remainder</td></tr>
<tr><td>②</td><td>0.10 max.</td><td>9.5~11.0</td></tr>
<tr><td rowspan="2">Anticorrosive aluminium alloy bar</td><td>①</td><td rowspan="2">0.10 max.</td><td colspan="2">Total 0.45 max.</td><td>0.10 max.</td><td>2.2~2.8</td><td rowspan="2">0.10 max.</td><td rowspan="2">—</td><td>0.15~0.35</td></tr>
<tr><td>②</td><td>0.30 max.</td><td>0.40 max.</td><td>0.05~0.20</td><td>4.5~5.6</td><td>0.05~0.20</td></tr>
</table>

side of the bent portion. The sharp edge of the test pieces to be removed by filing or machining to a radius of 1.5 *mm*.

(3) *Chemical composition*
Chemical composition of aluminium alloy castings and anticorrosive aluminium alloy bars is to comply with the requirements in **Table 4.8.25**.

5. The glass of side scuttles is to be strengthened glass in accordance with *KS B* 8819 (*Strengthened Glass for Ship's Side Scuttles*) or equivalent thereto.

6. The clear glass used for side scuttles is to be perfectly plane one both sides and to have such transparency as may be acceptable in practical use and free from any injurious flaw, crack and bubble. The surface is to be finished with polishing and the edge with grinding.

805. Hydrostatic tests

Each side scuttle is to be tested hydrostatically without fitting plug and deadlight at a pressure of 0.1 *MPa*, for Grade *A* and Grade *B* side scuttles and 0.07 *MPa* for Grade *C* side scuttles, and to stand the test without leaking or any other defect.

806. Dispensation with tests

The material test and hydrostatic test for Grade *C* side scuttles may be dispensed with, where these scuttles have appropriate certificates accepted by this Society.

807. Marking

For the side scuttles which have been satisfactorily tested and inspected, the Society's brand, test number and grade identification of the side scuttles are to be stamped on suitable places of the side scuttles.

SECTION 9
Rectangular Windows

901. Application

1. The rectangular windows are to be of kind complying with the requirements in this Section or of kind equivalent or higher, rectangular windows other than specified in this section can be used where those are in accordance with the requirements in the International Guidances or the Guidances accepted by the Administration

2. Grade *E* rectangular windows and grade *F* rectangular windows are to be so arranged that the design pressure is less than the maximum allowable pressure determined according to their nominal sizes and grades.(See **903.** (2))

3. No rectangular windows is to be provided for spaces below the freeboard deck, the first tier superstructures and the first tier deckhouse considered buoyant in the stability calculations or which protects openings leading to spaces below the freeboard deck inside.

902. Grades

Rectangular windows are classified into the following two grades, divided into "fixed type" and "hinged type" according to the types of glassholders of the windows and divided into "bolted type" and "welded type" according to the method of fastening the windows.

(1) Grade *E* window(Mark *RPE*) (See **Table 4.8.26**)
(2) Grade *F* window(Mark *RPF*) (See **Table 4.8.27**)

903. Construction and dimensions

The construction and dimensions of the main parts of the rectangular windows are to be in accordance with the requirements in the following Sub-paragraphs and are determined in **Table 4.8.26** and **Table 4.8.27** in accordance with their nominal diameters and grades. Other parts are to be determined at the discretion of the Surveyor.

(1) Maximum allowable pressure
The maximum allowable pressure for rectangular window is to be in accordance with the requirements as given in **Table 4.8.26** and **Table 4.8.27**. Where one or both dimensions(width and height) of a window are different from those given in **Table 4.8.26** and **Table 4.8.27**, maximum allowable pressure(p) is to be determined using the following formula.

$$p = \frac{40000t^2}{\beta b^2} \quad (kPa)$$

t : glass thickness (mm)
β : factor obtained from the graph of **Fig. 4.8.3**
b : minor dimension of the window (mm)

(2) Design pressure and maximum allowable pressure of rectangular windows.
(A) The design pressure of rectangular windows is to be less than the maximum allow-

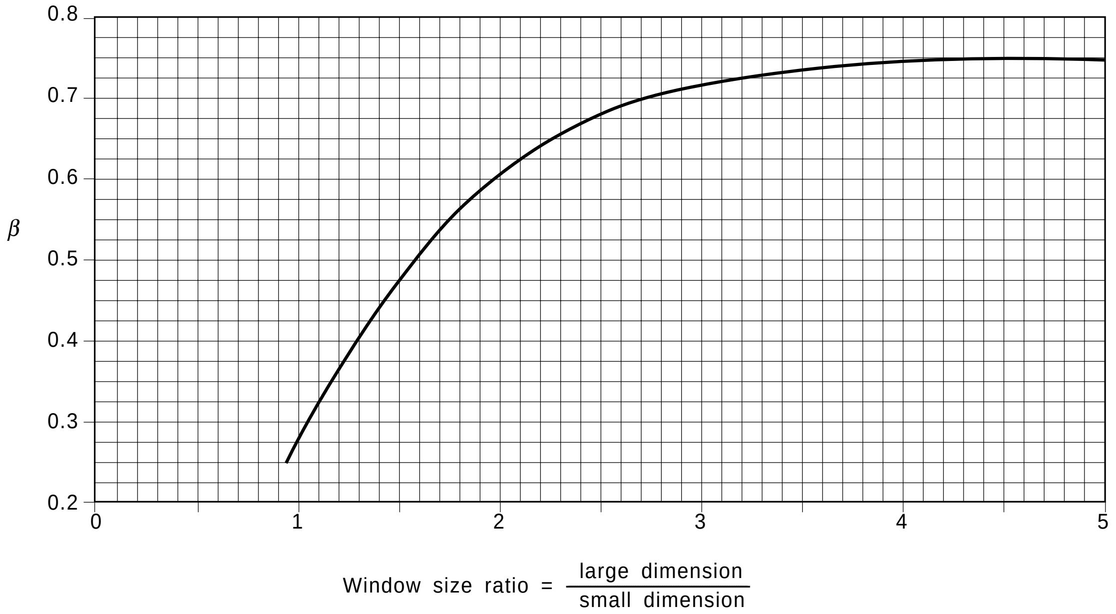


Fig. 4.8.3 Curve for determination of β based on window size ratio

Table 4.8.26 Grade E rectangular window

Items	Nominal size, width (mm) x height (mm)							
	300x425	355x500	400x560	450x630	500x710	560x800	900x630	1000x710
Maximum allowable pressure (kPa)	99	71	80	63	80	64	81	64
Glass thickness (mm)	10	10	12	12	15	15	19	19
Obscured glass thickness (mm)	15	15	19	19	-	-	-	-
Minimum number of fasteners	4	4	4	4	6	6	6	8

Table 4.8.27 Grade F rectangular window

Items	Nominal size, width (mm) x height (mm)								
	300x425	355x500	400x560	450x630	500x710	560x800	900x630	1000x710	1100x800
Maximum allowable pressure (kPa)	63	45	36	28	36	28	32	25	31
Glass thickness (mm)	8	8	8	8	10	10	12	12	15
Obscured glass thickness (mm)	12	12	12	12	15	15	19	19	-
Minimum number of fasteners	4	4	4	4	6	6	6	8	8

able pressure(See **Table 4.8.26** and **Table 4.8.27**) determined by their nominal sizes and grades. The design pressure(P) is to be determined using the following formula.

$$P = 10ac(bf - y) \quad (kPa)$$

a, b, c and f : As specified in **Pt 3, Ch 17, 201.**

y : Vertical distance from summer load line to sill of rectangular windows. Where timber load line is assigned, vertical distance from timber load line to sill of rectangular window. (m)

(B) Notwithstanding the provision of (A) above, the design pressure is not to be less than minimum design pressure as given **Table 4.8.28.**

(3) Glazing

(A) Appropriate glazing material resistant to sea water and ultraviolet light is to be used.

(B) Mounting

When glazing, glass pane is to be centralized in the glassholder of hinged type rectangular windows or in the main frame of fixed type rectangular windows so that there is the same clearance all round.

(4) Fasteners(closing device and hinge)

(A) The fasteners of glassholders and deadlights of grade E and F windows are to be made up of the closing devices and hinges with round hole, and the number should be not less than that in the **Table 4.8.26** and **Table 4.8.27.**

(B) The total number of the fasteners and their construction is to be such that the rectangular window meets the strength and watertightness requirements in **905.**

(C) Where the hole for the hinge of the glassholder and deadlight is oval, the hinge is not regarded as a fastener.

(5) Gaskets for glassholder and glass retaining frame

Appropriate gaskets are to be used to ensure watertightness of main frame and the glassholder and secured in the groove by means of a suitable adhesive.

(6) Fixing device

All hinged rectangular windows are to be provided with a fitted fixing device like hook.

Table 4.8.28 Minimum design pressure

Length of ship	$L \leq 250\ m$	$L > 250\ m$
Exposed front bulkhead of the first tier superstructure (kPa)	25 + L/10	50
Others (kPa)	12.5 + L/20	25

904. Materials

1. Main frame, glassholder and glass retaining frame

The materials used for the main components of the rectangular windows(such as main frame, glassholder and glass retaining frame) are to be in accordance with the requirements as given in **Table**

Table 4.8.29 Material

Type of rectangular window	Method of fastening the rectangular window	Material		
		Main frame	Glassholder	Glass retaining ring
Hinged	Bolted	Brass(1)		
		Aluminium alloy(1)		
	Welded	Mild steel	Brass(1)	
		Mild steel		Brass(1)
		Mild steel		
		Mild steel	Aluminium alloy(1)	
		Aluminium alloy (only wrought or extruded)	Aluminium alloy(1)	
Fixed	Bolted	Brass(1)	-	Brass(1)
		Aluminium alloy(1)	-	Aluminium alloy(1)
	Welded	Mild steel	-	Brass(1)
		Mild steel	-	Mild steel
		Mild steel	-	Aluminium alloy(1)
		Aluminium alloy (only wrought or extruded)	-	Aluminium alloy(1)
(Note) (1) The use of cast or wrought alloy is optional.				

4.8.29 and these materials are to have the following properties.

(1) resistant to corrosion
(2) minimum mechanical properties as given in **Table 4.8.30**(One tensile test specimen is to be taken from each cast. Where the number of castings from one cast exceeds 50, an additional specimen is to be taken from each 50 castings of fraction thereof).

Table 4.8.30 Tensile strength and elongation for the main components

Type of rectangular window	Tensile strength (N/mm^2) min.	Elongation (%) min.
Grade E	180	10
Grade F	140	3

2. Closing device and hinge pin

The materials used for bolts, pins and nuts of closing devices and hinge pins for glassholder are to have the following properties.

For aluminum alloy rectangular windows, the bolts (screw-in bolt or swingbolt) of closing device and the hinge pin of the glassholder are to be made of non-corrodible steel, stainless steel or such alloy which are not likely to cause corrosion of rectangular windows, bolts and pins.

(1) resistant to corrosion
(2) no effect on the corrosion resistance of other parts
(3) minimum mechanical properties as given in **Table 4.8.31**(One tensile test specimen is to be taken from each cast. Where the number of casting from one cast exceeds 50, an additional specimen is to be taken from each 50 castings of fraction thereof. For aluminum extruded shapes of aluminum alloy, the extruded shapes of the same dimensions, made from same cast and heat treated simultaneously, are treated as one lot and one tensile test specimen is to be taken from every lot. Where the number of extruded shapes from every lot exceeds 50, an additional specimen is to be taken from each 50 lots of fraction thereof.)

Table 4.8.31 Tensile strength and elongation for the closing device

Type of rectangular window	Swingbolt and pin, hinge pin		Nut	
	Tensile strength (N/mm^2) min.	Elongation (%) min.	Tensile strength (N/mm^2) min.	Elongation (%) min.
Grade E	350	15	250	14
Grade F	250	14	180	8

3. Glass panes

The glass of rectangular windows are to be in accordance with the requirements of the International Standard, or equivalent or higher standard.

4. Where steel or iron is used, the rectangular windows are to be galvanized.

905. Testing

1. Watertightness test

(1) On board test
To ensure that the fitted windows and packing are watertight, a hose test is to be carried out in accordance with **Pt 3, Ch 1, 209, 2.** (3).
(2) Shop test
Hydraulic test is to be carried out by the manufacturer before despatch by means of batch tests for about 10% of the delivery batch(a minimum of one window) at a test pressure of 25 kPa or the equivalent.

2. Mechanical strength test

A prototype rectangular window is to be subjected to a mechanical strength test by a suitable test method, applying a load equivalent to the following pressure.

Grade E window : 75 kPa

Grade F window : 35 kPa

3. Fire-resistant test

Rectangular window for fire-resistant construction is to be subjected to prototype testing and to comply with the requirements in **Pt 8, Ch 1.**

4. Heating test

Rectangular window for heating system is to be in accordance with the requirements of the International Standard, or equivalent or higher standard.

906. Dispensation with tests

The material test and hydraulic test for rectangular windows may be dispensed with, where these rectangular windows have appropriate certificates accepted by this Society.

907. Marking

For the rectangular windows which have been satisfactorily tested and inspected, this Society's brand, test number and grade identification of the rectangular windows are to be stamped on suitable places. ⚓

PART I

MACHINERY INSTALLATIONS

CHAPTER 1
GENERAL

SECTION 1
General

101. Application

1. The requirements of this Part apply to the machinery installations intended for the ships which have no special limitations for their service area and purpose. For machinery installations intended for the ships having any limitations for their service area or intended for the small ships, the requirements in this Part may be modified. Special consideration is to be given to the ships with any limitations for their purpose.
2. The machinery installations which do not comply with the requirements of this Part may be accepted, provided that they are considered acceptable by the Society.
3. For the strength and construction of the parts of machinery on which the requirements of the Rules cannot be applied, the manufacturer is to submit for approval the detailed methods of strength calculation and data to the Society and the reliability for the strength of the parts may be decided from the results of measuring strain or deformation of them by means of a proper loading method approved by the Society. For machinery of new design, the Society may request plans and design data of more detailed parts to be submitted in addition to those specified in the Rules.
4. Since the formulae for the strength of the parts of machinery in the Rules are based upon the consideration that there is no dangerous vibration in the installation within the range of operating speeds, the manufacturers of the machinery are required to pay special attention to this point and take responsibility in the application of these formulae.
5. For the purpose of determining the power of main and auxiliary internal combustion engines, the ambient reference conditions are to be such as given in **Table 5.1.1**. However, the engine manufacturers shall not be expected to provide simulated ambient reference conditions at a test bed.

Table 5.1.1 Ambient Reference Conditions

Description	Ambient reference conditions
Total barometric pressure	0.1 MPa
Air temperature	45 °C
Relative humidity	60 %
Sea water temperature (charge air coolant-inlet)	32 °C

102. Definitions

1. **The maximum continuous output of engine** is the maximum output at which the engine can run safely and continuously in the running condition at full load draught, in the engine for propulsion (hereinafter referred to as "**main engine**"). In the engine excluding main engine (hereinafter referred to as "**auxiliary engine**"), the maximum continuous output of engine is the maximum output at which the engine can run safely and continuously in the intended condition.
2. **Number of maximum continuous revolutions** is the number of revolutions at the maximum continuous output.
3. **Propeller shaft Kind 1** or **Stern tube shaft Kind 1** is the shaft which is provided with effective measures against corrosion by sea water, or the shaft which is made of approved corrosion resistance material. The propeller shaft or stern tube shaft other than specified above is Kind 2.
4. **Design pressure** is a pressure used in the calculations made to determine the scantlings of each component and is the maximum permissible working pressure to the component. However, the design pressure is to be not less than the highest set pressure of any relief valve.

5. **Essential auxiliaries** are the auxiliary machinery for important use, and are those for propulsion of ships and for safety of lives and ships, and those for facilities in relation to the purpose of ships.

6. **Boiler** is the plant which generates steam or hot water by means of flame, combustion gas or other hot gases, including the accessories.

7. **Main boiler** means the boiler used in moving the propulsion steam engines.

8. **Essential auxiliary boiler** means the auxiliary boiler other than the main boiler used in moving the essential auxiliaries.

9. **Exhaust gas boiler** is a boiler which generates steam or hot water solely by exhaust gas from internal combustion engine and has a steam space or a hot well and has an outlet of steam or hot water.

10. **Exhaust gas economizer** is the equipment without any steam space or hot well which generates steam or hot water solely by exhaust gas from internal combustion engine and supplies to other boiler.

11. **Thermal oil installation** is the arrangement in which thermal oil is heated and circulated for the purpose of heating cargo or fuel oil or for production of steam and hot water for auxiliary purpose.

12. **Pressure vessel** is a vessel which contains gas or liquid, intended for the pressure exceeding the atmospheric pressure at its top. It includes heat exchangers and does not contact with flame, combustion gas or hot gas.

13. **Dead ship condition** is the condition under which the main propulsion plant, boilers and auxiliaries are not in operation due to the absence of power.

14. **Piping system** is a general term of pipes, valves and pipe fittings.

103. Construction, materials and installation

1. The construction, installation, lubricating system and cooling system of machinery are to be such that they cause no hindrance to their proper operations under the condition as given in **Table 5.1.2**.

2. All components and systems of machinery are to be designed to ensure proper operation under the temperature conditions given in **Table 5.1.3**.

Table 5.1.3 Temperature conditions

Installed location		Temperature range (°C)
Air	In enclosed spaces	0 ~ 45(1)
	On machinery components, boilers in spaces subject to higher or lower temperature	According to specific local conditions
	On the open deck	-25 ~ 45(1)
Sea water	—	32(1)

NOTE:
(1) The Society may approve other temperatures in the case of ships intended for restricted service.

3. Means are to be provided to ensure that machinery installations can be brought into operation from the dead ship condition without external aid.

4. Materials intended for the main parts of machinery are to be of fine quality in accordance with the requirements of **Pt 2, Ch 1**. The process of manufacturing each part is to be in accordance with the best method based on the past experiences and results. The materials other than those prescribed in the Rules may, however, be used where sufficient data are submitted in connection with the design and are specially approved.

5. In order to maintain sufficient manoeuvrability of a

Table 5.1.2 Angle of inclination

Type of machinery installations	Angle of inclination (deg)(2)			
	Athwart-ships		Fore-and-aft	
	Static	Dynamic	Static	Dynamic
Main and auxiliary machinery	15	22.5	5(4)	7.5
Safety equipment (emergency power installations, emergency fire pumps and their devices) Switch gear(1) (electrical and electronic appliances and remote control systems)	22.5(3)	22.5(3)	10	10

NOTES:
(1) Up to an angle of inclination of 45° no undesired switching operation or operational changes may occur.
(2) Athwartships and fore-and-aft inclinations may occur simultaneously.
(3) In ships for the carriage of liquefied gases and of chemicals the emergency power supply must also remain operable with the ship flooded to a final athwartships inclination up to a maximum of 30 $degrees$.
(4) Where the length of the ship exceeds 100m, the fore-and-aft static angle of inclination may be taken as 500/L degrees.(L : Length of the ship as defined in **Part 3, Ch 1, 101.** of the Rules, m)

ship in all normal circumstances, the main propulsion machinery is to be capable of running astern. The main propulsion machinery is to be capable of maintaining in free route astern at least 70% of the ahead revolutions for a period of at least 30 *minutes*. The output astern which may be developed in transient conditions is to be such as to enable the braking of the ship within reasonable time. For the main propulsion systems with reversing gears, controllable pitch propellers or electric propeller drive, running astern is not to lead to the overload of propulsion machinery.

6. The rotating, reciprocating and high temperature parts and electrically charged parts are to be arranged with suitable protections for the safety of watchmen, operators or men neighbouring to these parts. Nuts of important parts and moving parts are to be well secured by effective means to prevent from slacking.

7. All surfaces of machinery installations with high temperature above 220°C e.g. steam, thermal oil and exhaust gas lines, silencers, exhaust gas boilers, turbo blowers, etc and which may be impinged as a result of leakage of flammable fluid, are to be effectively insulated with non-combustible material to prevent the ignition of combustible materials coming into contact with them. Where the insulation is oil absorbent or may permit the penetration of oil, the insulation are to be encased in steel sheathing or equivalent material.

104. Automatic control devices

Automatic or remote control devices for propelling machinery, essential auxiliaries or cargo handling gears, and specifically, the facilities of unmanned operation of engines are to be in accordance with the requirements of **Pt 6, Ch 2**.

105. Anti-freezing devices

The machinery fitted in ships which may serve in cold districts are to be provided with equipment for prompt starting and adequate devices to prevent the fuel oil or lubricating oil from coagulation. Suction and discharge openings to sea are to be suitably protected from becoming blocked up with ice. Ships equipped with anti-freezing device and desiring to be registered for "Ice strengthening" are to comply also with the requirements of **Pt 3, Ch 20**.

106. Communication between navigating bridge and machinery spaces

At least two independent means are to be provided for communicating orders from the navigating bridge to the position in the machinery space or in the control room from which the speed and direction of thrust of the propellers are normally controlled. One of these are to be an engine-room telegraph which provides visual indication of the orders and responses both in the machinery spaces and on the navigating bridge. Appropriate means of communication are to be provided from the navigating bridge and the engine-room to any other position from which the speed or direction of thrust of the propellers may be controlled.

107. Engineers' alarm

An engineers' alarm is to be provided to be operated from the engine control room or at the manoeuvring platform as appropriate and is to be clearly audible in the engineers' accommodation.

108. Ventilating systems in machinery spaces

Machinery spaces of Category A are to be adequately ventilated so as to ensure that when machinery or boilers therein are operating at full power in all weather conditions including heavy weather, an adequate supply of air is maintained to the spaces for the safety and comfort of personnel and the operation of the machinery. And other machinery space is to be adequately ventilated appropriate for the purpose of that machinery space.

109. Protection against noise

Measures are to be taken to reduce machinery noise in machinery spaces to acceptable levels as determined by the Administration. If this noise can not be sufficiently reduced, the source of excessive noise is to be suitably insulated or isolated or a refuge from noise is to be provided if the space is required to be manned. Ear protectors are to be provided for personnel required to enter such spaces, if necessary.

SECTION 2
Plans and Documents

201. Plans and documents

Before the work is commenced, the shipyards or the manufacturers of machinery are to submit plans in triplicate and a copy of documents, specified in this Section, to the Society for approval. Where, however, the machinery is considered acceptable by the Society or is of the similar model already approved by the Society, the submission of plans and documents may be partially or wholly omitted according to the discretion of the Society. The plans intended for approval are to be contained such descriptions to be clearly stated the materials used, scantlings, arrangements, method of fixing and other matters in compliance with the requirements of the Rules. The Society, where considered necessary, may require further plans and documents other than those specified in this Section.

202. Plans and documents to be submitted by the shipyard

1. Plans for approval

(1) Machinery room arrangement.
(2) Installation of main engine, reduction gear, reversing gear and boiler.
(3) Shaft arrangement.
(4) Various piping diagrams on board and in engine room of the ship.
(5) Details of fuel oil or lubricating oil tanks not built in as the part of hull.
(6) Refrigerant's pipe arrangement for cargo refrigerating installation.
(7) Welding details of main component parts of Class I and Class II piping systems.
(8) Calculation sheets for torsional vibration.
(9) List of spare parts (not required where included in the specification).

2. Documents

(1) Machinery part specification, and specification and instructions in connection with automation.
(2) List of particulars on main engine, boiler, shaft arrangement, main auxiliaries, etc. in engine room.
(3) Material specifications for main component parts.
(4) strength calculations for main component parts.

203. Plans and documents to be submitted by the manufacturers of internal combustion engines

1. Plans and documents for approval

(1) Bedplate or crankcase.[(1)]
(2) Thrust shaft and thrust bearing assembly.
(3) Thrust bearing bedplate.[(1)]
(4) Frame or column.[(1), (2)]
(5) Crankshaft, details (including balance weights, bolts and coupling bolts) and assembly, each cylinder No.
(6) Piping arrangements fitted to engines (including fuel oil, lubricating oil, cooling oil, cooling water, starting air systems and indicating diameter, materials and working pressure of pipes).
(7) Schematic diagram of engine control and safety system.
(8) Structural detail and arrangement of crankcase explosion relief valves.
(9) High pressure fuel oil pipe with its shielding and clamping.
(10) Arrangement of foundation bolts (for main engine with built-in thrust shaft only).
(11) Sectional assembly of exhaust gas turbo-charger.
(12) Material specifications of main parts (including all details for non-destructive tests and pressure tests).
(13) Welding details for main component parts.
(14) List of spare parts.

2. Plans and documents for reference

(1) Main particulars of engine (Kind, type, maximum continuous output, maximum continuous revolution, firing order, maximum pressure in cylinders, mean effective indicated pressure, brake mean effective pressure, weight of reciprocating parts of each cylinder, weight and diameter of flywheel, weight and radius of balance weight as well as its position, and specifications of exhaust gas turbocharger, etc., are to be stated).
(2) Longitudinal and transverse sectional assembly.
(3) Tie rod.
(4) Cylinder cover, assembly.
(5) Cylinder jacket or engine block.[(2)]
(6) Cylinder liner.
(7) Piston, crosshead, piston rod and connecting rod, assembly.
(8) Camshaft drive, assembly.
(9) Shielding and insulation of exhaust pipes, assembly.
(10) Data for vibration of engine (construction and arrangement of dampers, detuners, balancers or compensators, and data for torsional and axial vibration of shafting).
(11) Flexible mounting of engine(construction and arrangement of mountings, data for material characteristics and natural frequencies).
(12) Strength calculations for main component parts.
(13) Operation and service manuals.

NOTES:
(1) Approval refers to welded design only. For cast design, plans are to be submitted for reference.
(2) Plans are sufficient only for one cylinder.

204. Plans and documents to be submitted by the manufacturers of steam turbines

1. Plans for approval

(1) Sectional assembly.
(2) Turbine casings, rotors and turbine blades.
(3) Details of turbine installation.
(4) Sectional assembly of main condenser.
(5) Welding details for main component parts.
(6) List of spare parts.

2. Documents

(1) Main particulars of turbines at maximum continuous output (output, number of revolutions per minute of turbine rotor, steam pressure and tem-

perature in steam chests, vacuum of condenser or status of exhaust chamber).
(2) Critical speed of turbine rotors, number of blades in each stage, the number of nozzles in each stage and its arrangement, various piping diagrams, diagrams of control and safety device system, the other data where this Society considers necessary.
(3) Material specifications of main component parts.
(4) Data for torsional vibration of shaftings.
(5) Strength calculation for turbine rotors and blades.

205. Plans and documents to be submitted by the manufacturers of shafting system

1. Plans for approval

(1) Thrust shaft.
(2) Intermediate shaft.
(3) Propeller shaft.
(4) Stern tube, stern tube bearing and strut bearing.
(5) Coupling and coupling bolts.
(6) Propeller.
(7) List of spare parts.

2. Documents

(1) Specified data for the calculation of shaft system.
(2) Data regarding calculations for torsional vibration of shaftings.
(3) Strength calculations for main component parts.

206. Plans and documents to be submitted by the manufacturers of power transmission system

1. Plans for approval

(1) Sectional assembly.
(2) Construction plan for the main component parts for gears, gear shafts, flexible coupling and flexible shafts.
(3) Welding details for main component parts.
(4) Piping arrangements fitted to the power transmission system.
(5) List of spare parts.

2. Documents

(1) Main particulars (transmitted power and revolutions per minute for each pinion at maximum continuous output, number of teeth in each gear, module, pitch circle diameters, pressure angle of teeth, helix angles, face widths, centre distances, tool tip radius, shape of teeth backlash, amount of profile shift, amount of profile and tooth trace, finishing method of tooth flank, and its modification are to be stated).
(2) Material specifications for power transmitting parts (chemical properties, heat treatment, quality of material, mechanical properties and its test method are to be stated).
(3) Strength calculations for main component parts.
(4) Data for torsional vibration of shaftings.

207. Plans and documents to be submitted by the manufacturers of boilers, Class 1 and 2 pressure vessels

1. Plans for approval

(1) General arrangement of boiler and pressure vessel.
(2) Details of boiler shells and headers.
(3) Details of washers for mountings and nozzles.
(4) Arrangement and details for boiler tubes, superheater, reheater, economizer and/or exhaust gas heater.
(5) Arrangement or its diagrams for air preheater and boiler mountings.
(6) Assembly of safety valve.
(7) Systematic diagrams for automatic and remote control.
(8) Welding details of main component parts.
(9) List of spare parts.

2. Documents

(1) Main particulars (kind, type, design pressure and temperature, steam pressure and temperature at superheater outlet, maximum designed evaporation per hour, radiant heating surface, contact heating surface, temperature of feed water, furnace volume, fuel consumption at maximum evaporation, burning capacity and number of oil burners, setting pressure of safety valve are to be stated).
(2) Strength calculations for main component parts.

208. Plans and documents to be submitted by the manufacturers of essential auxiliaries

1. Plans for approval

(1) Sectional assembly (materials of main component parts are to be stated).
(2) List of spare parts.

2. Documents

(1) Main particulars (kind of prime mover, output, number of revolutions,capacity, and principal dimensions are to be stated).

SECTION 3
Tests and Inspections

301. Shop Tests

Before installation on board, machinery installations are to be tested and inspected at the plant provided with sufficient facilities necessary for the tests in accordance with the relevant requirements of each Chapter and shop trials deemed appropriate by the Society are to be carried out.

302. On board tests

After installation on board, machinery installations are to be tested and inspected in accordance with the relevant requirements of each chapter, and those are to be verified at the sea trials that they have normal functions and are free from excessive vibrations.

303. Omission of tests

Where auxiliaries or materials have certificates which are considered appropriate by the Society, a part or all of the tests may be omitted.

304. Additional tests

The Society may require, when deemed necessary, other tests and inspections than those prescribed in this Part or the records of the tests carried out by the manufacturer.

305. Inspections based on Quality Assurance Scheme for Machinery

Where the machinery installations are manufactured by quality assurance scheme specified in **Guidance for Approval of Manufacturing Process and Type Approval, Etc.,** a part or all of tests may be omitted.

SECTION 4
Spare Parts and Tools

401. Application

1. In general the spare parts and tools mentioned in the following Article are to be furnished in the engine room or other convenient places on board. The ships restricted in service area are to comply with the special requirements given by the Society.

2. Where two or more machinery of same dimension, type and for same service are installed and their parts are exchangeable, the spare parts for one machinery may be acceptable. Where the number of the machinery of about equal capacity under the normal service condition exceeds the required number, no spare parts are required for the machinery.

402. Internal combustion engines

Description and number of spare parts for main and essential auxiliary engines are to be as given in **Table 5.1.4**.

403. Steam turbine

Description and number of spare parts for main and essential auxiliary steam turbines are to be as given in **Table 5.1.5**.

404. Shafting and power transmission system

Description and number of spare parts for shafting and power transmission system are to be as given in **Table 5.1.6**.

405. Boiler

Description and number of spare parts for boilers are to be as given in **Table 5.1.7**.

406. Essential Auxiliary

Description and number of spare parts for essential auxiliaries are to be as given in **Table 5.1.8**.

407. Tools and Instruments

All ships are to be provided with various tools and instruments as shown in **Table 5.1.9** ⚓

Table 5.1.4 Spare Parts for Internal Combustion Engines

Item	Remarks	Number required	
		Main engine	Aux. engine
Cylinder cover	Cylinder cover, complete with all valves, joint rings and gaskets. (For engine without covers, the respective valves)	1	—
	Cylinder cover bolts and nuts, for one cylinder	1/2 set	—
Cylinder liner	Cylinder liner, complete with joint rings and gaskets	1	—
Pistons	Crosshead type: Piston of each type fitted, complete with piston rod, stuffing box, skirt, rings, studs and nuts	1	—
	Trunk piston type: Piston of each type fitted, complete with skirt, rings, studs, nuts, gudgeon pin and connecting rod.	1	—
Piston rings	Piston rings for one cylinder	1set	1set
Piston cooling	Telescopic cooling pipes and fittings or their equivalent, for one cylinder unit	1set	1set
Cylinder valves	Exhaust valves, complete with casings, seats, springs and other fittings for one cylinder	2sets	2sets
	Air inlet valves, complete with casings, seats, springs and other fittings for one cylinder.	1set	1set
	Starting air valve, complete with casing, seat, springs and other fittings	1	1
	Relief valve, complete with casing, springs and other fittings	1	1
	Fuel valves, complete with casings, springs and other fittings for one engine (For engine with 3 or more fuel valves per cylinder, 2 fuel valves complete per cylinder and other fuel valves need no casing)	1set	1/2set
Fuel injection pumps	Fuel injection pump, complete. When replacement at sea is practicable, a complete set of working parts for one pump (plunger, sleeve, valves, springs, etc.)	1	1
Fuel injection piping	High pressure fuel pipe of each size and shape fitted, complete with couplings	1	1
Main bearings	Main bearings or shells for one bearing of each size and type fitted, complete with shims, bolts and nuts	1set	1set
Connecting rod bearings	Bottom-end bearings or shells of each size and type fitted, complete with shims,bolts and nuts for one cylinder	1set	1set
	Top-end bearings or shells of each size and type fitted, complete with shims, bolts and nuts for one cylinder	1set	1set
	Trunk piston type: Gudgeon pin with bush for one cylinder	—	1set
Cylinder lubricators	Lubricator, complete, of the largest size, with its driving chain or gear wheels	1	—
Scavenging system	Suction and delivery valves for one pump of each type fitted, complete	1set	—
Gaskets and packings	Special gaskets and packings of each size and type fitted, for cylinder covers and cylinder liner for one cylinder	—	1set

Table 5.1.5 Spare Parts for Steam Turbines

Item	Remark	Number required
Main bearings	Bearing bushes or roller bearings of each size and type fitted for the shafts of the turbine rotor and of the reduction gear, if any, for one engine	1
Turbine thrust	Pads for one face of tilting pad type thrust with liners, or rings for turbine adjusting block with assorted liners, for one engine. When the pad of one face differ from those of the other, a complete set of pads is to be provided.	1 set
Turbine shaft	Carbon sealing rings, where fitted, with springs for each size sealing rings and type of gland, for one engine	1 set
Oil filters	Strainer baskets or inserts, for filters of special design, of each type and size	1 set

Table 5.1.6 Spare Parts for Shafting System

Item	Remark	Number required
Main thrust bearing	Pads for one face of tilting pad type thrust with liners, or rings for turbine adjusting block with assorted liners, for one engine. When the pad of one face differ from those of the other, a complete set of pads are to be provided.	1 set
	Complete thrust shoe for one face of solid ring type	1
	Inner and outer race with roller, where roller thrust bearings are fitted	1
Reduction and/or reverse gear	Complete bearing bush, of each size fitted in the gear case assembly	1 set
	Roller or ball race, of each size fitted in the gear case assembly	1 set

Table 5.1.7 Spare Parts for Boilers

Item	Remarks	Number required
Safety valve spring of each size	Including superheater safety valve springs	1
Oil burner nozzles, complete, for one boiler		1 set
Round type water gauge glasses	Including packings	12
Flat type water gauge glasses		2
Flat type water gauge frame		1
Smoke tubes and stay tubes	For each size	5% of total number of tubes for one boiler
Water tubes and superheater tubes	For each size	5% of total number of tubes for one boiler

NOTES:
The number of water gauge glasses of round type and flat type are required to be the number in this Table for each boiler. The number of flat type water gauge frames is required to be one for two boilers.

Table 5.1.8 Spare Parts for Essential Auxiliaries

Item	Remarks	Number required
Piston pumps	Valves with seats and springs of each size fitted	1 set
	Piston rings of each type and size for one piston	1 set
Central and gear type pumps	Bearing of each type and size	1
	Rotor sealings of each type and size	1
Compressors for essential service	Piston rings of each type and size for one piston	1 set
	Suction and delivery valves complete of each size	1/2 set

NOTES:
1. When sufficiently rated stand-by pump is available, the spare parts for other pumps except for bilge pump may be dispensed.
2. Where the stand-by cooling pumps, stand-by lubricating pumps or stand-by fuel oil supply pumps are not provided in accordance with the requirements of **Ch 6. 702. 7, 801. 3** and **903. 1,** one complete spare of each pump is to be carried on board.

Table 5.1.9 Tools and Instruments

Item	Remarks		Number required
Tube stoppers or plug	For main boiler and essential auxiliary boilers (including those for super-heater and economizer tube)	Water tube boilers	12 for each size
		Other type boilers	12 for each size
Tube expanders	For main boiler and essential auxiliary boilers		1 for each size
Standard pressure gauge	For all boilers, gauge tester will be aceptable		1
Water tester	For all boilers, two salinometer will be acceptable		1
Special tools and instruments for maintenance or repair work of the machinery			1set

CHAPTER 2
MAIN AND AUXILIARY ENGINES

Section

SECTION 1
General

101. Application

1. The requirements of this Chapter apply to main engines and auxiliary engines driving generators and essential auxiliaries. For the small auxiliary engines and emergency generator driving engines, some requirements of this Part may be modified appropriately provided that the Society considers it acceptable.

2. Engines driving generators for electric propulsion are to comply with the requirements in **Pt 6, Ch 1, Sec 17**, in addition to the relevant requirements of this Chapter.

3. Internal combution engines driving emergency generators are to comply with the requirements in **Pt 6, Ch 1, Sec 14**.

4. Piping arrangements

Piping arrangements are also to comply with the requirements of **Ch 6** in addition to the requirements of this Chapter.

5. Welding

Where main component parts of engines are to be welded, the Society, when considered necessary, may request preliminary tests or appropriate form of tests in connection with the work before the work is commenced. Welding methods, etc., are also to be approved. These requirements are also applicable in case of welding repairs to these parts.

6. Instruments

Tachometers, pressure gauges and thermometers which are necessary for safe operation are to be provided on main propulsion and auxiliary engines.

SECTION 2
Internal Combustion Engines

201. Materials

1. Tests

Materials intended for the parts marked in **Table 5.2.1** are to be tested and inspected in the presence of Surveyors and to comply with the requirements of **Pt 2, Ch 1**.

2. Cylinders, cylinder liners, cylinder covers, pistons and other parts subject to high temperature or pressure are to be of materials suitable for the stress and temperature to which they are exposed.

202. Construction and installation in general

1. Frames and bedplates are to be of rigid and oiltight construction and the bedplate is to be provided with a sufficient number of holding down bolts to thoroughly secure it to the engine seatings. Resin chocks subjected to the approval by the Society or flexible mounting may be used.

2. Where the structures above engines and their surroundings are constructed with inflammable materials such as wood and the like, adequate measures are to be for the protection against fire.

3. Exhaust gas turbo-charger

(1) Engines for propulsion purpose fitted with exhaust gas turbo-charger are to be so arranged that the ship can proceed with safe voyage in case of failure in the part of the turbo-chargers.

(2) Where main engine can not be operable only with the exhaust gas turbo-chargers in case of starting or low speed range, the auxiliary scavenging blower is to be provided. Means are to be provided so that the engine can be started and operated in case of failure of the scavenging blowers.

Table 5.2.1 Tests

No.	Component parts	Material test	Magnetic particle test or liquid penetrant test	Ultrasonic test
1	Crank shafts (Solid forged shaft or arm, pin and journal of built up shaft)	○	○	○
2	Crank shaft coupling flanges (non-integral) for main power transmission and coupling bolts	□	—	—
3	Steel piston crowns	□	□	○
4	Piston rods	□	□	□
5	Connecting rods	○	○	□
6	Crossheads	□	—	—
7	Cylinder liners (steel parts)	△	—	—
8	Steel cylinder covers	△	□	○
9	Bed plates and thrust blocks of welded construction, plates and transverse bearing girders made of forged or cast steel	○	○	○
10	Frames and crankcases of welded construction	○	○	○
11	Tie rods	○	□	—
12	Supercharger shaft and rotor, including blades	△	—	—
13	Bolts and studs for cylinder covers, crossheads, connecting rod bearing, and main bearings	△	□	—
14	Steel gear wheels for camshaft drive	□	□	—

NOTES:
1. Where, mark ○ for the parts of all engines, △ for the parts of engines with cylinders over 300mm in diameter, □ for the parts of engines with cylinders over 400mm in diameter, — for the parts of engines need not to be tested.
2. Supercharger described 12 is understood as turbo-chargers and engine driven compressors (including "root blowers"), but not auxiliary blowers.
3. This table does not apply to the internal combustion engines and superchargers which are manufactured in the way of mass produced methods.

4. Fuel oil valve

Fuel oil injection valves to cylinders are to be arranged operable by hand or other means without interrupting the oil supply, while the engine stops.

5. Starting arrangement

(1) Where compressed air is used for engine starting, the starting arrangements are to comply with the requirements of **Ch 6, Sec 10.**

(2) Where the main engine is arranged for electric starting, two separate batteries are to be fitted and connected in parallel. Each battery is to be capable of starting the main engine when in cold and ready to start conditions and the combined capacity of the batteries is to be sufficient without recharging to provide within 30 minutes the number of starts of main engines as required in **Ch 6, 1001. 1.**

(3) Where the auxiliary engine is arranged for electric starting, two separate batteries are to be fitted. The capacity of the batteries for starting the auxiliary engine is to be sufficient for at least three starts for each engine when in cold and ready to start conditions. In the case of a single auxiliary engine only one battery may be required.

(4) Electric starting arrangements for auxiliary engines may be supplied by separate circuits from starting batteries of the main engine when such are provided. In this case, the capacity of the batteries for starting the main engine is to be more than sum of the capacity required in (2) and (3) above, and the amount consumed for engine monitoring purposes.

(5) The starting batteries are to be used for starting and the engine's own monitoring purposes only. Provision is to be made to maintain continuously the stored energy at all times.

(6) Starting arrangement and capacity of prime movers driving emergency generating sets are to be in accordance with the requirements in **Pt 6, Ch 1, Sec 14**.

6. Lubricating oil arrangements

(1) Where the crank cases are of closed type, they are to be arranged so that the contained oil may be drained at any time. Lubricating oil drain pipes from the engine sump to the drain tank are to be submerged at their outlet ends.

(2) Lubricating oil pipe lines are to be provided with a pressure gauge or other appropriate means

at a suitable position to indicate that the proper circulation is maintained.

(3) Lubricating devices for rotor shafts of exhaust gas turbochargers are to be designed so that the lubricating oil may not be drawn into the charging air.

7. Cooling arrangements

(1) Provision is to be made for an uniform supply of cooling water or oil to each cylinder and piston. Drain cocks are to be fitted to water jackets and water pipe lines at their lowest positions.

(2) Cooling water from each cylinder is to be arranged to discharge from the highest position and thermometer is to be fitted at the outlet.

203. Safety devices

1. Each main engine is to be provided with a speed governor so adjusted that the engine speed can not exceed the maximum continuous revolutions by more than 15 %. In addition to the normal governor, each main engine having a maximum continuous output of 220 kW [300 PS] and above, and which can be declutched or which drives a controllable pitch propeller, is to be provided with a separate over-speed protective device so adjusted that the speed can not exceed the maximum continuous revolutions by more than 20 %.

2. Engines driving ship service generators are to be provided with governors complying with the requirements of **Pt 6, Ch1, 202.2** and **3**. In addition to the normal governor, each auxiliary engine driving electric generator and having a maximum continuous output of 220 kW [300 PS] and above is to be provided with a separate overspeed protective device so adjusted that the speed can not exceed the maximum continuous revolutions by more than 15 %.

3. Each cylinder of engines having a bore exceeding 230 mm is to be provided with a relief valve adjusted to operate at not more than 40 % above the combustion pressure at the maximum continuous output. However, the relief valves may be replaced by effective warning devices of an approved type for overpressure in each cylinder.

4. Crankcase door

Crankcase and crankcase doors are to be of sufficient strength, and crankcase doors are to be fastened securely enough, so that they may not be readily displaced by an explosion. A warning notice is to be fitted either on the control stand or, preferably, on a crankcase door on each side of the engine. This warning notice is to state as follows. "Whenever overheating is suspected within the crankcase, the crankcase doors or sight holes are not to be opened before a reasonable time sufficient to permit adequate cooling after stopping the engine."

5. Relief valve of crankcase

Engines having a cylinder bore of 200 mm and above or a crankcase volume of 0.6 m^3 and above are to be provided with relief valves of an approved type, as follows, for the purpose of relieving the excess pressure in the event of an internal explosion.

(1) Crankcase relief valves are to be designed and built to open quickly at an overpressure not more than 0.02 MPa in the crankcase and to close quickly and automatically in the crankcase.

(2) The number and location of the relief valves are as follows.

(a) Engines having cylinder bore not exceeding 250 mm are to have at least one valve near each end, but, over eight crankthrows, an additional valve is to be fitted near the middle of the engine.

(b) Engines having a cylinder bore exceeding 250 mm but not exceeding 300 mm are to have at least one valve in way of each alternate crank-throw, with a minimum of two valves.

(c) Engines having a cylinder bore exceeding 300 mm are to have at least one valve in way of each main crankthrow.

(3) The free area of each relief valve is not to be less than 45 cm^2. The combined free area of the valves fitted in an engine is not to be less than 115 cm^2 per cubic metre of the crankcase gross volume. The volume of the fixed parts in the crankcase or separate space prescribed above may be deducted in estimating the gross volume.

(4) Crankcase relief valve discharges are to be properly shielded in order to reduce the possible danger from emission of flame.

6. Joining together of ventilating pipes of two or more engines is not permitted, nor interconnection of crankcases by oil drain pipes. Ventilation of crankcase and any arrangement which could produce a flow of external air within the crankcase, is forbidden except cases of (1) and (2) below.

(1) Vent pipes, where provided, are to be as small as practicable to minimize the inrush of air after explosion. Vent pipes from crankcase of propulsion engines are to be led to a safe position on deck or other approved positions.

(2) If a forced extraction of the gases from the crankcase is provided (e. g. for smoke detection purpose), the vacuum in the crankcase is not to exceeds 25 mm of water.

7. Additional relief valves are to be fitted in separate spaces of crankcase such as gear or chain case of camshaft or similar drives, when the gross volume of such spaces exceeds 0.6 m^3.

8. Protective devices for scavenge manifolds

(1) For crosshead type engines, scavenge spaces in open connection to the cylinders are to be connected to an approved fire extinguishing system, which is to be entirely separate from the fire extinguishing system of the engine room.

(2) Scavenge spaces in open connection to the cylinders are to be provided with explosion relief valves for preventing an overpressure in the event of explosion and minimizing the possibility of injury to personnel.

9. The starting air mains are to be protected against the explosion arising from improper functioning of starting valves by the following arrangements:

(1) An isolating non-return valve or equivalent thereto is to be provided at the starting air supply connection to each engine.

(2) In direct reversing engines having a main starting manifold, a bursting disc or flame arrester is to be fitted at the starting valve on each cylinder; in non-reversing engines having a main starting manifold, at least one such device is to be fitted at the supply inlet to the starting air manifold on each engine. However, the above mentioned device may be omitted for engines having bore not exceeding 230 mm

10. Alarms of lubricating oil system

Lubricating system to be used for main and auxiliary engines above 37 kW [50 PS] is to be provided with alarm devices which give visual and audible alarm in the event of failure of lubricating oil pressure supply or appreciable reduction in pressure of the lubricating oil supply.

11. All external high pressure fuel delivery lines between the high pressure fuel pumps and fuel injectors are to be protected with a jacketed piping system capable of containing fuel from a high pressure line failure. A jacketed pipe is to incorporate an outer pipe into which the high pressure fuel pipe is placed forming a permanent assembly. The jacketed piping system is to include a means for collection of leakages and arrangements are to be provided for an alarm to be given in case of a fuel line failure. If flexible hoses are used for shielding purpose, these are to be of an approved type. An alternative means of jacketed pipe is to be in accordance with the requirements which the Society considers appropriate.

204. Crank shafts

1. Application

The following requirements are to be applied to the crank shafts of diesel engines. For the crank shafts of internal combustion engines other than diesel engines, special consideration will be given.

2. Required diameter

The required diameter of crank pins or journals is not to be less than that given by the following formula:

$$d_c = \left\{ D^2 (M + \sqrt{M^2 + T^2}) \right\}^{\frac{1}{3}} \quad (mm)$$

$$M = 10^{-2} APL$$

$$T = 10^{-2} BP_i S$$

where:

D = Diameter of cylinder (mm).
S = Length of stroke (mm).
L = Span of bearings adjacent to crank measured from centre to centre (mm).
P = Maximum pressure in cylinder (MPa).
P_i = Indicated mean effective pressure (MPa).
A and B = Coefficients given in **Table 5.2.2** for engines having equal firing intervals (in case of vee engines, equal firing intervals on each bank). Special consideration will be given to the values of A and B for engines having unequal firing intervals or not covered by the **Table**.

205. Dimensions of crank arms

1. Solid shaft

For solid shafts, the thickness and breadth of crank arms are to comply with the following formula or the conditions shown in **Fig. 5.2.1** in connection with the diameters of crank pin and journal. However, the thickness of crank arms is not to be less than 0.36 times the diameter of crank shaft. When the actual diameter of crank shaft is larger than the minimum required diameter of crank shaft, the left side of the following formula may be multiplied by $(d_c/d)^3$.

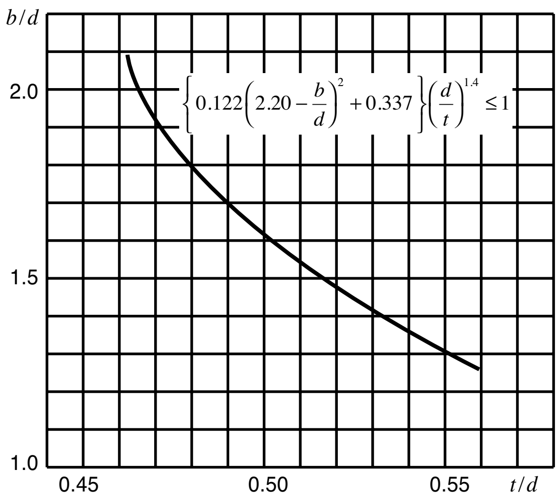


Fig. 5.2.1 Relationship between b/d and t/d

Table 5.2.2 Coefficients A and B

(1) Single Acting In-line Engine

Number of cylinders		1	2	3	4	5	6	7	8	9	10	11	12
2-stroke cycle	A	1.00											
	B	8.8	8.8	10.0	11.1	11.4	11.7	12.0	12.3	12.6	13.4	14.2	15.0
4-stroke cycle	A	1.25											
	B	4.7	4.7	4.7	4.7	5.4	5.4	6.1	6.1	6.8	6.8	7.4	7.4

(2) Single Acting Vee Engine with Parallel Connecting Rods

	Number of cylinders	Minimum firing interval between two cylinders on one crank throw											
		45°		60°		90°		270°		300°		315°	
		A	B	A	B	A	B	A	B	A	B	A	B
2-stroke cycle	6	1.05	17.0	1.00	12.6	1.00	17.0						
	8		17.0		15.7		20.5						
	10		19.0		18.7		20.5						
	12		20.5		21.6		20.5						
	14		22.0		21.6		20.5						
	16		23.5		21.6		23.0						
	18		24.0		21.6		23.0						
	20		24.5		24.2		23.0						
4-stroke cycle	6	1.60	4.1	1.47	4.0	1.40	4.0	1.40	4.0	1.30	4.4	1.20	4.3
	8		5.5		5.5		5.5		5.5		5.3		5.2
	10		6.7		7.0		6.5		6.5		6.1		5.9
	12		7.5		8.2		7.5		7.5		6.9		6.6
	14		8.4		9.2		8.5		8.5		7.5		7.3
	16		9.3		10.1		9.5		9.5		8.2		7.9
	18		10.1		11.1		10.5		10.5		8.8		8.5
	20		11.5		14.0		11.5		11.5		9.5		9.2

$$\left\{0.122(2.20-b/d)^2+0.337\right\}(d/t)^{1.4}\leq 1$$

where:

b = Breadth of crank arm (mm).
t = Thickness of crank arm (mm).
d = Actual diameter of crank pin or journal (mm).
d_c = Minimum required diameter of crank shaft (mm).

2. The fillet radius at the root of crank arms with crank pins or journals in solid crank shaft is not to be less than 0.05 times the actual diameter of the crank pins or journals respectively.

3. Semi-built-up crank shaft

In semi-built-up crank shafts, the dimensions of crank arms in way of the shrinkage fit are to comply with the following formulae. However, the dimensions of crank arms in way of the fillet parts with crank pin are to be in accordance with the requirements of **Pars 1** and **2**.

$$t_1 \geq \frac{C_1 T D^2}{C_2 d_h^{\,2}} \times \frac{1}{\left(1-\dfrac{1}{A_s^{\,2}}\right)}$$

$$t_2 \geq 0.525 d_c$$

where:

t_1, t_2 = Thickness of crank arm measured parallel to the axis (mm).
C_1 = 10 for 2 cycle in-line engines.

= 16 for 4 cycle in-line engines.

T = $10^{-2}\ BP_iS$ (see **204. 2**).

C_2 = 12.8 α − 2.4 α^2, but in case of the hollow shaft, C_2 is to be multiplied by $(1-R^2)$.

$$\alpha = \frac{\text{Shrinkage interference}}{d_h} \times 10^3$$

$$R = \frac{\text{Inside Diameter}}{\text{Outside Diameter}} \text{ for hollow shafts.}$$

d_h = Diameter of the hole at shrinkage fit (mm).

$$A_s = \frac{\text{External diameter of arm}}{d_h}$$

d_c = Minimum required diameter of crank shaft specified in **204.2** (mm).

4. Built-up crank shaft

In built-up crank shafts, the dimensions of crank arms in way of the shrinkage fit are to be in accordance with the requirements of **Par 3**.

5. Shrinkage interference

In case of built-up or semi-built-up crank shafts, crank arms are to be securely shrunk on the crank pins or journals. The shrinkage interference "α_s" is to be as given below.

$$\frac{\sigma_y \cdot d_h}{E_m} \le \alpha_s \le \left(\frac{\sigma_y \cdot d_h}{E_m} + \frac{0.8 d_h}{1000}\right)\frac{1}{1-R^2}$$

where:

σ_y = Specified minimum yield stress of material for crank web (N/mm^2 [kgf/mm^2]).

E_m = Young's modulus (N/mm^2 [kgf/mm^2]).

d_h, R = As specified in **Par 3**.

206. Material consideration

Where it is proposed to make the crank shafts or arms by carbon steel or low alloy steel having a specified tensile strength greater than 440 N/mm^2 [45 kgf/mm^2], the diameter of crank shafts may be reduced by multiplying the following coefficient, K_m. This provision, however, is not to be applied to d_c in **205. 3** and K_m for other materials will be determined in each case by the Society.

$$K_m = \sqrt[3]{\frac{440}{440 + \frac{2}{3}(S-440)}}$$

$$\left[K_m = \sqrt[3]{\frac{45}{45 + \frac{2}{3}(S-45)}} \right]$$

where:

S = Specified minimum tensile strength of proposed material. For the high tensile strength exceeding 1,000 N/mm^2 [102 kgf/mm^2], S is to be taken as 1,000 N/mm^2 [102 kgf/mm^2].

207. Hollow shaft

Where crank pins or journals are hollow, the required outside diameter of the hollow shaft is not to be less than that obtained from the formula in **204. 2** multiplying by the following coefficient except where the inside diameter is less than one-third of the outside diameter.

$$K_h = \sqrt[3]{\frac{1}{1-R^4}}$$

where:

$$R = \frac{\text{Inside Diameter}}{\text{Outside Diameter}} \text{ for hollow shafts.}$$

208. Special consideration

Special consideration may be given to the diameter of crank shafts or the dimensions of the arms not complying with the requirements of the Rules, if the detailed data and calculations on the strength of these shafts or arms are submitted. In special cases where different manufacturing methods are made, the detailed information connected there-with and test results concerned are to be submitted to the Society for consideration. Where they are considered superior to the material strength available by the ordinary manufacturing methods, the diameter of crank shafts and dimensions of crank arms may be reduced.

209. Flywheel shafts and other shafts

Where flywheels or eccentric sheaves for pumps are fitted on crankshafts or additional shafts between the aftermost journal bearing and the thrust shaft, the shaft diameter in way of the part is not to be less than the required diameter of the crankshaft determined by the formula in **204.2**.

210. Shaft couplings and coupling bolts

1. The required diameter of coupling bolts between crankshafts and thrust shaft, and others mentioned in **209.** at the joining faces of the coupling is to be determined by the following formula:

$$d_b = 0.7\sqrt{\frac{d_c^{\ 3}}{nD} \cdot \frac{440}{T_b}} \quad (mm)$$

$$\left[d_b = 0.7\sqrt{\frac{d_c^{\ 3}}{nD} \cdot \frac{45}{T_b}} \quad (mm) \right]$$

Table 5.2.3 Test pressure

Item	Test Pressure
Cylinder cover, cooling space Cylinder liner, over the whole length of cooling space Piston crown,cooling space	0.7MPa
Cylinder jacket, cooling space Exhaust valve and exhaust pipe, cooling space Turbo-charger cooling jacket, cooling space	0.4MPa or 1.5P, whichever is the greater
Fuel injection pump body, pressure side Fuel injection valve Fuel injection pipe	1.5P or P + 30MPa, whichever is the less
Scavenge pump cylinder	0.4MPa
Heat exchanger	Apply the requirements of **Ch 5, 319. 1**
Auxiliary machinery and engine piping system	Apply the requirements of **Ch 6, Sec 12.**
Hydraulic piping for exhaust valve drive	1.5 P

NOTES:
1. P : Design pressure (MPa).
2. In case of steel forging, the tests other than hydraulic test may be accepted.
3. Where the Society accepts, connected with the hydraulic test pressure indicated in the Table may be lowered or the test may be omitted.

where:

d_b = Diameter of coupling bolts (mm).
n = Number of bolts.
D = Diameter of pitch circle (mm).
d_c = Required diameter of crankshaft determined by the formula in **204. 2** (mm).
T_b = Specified minimum tensile strength of proposed material (N/mm^2 [kgf/mm^2]). For the tensile strength exceeding 1,000 N/mm^2 [102 kgf/mm^2], T_b is to be taken as 1,000 N/mm^2 [102 kgf/mm^2].

2. The thickness of shaft coupling flanges at the pitch circle of bolt holes is not to be less than the required diameter of coupling bolts given in **Par 1**. The fillet radius at the root of shaft coupling is not to be less than 0.08 times the actual diameter of applicable shaft. Where, however, the curvature at fillet is recessed in way of nuts and bolt heads, the radius of curvature is to be 0.125 times and above the diameter of the shaft at flanged coupling.

3. Where the shaft couplings are separate from the shaft, the couplings are to be of forged or cast steel and are to have strength enough to resist the transmitting torque of shaft and the astern pull. In this case, the shaft is to be of construction to avoid excessive stress concentration.

211. Tests and Inspections

1. Hydraulic test

Items and associated components for engines are to be tested by hydraulic pressure as indicated in **Table 5.2.3.**

2. Balancing test

The rotating assemblies of exhaust gas turbo-chargers are to be subjected to dynamic balancing tests after their assembly.

3. Type approval of engine

For diesel engines with novel design features or those with no service records, in case where deemed necessary by the Society, they are to be type approved in accordance with the procedure as deemed appropriate by the Society.

SECTION 3
Steam Turbines

301. Emergency propulsion

Ships equipped with steam turbines are to be provided with means to maintain emergency propulsion in the event of failure of one main boiler.

302. Materials

1. Materials intended for turbine rotors, blades and turbine casings are to comply with the requirements of **Pt 2, Ch 1**.

2. Component parts such as turbine cylinders subjected to high temperature and pressure are to be made of the material suitable for the stresses and heat to which they are exposed and are to be properly heat-treated to remove internal stresses. Cast iron is not to be used where the maximum working temperature exceeds 230 °C.

303. General construction

1. Steam turbine cylinders are to be provided with suit-able drain devices.
2. Built-up turbine rotors of shrinkage fit type are to be properly secured by keys, dowel pins, or other approved means.
3. **Thermal expansion**

   The structure of the parts of a turbine is to have proper fits and clearances, and to be free from distortions and other harmful deformations against thermal expansion. Turbines are to be installed on the seatings without excessive restriction against thermal expansion.
4. For ships provided with one multi-cylinder steam turbine, the engine is to be so constructed as to be capable of continuing the safe navigation successively when steam led to any one of the cylinders is cut off. In this case, the steam pressure and temperature are to be so determined as to be free the turbine and condenser from failing the safety.
5. Efficient steam strainers are to be provided close to the inlets to ahead and astern high pressure turbines or alternatively at the inlets to manoeuvring valves.
6. The turning gear of propulsion steam turbines is to be driven by independent power and where driven by electric motors, they shall be of the continuous rated.

304. Safety devices

1. All main and auxiliary turbines are to be provided with overspeed protective devices to prevent the design speed from being exceeded by more than 15%. Where two or more turbines are coupled to the same main gear wheel set, the Society may agree that only one overspeed protective device be provided for all the turbines. Where main turbine installation incorporates a coupling which can be declutched or which drives a controllable pitch propeller, a separate speed governor in addition to the overspeed protective device is to be fitted and is to be capable of controlling the speed of unloaded turbine without bringing the overspeed protective device into action. Turbines driving electric generator are to be provided with governors complying with the requirements of **Pt 6, Ch 1, 202. 2** and **3**, in addition to the above.
2. Steam turbines are to be provided with a quick acting device which will automatically shut off the steam supply in the case of dangerous lowering of oil pressure in bearing lubricating system, and the device is also to be manually operated.
3. Propulsion steam turbines and main turbo-generators are to be provided with a satisfactory emergency supply of lubricating oil which will come into use automatically when the pressure drops below predetermined value. The emergency supply may be obtained from a gravity tank containing sufficient amount of oil to maintain adequate lubrication until the turbine is brought to rest or by equivalent means. For other safety devices of lubricating systems, the requirements of **Ch 6, Sec 8**, are to be applied.
4. Main turbines are to be provided with devices which automatically shut off the steam supply for ahead turbines in the case of low main condenser vacuum and the device is also to be manually operated.
5. Where the exhaust steam is extracted from turbine cylinders, approved means are to be provided to prevent the steam flowing backward to cylinders. A sentinel relief valve is to be fitted at the exhaust end of all turbines.

305. Turbine rotors

1. Turbine rotors (or discs) are to be so designed that excessive vibration may not occur within the operating range of speeds, and since the strength calculation of following **Par 2** does not include the factors of creep and others of the materials, special considerations are to be given by each manufacture to these points, as considered necessary.
2. **Mean tangential stress**

   Mean tangential stress of turbine rotors (or discs) is to satisfy the following conditions.

$$T_m = \frac{1.10\,N^2}{A}\left(\rho I + \frac{rW}{2\pi}\right)\ (N/mm^2)$$

$$\left[\ T_m = \frac{0.112\,N^2}{A}\left(\rho I + \frac{rW}{2\pi}\right)\ (kgf/mm^2)\ \right]$$

$$T_m \le \frac{Y}{3}$$

$$T_m \le \frac{T_S}{4}$$

where:

T_m = Mean tangential stress (N/mm^2 [kgf/mm^2]).
N = Number of maximum continuous revolutions per minute divided 1,000 (rpm/1,000).
A = Sectional area of wheel profile on one side of axis of rotation (cm^2).
I = Moment of inertia of area A on one side of axis of rotation (cm^4).
ρ = Specific weight of turbine rotor (or disc) material (kg/cm^3).
W = Total weight of blade including roots (kg)
r = Distance between the center of gravity of blade (including root) and the center line of shaft (cm).

Table 5.2.4 Test Pressure

Item		Test Pressure	Remark
Turbine cylinders, high pressure turbine steam chests, steam receivers		1.5 P or 0.2 MPa, whichever is the greater	P = Design pressure (MPa)
Steam strainers, manoeuvring valve chests, other accessories		2 P	
Main condenser	Steam space	0.1 MPa	
	Water space	$P_1+P_2+0.1MPa$ or $0.2MPa$, whichever is the greater	Where the scoop system is adopted, $P_1+P_2+0.1MPa$ or $0.35MPa$, whichever is the greater.

NOTES:
P_1 = Maximum discharge pressure which the circulating pumps can develop with the discharge valve closed. (MPa).
P_2 = Maximum suction pressure which is developed under the full draught condition. (MPa).

Y = Specified minimum yield stress or proof stress of the material (N/mm^2 [kgf/mm^2]).
T_s = Specific minimum tensile strength of the material (N/mm^2 [kgf/mm^2]).

306. Strength and sectional area of turbine blades

Turbine blades are to be so designed as to avoid abrupt changes in section and to provide an ample amount of stiffness to minimize deflection and vibration. The minimum sectional area at the root of the blade is to be determined by the following formula:

$$A = \frac{4.395\,WN^2 r}{S} \quad (cm^2)$$

$$\left[A = \frac{0.448\,WN^2 r}{S} \quad (cm^2) \right]$$

where:

W = Weight of one blade (kg).
N = Number of maximum continuous revolutions per minute divided by 1,000 (rpm/1,000).
r = Distance between the centre of gravity of blade and centre line of shaft (cm).
S = Specified minimum tensile strength of blade material (N/mm^2 [kgf/mm^2]).

307. Tests and inspections

1. Hydraulic test

Turbines and accessory parts are to be tested by hydraulic pressures given in **Table 5.2.4**.

2. Balancing test

Turbine rotors are to be dynamically balanced after attaching the blades.

SECTION 4
Gas Turbines

401. Application

Requirements on gas turbines will be specially considered in each case at the submission of detailed plans and data.

402. General construction

The requirements of **Sec 3** of this Chapter for steam turbines may be applied for the construction of gas turbines; the requirements of **Ch 5** may be applied for pressure vessels and heat exchangers; the requirements of **Ch 6** may be applied for the piping system; and the requirements of **Pt 2, Ch 1** may be applied for the materials of main component parts. ⚓

CHAPTER 3
SHAFTING SYSTEM

SECTION 1
General

101. Welded structure component

Where the main component parts are of welded structure, the Society may require the preliminary test and other tests for the fabrication of welding before the work is commenced when considered specifically necessary. The welding procedure is to be approved. This requirement also applies to repair of main component parts by welding.

102. Other propulsion and maneuvering machinery

The propulsion and maneuvering machinery not specified in this chapter are to comply with the special requirements given by the Society.

SECTION 2
Shaftings

201. Application

1. The requirements of this Section apply to the shaftings of ships having diesel engines, steam turbines and gas turbines as their main engines and of ships of electric propulsion.
2. The shafting of essential auxiliary machinery is to comply with the corresponding requirements of this Section.

202. Materials

1. The materials for intermediate shaft, thrust shaft, stern tube shaft, propeller shaft, shaft coupling and coupling bolts are to comply with the requirements for steel forging of **Pt 2, Ch 1**. Built-up type shaft couplings may be of steel castings conforming to the requirements in **Pt 2, Ch 1**.
2. The elongation of the material in **Par 1** is not to be less than 16 % except when an approval is specially obtained by the Society.

203. Intermediate shaft and thrust shaft

The diameters of intermediate shaft and thrust shaft are not to be less than those obtained by the following formula:

$$d_o = F \cdot K_1 \sqrt[3]{\frac{P}{n} \times \frac{560}{(T+160)}} \quad (mm)$$

$$\left[d_o = F \cdot K_1 \sqrt[3]{\frac{0.735P}{n} \times \frac{57.1}{(T+16.3)}} \quad (mm) \right]$$

where:

P = Shaft output of engine at maximum continuous output (kW [PS]).

n = Number of shaft revolution at maximum continuous output (rpm).

F = Factor for the type of propulsion installations
- · 100 for diesel installations
- · 95 for turbine installations, diesel installations with slip type coupling, electric propulsion installations.

T = Specified minimum tensile strength (N/mm^2 [kgf/mm^2]) of proposed material. For the tensile strength exceeding 800 N/mm^2 [82 kgf/mm^2], T is to be taken 800 N/mm^2 [82 kgf/mm^2].

K_1 = Factor for different shaft design features, the values given by **Table 5.3.1**.

204. Propeller shaft and stern tube shaft

1. The diameter of propeller shaft and stern tube shaft is not to be less than that obtained by the following formula:

Table 5.3.1 Values of K_1

For intermediate shafts with					For thrust shafts with	
Integral coupling flange	Shrink fit coupling flange	Keyways	Radial holes, transverse holes	Longitudinal slots	On both side of thrust collar	In way of axial bearing where a roller bearing is used as a thrust bearing
1.00	1.00	1.10(1)	1.10(2)	1.20(3)	1.10	1.10

NOTES:
(1) After a length of not less than $0.2d_o$ from the end of the keyway the shaft diameter may be reduced to the diameter calculated with K_1 = 1.0. The fillet radius in the transverse section of keyway bottom is to be $0.0125d_o$ or more.
(2) Diameter of bore not more than $0.3d_o$.
(3) Length of the slot not more than $1.4d_o$, width of the slot not more than $0.2d_o$ whereby d_o is calculated with K_1 = 1.0.

Table 5.3.2 Value of K_2

Kind of shaft	Propeller fitting method(1)	K_2 (3)
Propeller shaft	Keyed	1.26
	Keyless fitting by shrink fit	1.22
	Flange(2)	1.22
Stern tube shaft		1.15

NOTES:
(1) Other propeller fitting methods are subject to special consideration.
(2) The fillet radius in the base of the flange is to be at least the order of 0.125 d_p.
(3) K_2 is applied to the shafts to which effective measures against corrosion by sea water are taken.
The diameters of Kind 1 shaft made of approved corrosion-resistant materials and Kind 2 shaft to which no effective measures against corrosion by sea water are taken are to be dealt with as considered appropriate by the Society.

$$d_p = 100 \times K_2 \sqrt[3]{\frac{P}{n} \times \frac{560}{(T+160)}} \quad (mm)$$

$$\left[d_p = 100 \times K_2 \sqrt[3]{\frac{0.735P}{n} \times \frac{57.1}{(T+16.3)}} \quad (mm) \right]$$

where:

P, n = As specified in **203**.
K_2 = Factor concerning different shaft design features, the values given by **Table 5.3.2**.
T = Specified minimum tensile strength (N/mm^2 [kgf/mm^2]). where the tensile strength of the steel used shall be between 400~800 N/mm^2 [$41 \sim 82\ kgf/mm^2$]. For the tensile strength exceeding 600 N/mm^2 [61 kgf/mm^2], T is to be taken as 600 N/mm^2 [61 kgf/mm^2].

2. Reducing diameter

The diameter of the portion of the propeller shaft of the length of the forward edge of the bearing immediately forward of the propeller or the length of $2.0d_p$ ($4d_p$ in water-lubricated) from the forward face of the propeller boss or, if applicable, the forward face of the propeller flange, whichever is greater, may be reduced to the diameter in accordance with the formula in **Par 1** with the K_2 values as 1.15. The diameter of inboard end of the propeller shafts or stern tube shafts may be gradually reduced at the coupling to the value determined in **Par 1** with the values of K_2 replaced by K_1 the same as intermediate shafts in **Table 5.3.1**.

3. Sleeves

(1) Thickness of sleeves
The thickness of sleeves fitted with propeller shafts and stern tube shaft is not to be less than that given by the following formulae:

$$t_1 = 0.03d_p + 7.5 \quad (mm)$$
$$t_2 = 0.75t_1 \quad (mm)$$

where:
t_1 = Thickness of sleeves in contact with stern tube bearing or strut bearing (mm).
t_2 = Thickness of sleeves of other parts than the above (mm).
d_p = Minimum required diameter of propeller shaft (mm).

(2) Manufacturing of sleeves
Sleeves are to be of bronze of high grade or above its equivalent thereto and free from porosity and other defects.

(3) Security of sleeves
Sleeves are to be shrunk on or forced on the shaft by pressure and they are not to be secured by pins or bolts.

4. Taper of propeller shaft cone

The propeller shaft cone is to be provided with the 1/10 (the 1/15 in keyless propeller) or less taper at the stern end of the propeller shaft.

5. Key of propeller shaft

(1) Key and keyway
Where a key is provided to the taper part of the propeller shaft, the key is to be tightly fitted in the keyway and to be secured by use of a set bolt. Sufficient radius is to be provided at the bottom fillet, in general, the fore end of the keyway is to be made a spoon shaped ending. For fitting part of small ship's propeller, it may be complied with $KS\ V\ 4811$.

(2) Set bolt for key
Two screw pins are to be provided for securing the key in the keyway, and the forward set bolt is to be placed at least one-third of the length of the key from the end. The depth of the tapped holes for the set bolt is not to exceed the bolt diameters, and the edges of the holes are to be bevelled slightly.

205. Hollow shaft

In accordance with the kind of shafts, the outside diameter of hollow shaft is not to be less than that given by the corresponding formula specified in **203**. and **204**. multiplying by the following coefficient K_h. For the R not exceeding $0.4d_0$, K_h is to be taken as 1.

$$K_h = \sqrt[3]{\frac{1}{1-R^4}}$$

where:

$R = \dfrac{\text{Inside Diameter}}{\text{Outside Diameter}}$ for hollow shafts.

d_0 = actual outside diameter of shaft.

206. Stern tube bearing and sealing device

1. The length of stern bearing in the stern tube or of strut bearing supporting the weight of propeller is to comply with the following requirements.

(1) The bearings are to be type approved by the Society in their materials, construction and lubricating arrangements when rubber or synthetic materials are used.

(2) For sea water lubricated bearings of lignum vitae, rubber or synthetic materials, the length of the bearing is to be not less than 4 times the required diameter of the shaft in way of the bearing.

(3) For oil lubricated bearings of white metal or synthetic materials, the length of the bearing is to be not less than 2 times the required diameter of the shaft in way of the bearing. The length of the bearing may be less provided the nominal bearing pressure is not more than $0.8MPa$ as determined by static bearing reaction calculation taking into account shaft and propeller weight which is deemed to be exerted solely on the aft bearing divided by the projected area of the shaft. For oil lubricated bearings of synthetic materials, the length of the bearing may be less provided the nominal bearing pressure is not more than $0.6MPa$ as determined by static bearing reaction calculation taking into account shaft and propeller weight which is deemed to be exerted solely on the aft bearing divided by the projected area of the shaft. However, the minimum length is to be not less than 1.5 times the actual diameter.

(4) The oil lubricated stern tube is always to be filled with oil and provision is to be made for cooling the oil by maintaining water in the aft-peak tank above the level of the stern tube or by other suitable means. Means for ascertaining the temperature of the oil in the stern tube are also to be provided. Where a gravity tank supplying lubricating oil to the stern tube bearing is fitted, it is to be located above the load water line and provided with a low level alarm device. Adequate means are to be provided to supply ample amount of clean water for lubrication and cooling in the sea water lubricated stern tube.

(5) Where the material has been proven satisfactory through testing and operating experience, consideration may be given to an increased bearing pressure or a lessened bearing length.

2. The sealing devices other than gland packing type sea water sealing device are to be type approved by the Society in their materials, construction and arrangement.

207. Shaft coupling and coupling bolts

1. Coupling bolt

The diameter of the coupling bolts at joining face of the couplings is not to be less than that given the following formula:

$$d_b = 0.65\sqrt{\frac{d_o^{\,3}(T+160)}{n \times D \times T_b}} \quad (mm)$$

$$\left[d_b = 0.65\sqrt{\frac{d_o^{\,3}(T+16.3)}{n \times D \times T_b}} \quad (mm) \right]$$

where:

d_o = Minimum required diameter of intermediate shaft (mm).

n = Number of bolts.

D = Diameter of pitch circle (mm).

T = Specified minimum tensile strength of the intermediate shaft material (N/mm^2 [kgf/mm^2]).

T_b = Specified minimum tensile strength of bolt material, while in general $T \leqq T_b \leqq 1.7\,T$, but not higher than 1,000 N/mm^2 [102 kgf/mm^2].

2. Shaft coupling

(1) The thickness of coupling flange at the pitch circle is not to be less than that obtained by the following formulae, whichever is the greater.

$$t_1 = d_b \quad (mm)$$
$$t_2 = 0.2\,d \quad (mm)$$

where:

d_b = Minimum required diameter of bolts calculated for the material having the same tensile strength as the corresponding shaft.

d = Minimum required diameter of corresponding shaft.

(2) The fillet radius at the base of the flange is not to be less than 0.08 times the diameter of the shaft. The fillets are to have a smooth finish. Where the fillet is recessed in way of nuts and bolt heads, the fillet radius at the base of the flange is not to be less than 0.125 times the diameter of the shaft.

3. Demountable couplings

Where the shaft couplings are separate from the shaft, the couplings are to have strength enough to resist the transmitting torque of shaft and the astern pull. In this case, the shaft is to be of construction to avoid excessive stress concentration.

208. Tests and inspections

1. Hydraulic test of stern tube

Stern tubes are to be tested by hydraulic pressure of 0.2 MPa after manufacturing.

2. Leakage test

The oil sealing devices in stern tubes are to be tested for leakage under working oil pressure after being installed in ships.

3. Hydraulic test of sleeve

Propeller shaft sleeves and stern tube shaft sleeves are to be tested by hydraulic pressure of 0.1 MPa before they are to be shrunk or forced on the shaft.

SECTION 3
Propellers

301. Application

The requirements of this Section apply to screw propellers. The structure and strength of propellers of special design are to be in accordance with the requirements which the Society considers appropriate.

302. Materials

The materials of propellers and blade fixing bolts of built-up propeller are to be in accordance with the requirements of **Pt 2, Ch 1**.

303. Thickness of blade

1. The thicknesses of the propeller blades for solid propellers and controllable pitch propellers (fillet at the root of the blades is not to be considered in the determination of blade thickness) are not to be less than obtained from the formula in **Table 5.3.4**. In case of high speed ship, the higher requirement may be requested.

2. Consideration

For the blades of different materials from those specified in **Table 5.3.4**, the value of K will be determined by the Society in each case. For propellers having a diameter of 2.5 m and less, the value of K may be taken as the value in **Table 5.3.4** multiplied by the following factors.

for $D \leqq 2.0\,m$: 1.2
for $D > 2.0\,m$: $2.0 - 0.4\,D$

304. Fixing of blade

1. Fixing

Blade fixing bolts are to have sufficient strength as considered appropriate by the Society,and corrosion resistant materials are to be used or effective means precluding their direct contact with sea water are to be provided. Bolts are to be fitted tightly into the boss by flanging or other effective means, and nuts are to be secured by appropriate means to prevent loosening.

2. Recess

The recess for the blade fixing bolts are to be so provided that it has no significant influence to the strength at the root of blades.

3. Flange

The face of the flange of the blade is to be fitted tightly to the face of the boss, and the circumferential clearance of the edge of flange is to be kept to a minimum.

305. Fitting of propeller

1. The propeller is to be force-fitted on the taper of

Table 5.3.4 Thickness of Blade

Thickness of blade (mm)	$t_x = \sqrt{\dfrac{0.1\,K_1 \cdot P}{C_x\,K_2 \cdot Z \cdot N \cdot l_x}} \quad \left[\sqrt{\dfrac{0.0735\,K_1 \cdot P}{C_x\,K_2 \cdot Z \cdot N \cdot l_x}}\right]$

P : Maximum continuous output of main propulsion machinery ($kW[PS]$).
Z : Number of blades
N : Number of maximum continuous revolution per minute devided by 100
C_x : Section modulus values at the blade position x (Actual section modulus $\div\, l_x t_{ax}^2$), where C_x exeeds 0.1, C_x is to be taken as 0.1
l_x : Width of blade at the radius xR (m). (x : 0.25, 0.35, 0.6)
R : Radius of propeller (m).
x : Radius position having no dimension
t_{ax} : Actual thickness of Blades (m).
K_1, K_2 : Coefficient given by the following table

x \ Coefficient	Solid propeller	Controllable pitch propeller
0.25	$K_1 = \dfrac{61}{\sqrt{1+1.62\left(\dfrac{P_{0.25}}{D}\right)^2}}\left[0.092+0.329\left(\dfrac{D}{P_{0.7}}\right)+0.238\left(\dfrac{P_{0.25}}{D}\right)\right]$ $K_2 = K_m - \dfrac{D^3 \cdot N^2 \cdot \xi}{1000 l_{0.25} \cdot Z}\left[2.02+\dfrac{1.17\left(\dfrac{100E}{D}\right)+2.39}{\sqrt{1+1.62\left(\dfrac{P_{0.25}}{D}\right)^2}}\right]$	
0.35		$K_1 = \dfrac{61}{\sqrt{1+0.827\left(\dfrac{P_{0.35}}{D}\right)^2}}\left[0.074+0.264\left(\dfrac{D}{P_{0.7}}\right)+0.131\left(\dfrac{P_{0.35}}{D}\right)\right]$ $K_2 = K_m - \dfrac{D^3 \cdot N^2 \cdot \xi}{1000 l_{0.35} \cdot Z}\left[2.29+\dfrac{1.23\left(\dfrac{100E}{D}\right)+2.51}{\sqrt{1+0.827\left(\dfrac{P_{0.35}}{D}\right)^2}}\right]$
0.6	$K_1 = \dfrac{61}{\sqrt{1+0.281\left(\dfrac{P_{0.6}}{D}\right)^2}}\left[0.028+0.096\left(\dfrac{D}{P_{0.7}}\right)+0.026\left(\dfrac{P_{0.6}}{D}\right)\right]$ $K_2 = K_m - \dfrac{D^3 \cdot N^2 \cdot \xi}{1000 l_{0.6} \cdot Z}\left[1.48+\dfrac{0.68\left(\dfrac{100E}{D}\right)+1.38}{\sqrt{1+0.281\left(\dfrac{P_{0.6}}{D}\right)^2}}\right]$	$K_1 = \dfrac{61}{\sqrt{1+0.281\left(\dfrac{P_{0.6}}{D}\right)^2}}\left[0.028+0.100\left(\dfrac{D}{P_{0.7}}\right)+0.026\left(\dfrac{P_{0.6}}{D}\right)\right]$ $K_2 = K_m - \dfrac{D^3 \cdot N^2 \cdot \xi}{1000 l_{0.6} \cdot Z}\left[1.70+\dfrac{0.78\left(\dfrac{100E}{D}\right)+1.59}{\sqrt{1+0.281\left(\dfrac{P_{0.6}}{D}\right)^2}}\right]$

D : Diameter of propeller (m).
E : Rake of blade at propeller shaft center line (Distance between a cross of perpendicular line of blade tip and a cross of extension line of backface at shaft center line in the projection of maximum thickness section of the blade) (m).
P_x : Pitch at the radius xR (m). (x : 0.25, 0.35, 0.6, 0.7)

$\xi = \dfrac{A_E}{\dfrac{\pi}{4}D^2}$: Expanded area ratio

K_m : Values given by the following table.

Materials		K_m
Grey cast iron		0.6
Cast steel	RSC 42	0.9
	RSC 46	
	RSC 49	1.0
Copper alloy casting	RHB_SC 1	1.15
	RHB_SC 2	
	$RAlBC$ 3	1.3
	$RAlBC$ 4	1.15

the propeller shaft or to be firmly fixed to the shaft by other appropriate means. Propeller, on force fitting or drawing out, is not to be heated partially to a high temperature.

2. Where the propeller is force-fitted to the propeller shaft without the use of a key, the calculation sheets of the pull-up length are to be submitted for approval.

Where the propeller is bolted to the shaft, the blade fixing bolts are to have sufficient strength.

306. Hydraulic oil pump

Where, in controllable pitch propellers, pitch controlling devices are operated by oil pump, a stand-by oil pump or other suitable means are to be provided so that the ship may proceed the normal voyage in the event of failure of the oil pump.

307. Tests and inspections

1. Balancing tests

Propellers are to be subjected to static balancing tests.

2. Contact tests

Where the propeller is force-fitted to the taper of the propeller shaft cone, the contact marking between the mating surfaces is to be verified by contact facing-up test or other suitable means.

3. Confirmation of the pull-up length

Where a propeller is force-fitted to the propeller shaft without the use of a key, the pull-up length is to be confirmed and recorded.

SECTION 4
Power Transmission Systems

401. General

1. Application

The requirements of this Section apply to power transmission systems which transmit power from main propulsion machinery and prime movers driving generators (excluding emergency generator) and essential auxiliaries for propulsion and safety of ships.

2. Special requirement

The construction of other power transmission systems not specified in this Section is to be such that the Society considers appropriate, functioning safely and reliably and having sufficient strength against transmitted power.

3. Oil pressure pump or air compressor, etc.

Where the clutching device of power transmission systems for propulsion is operated with oil or air pressure, the stand-by oil pressure pumps or air compressor which can be used at any time by switchingover or any other appropriate unit are to be provided, thereby ensuring that a ship can keep the normal voyage. However, in the case of small ships the requirement for this stand-by unit can be dispensed with at the discretion of the Society.

4. Electro-magnetic slip coupling

The electro-magnetic slip couplings are also to comply with the requirements of **Pt 6, Ch 1, 1603. 4**.

5. Materials

The materials used for important parts of the power transmission system are to comply with the requirements in **Pt 2, Ch 1**. For small transmitted power, however, material tests may be omitted.

402. General construction of gearing

1. Gear of built-up type

Where a gear is of built-up type, the rim is to be of a thickness to ensure sufficient strength and is to have an enough shrinkage fit against transmitted power. Where shrinkage fit is made after cutting of the teeth, the accuracy of gearing, or the final tooth finishing is to be carried out after the shrinkage fit. Where gears are of welded construction, they are to have sufficient rigidity and are to be stress relieved before cutting of the teeth.

2. Casing

Gear casings are to have sufficient rigidity, and their construction is to be such that all possible facility is provided for inspection and maintenance. Where the casing is of welded structure, its construction and materials are to be approved by the Society.

3. Machining

Gear teeth are to be machined by hobbing machines of high accuracy, and it is recommended that the finishing, if available, is to be carried out as far as possible in a temperature controllable room. After the final machining, both edges of the teeth or any other sharp parts are to be properly hand finished. The surface hardening processes are to be carried out considering the influence of the thermal deformation to ensure that the necessary flank hardness and depth of hardened zone are obtained.

4. Other components of gears

Other components of the gears are also to be of reliable quality and their attachment are to be so arranged that they have no influence to the centres of gear shafts.

5. Noise

Gears are to be adjusted to give minimum noise in the normal range of revolution.

6. Lubricating oil arrangement

(1) Lubricating oil arrangement is also to comply with the requirements of **Ch 6, Sec 8**. Oil strainers used for gearing are to be those with a magnet if available.

(2) The gearing of the forced lubrication system with the driving units above 37 kW [50 PS] are to be provided with alarm devices which give visual and audible alarm in the event of failure of lubricating oil pressure supply or appreciable reduc-

tion in pressure of lubricating oil supply. For the lubricating oil arrangements other than forced lubrication system, suitable means are to be provided to ascertain oil level in sump.

403. Allowable tangential load for gears

1. Application

These provisions are applied to the external tooth cylindrical gears having an involute tooth profile. The external tooth cylindrical gears having tooth profiles other than the involute tooth profile are to comply with the requirements which the Society deems appropriate.

2. Allowable trangential load by bending strength

Allowable tangential loads decided for the bending strength of the teeth are to conform to the following condition:

$$P_{MCR} \leqq P_b$$

P_{MCR} = Tangential loads of gears at maximum continuous output, being the value to be obtained from the following formula:

$$P_{MCR} = \frac{1.91P}{nd_1 b} \times 10^6 \quad (N/cm)$$

$$\left[P_{MCR} = 71620 \frac{2P}{nd_1 b} \quad (kgf/cm) \right]$$

where:

P = Output which the pinion shares at maximum continuous output (kW [PS]).

n = Revolutions of the pinion at maximum continuous output (rpm).

d_1 = Pitch circle diameter of the pinion (cm).

b = Effective face width of the gears on the pitch circle of the shaft parallel section (cm).

P_b = Allowable tangential loads decided for the bending strength, being obtained from the following formula:

$$P_b = 9.81(K_1 \cdot S_b - K_2) \times K_3 (4.85 - \frac{30.6}{Z}) M \quad (N/cm)$$

$$\left[P_b = (K_1 \cdot S_b - K_2) \times K_3 (4.85 - \frac{30.6}{Z}) M \quad (kgf/cm) \right]$$

K_1 = External load magnification coefficient, being the value to be decided for the size of fluctuating loads working on the gears and to be given by the following formula. Where the value of K_1 cannot be calculated, the values in **Table 5.3.5** may be used.

$$K_1 = \frac{1.10 P_{MCR}}{P_{MAX}}$$

P_{MAX} = Instantaneous maximum tangential loads occurring within the continuous revolution range (N/cm [kgf/cm]).

K_2 = Internal load magnification value, being the value to be derived from the following formula or **Fig.5.3.2** which is dependent on the accuracy of gears and their overlap ratio.

$$K_2 = k_2 (d \cdot n)^{0.8}$$

where:

d = Pitch circle diameter of gears (cm).

Table 5.3.6 Values of k_2

Expected accuracy of finishing gears	k_2	
	ε ≧ 1.25	ε 〈 1.25
Those corresponding to finishing by shaving or grinding	0.044	0.088
those corresponding to finishing by hobbing	0.11	0.22

$$\varepsilon = \frac{10 \cdot b_e \cdot \sin\beta_o}{\pi M}$$

b_e = Face width (in case of double helical gears, the face width is for one side) (cm).
β_o = Helix angle.
M = Normal module.

Table 5.3.5 Values of K_1

Driving engine	Construction or method of connection	K_1	
		Gear for propulsion	Gear for auxiliaries
Steam turbine or electric motor	Single stage reduction gear	1.00	1.15
	Multiple stage reduction gear	1.00(1), 1.10(2)	1.15
Internal combustion engine	Hydro-dynamic or electro-magnetic coupling	1.00	1.15
	High elastic coupling	0.90	1.05
	Elastic coupling	0.80	0.95
	Rigid coupling	0.50	0.60

NOTES:
(1) marked is applicable only to the gearing connected directly with the propulsion shaft system.
(2) marked is applicable only to the gearing connected directly with the propulsion shaft system through effective flexible couplings.
(3) Where one pinion meshes with more than two wheels, 0.9 times these values may be applied as the value of K_1.

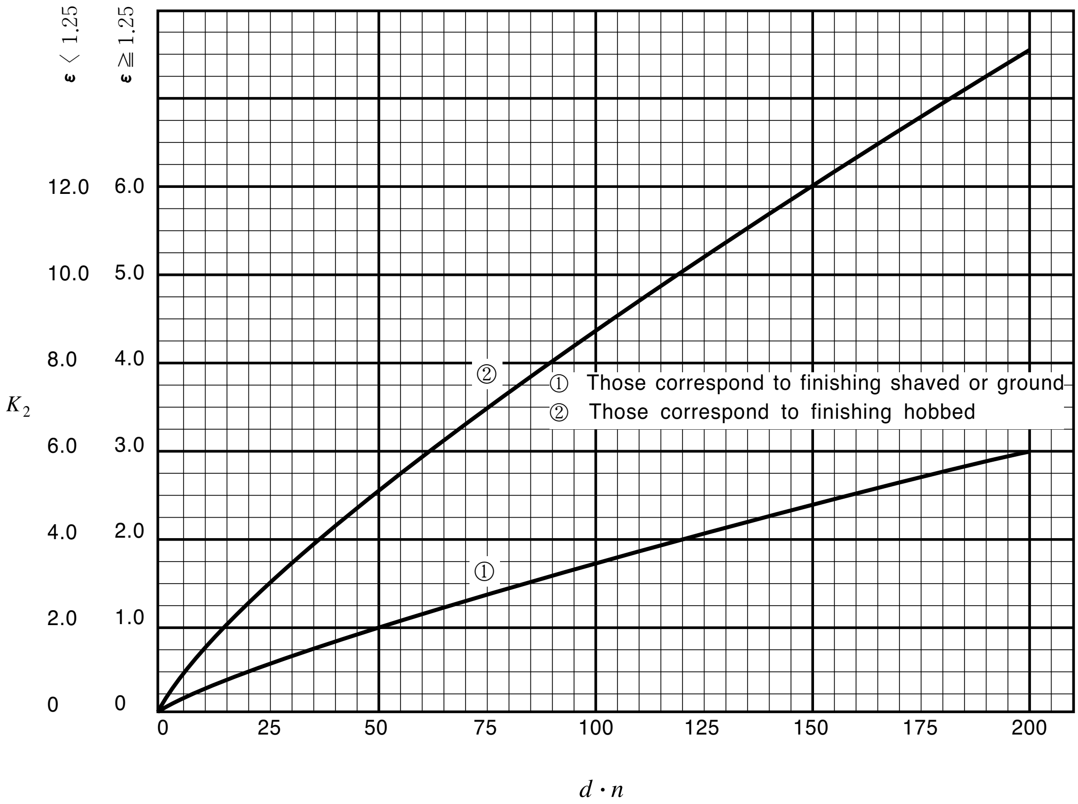


Fig. 5.3.2 Values of K_2

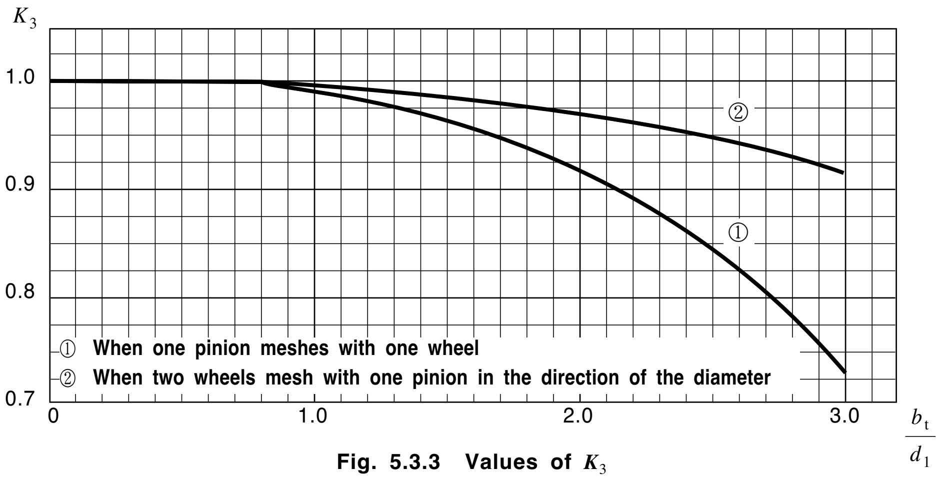


Fig. 5.3.3 Values of K_3

Table 5.3.7 Values of k_3

	k_3
When one pinion meshes with one wheel	0.01
When two wheels mesh with one pinion in the direction of the diameter	0.003

n = Number of revolution per minute of gears divided by 1,000 (rpm/1,000).

k_2 = Value given in **Table 5.3.6**.

K_3 =Load magnification coefficient, being the value to be derived from the following formula or **Fig.5.3.3** which is dependent on the face width and pitch circle diameter.

$$K_3 = 1 - k_3 (\frac{b_t}{d_1})^3$$

where:

b_t = Total face width of pinions (in case of double helical gears, central gap is included) (cm).

d_1 = Pitch circle diameter of pinion (cm).

k_3 = Value given by **Table 5.3.7**.

Z = Number of teeth.

S_b = The value related mainly to the material of gears, given by the following formula. In case of ahead idle gears and astern gears, however, 0.7 times and 1.2 times respectively such value are regarded as S_b values. In any case, S_b value is not to exceed 25.

Gears to which surface hardening process was applied including bottom land:

$$S_b = 0.83\sqrt{S}$$
$$\left[S_b = 2.6\sqrt{S} \right]$$

Other gears:

$$S_b = \frac{S+Y}{49} \cdot \frac{1}{F}$$
$$\left[S_b = \frac{S+Y}{5} \cdot \frac{1}{F} \right]$$
$$F = 1 + (0.0096S - 2.4)\left(\frac{0.04}{\gamma_0} + 0.02\right) \times (0.023M + 0.75)$$
$$\left[F = 1 + (0.094S - 2.4)\left(\frac{0.04}{\gamma_0} + 0.02\right) \times (0.023M + 0.75) \right]$$

where:

S = Specified minimum tensile strength of gear material (N/mm^2 [kgf/mm^2]).
Y = Specified minimum yield stress of gear material (N/mm^2 [kgf/mm^2]).
γ_o= Ratio between the tooth tip radius and module.
M = Normal module.

3. Tangential load by surface durability

The tangential loads of gears decided for surface durability of the teeth flank are to conform to the following condition, but these are not applicable to astern gears.

$$P_{MCR} \leqq P_S$$

P_{MCR} = As specified in **Par 2.**
P_S = Allowable tangential loads decided for the surface durability of the teeth flank and obtained by the following formula.

$$P_S = 9.81(K_1 \cdot S_S - K_2)K_3 \cdot K_4 \cdot \frac{i}{1+i} \cdot d_1 \quad (N/cm)$$
$$\left[P_S = (K_1 \cdot S_S - K_2)K_3 \cdot K_4 \cdot \frac{i}{1+i} \cdot d_1 \quad (kgf/cm) \right]$$

where:

K_1, K_2, K_3 = As specified in **Par 2**.
S_s = Decided by the material of gears and as given by the following formula:

Combination of gears both of which have been subjected to surface hardening process:

$$S_S = 2.236\sqrt{S_W}$$
$$\left[S_S = 7.0\sqrt{S_W} \right]$$

Combination of other gears:

$$S_S = \left(0.005\frac{H_{BP}}{H_{BW}} + 0.007\right) S_W + 7.5$$
$$\left[S_S = \left(0.05\frac{H_{BP}}{H_{BW}} + 0.07\right) S_W + 7.5 \right]$$

where:

S_W = Specified minimum tensile strength of wheel material (N/mm^2 [kgf/mm^2]).
H_{BP} = Hardness of tooth face of pinion (Brinell hardness H_B).
H_{BW} = Hardness of tooth face of wheel (Brinell hardness H_B).

K_4 = Lubricating coefficient, being the value decided for the following formula or **Fig. 5.3.4**, which is dependent on pitch circle diameter and number of revolution. In case of meshing with hardened gears, however, K_4 = 0.53.

$$K_4 = 0.3(d \cdot n)^{\frac{1}{6}}$$

d = Pitch circle diameter of gears (cm).
n = Number of revolution per minute of gears divided by 1,000 (rpm/1,000).
i = Gear ratio (number of teeth of wheel/number of teeth of pinion).
d_1 = Pitch circle diameter of pinion (cm).

4. Consideration

The Society may approve special gearing devices, notwithstanding the requirements of **Pars 2** and **3**, provided that the detailed data for design, machining, using and calculations on the strength are submitted.

404. Gear shaft

1. Gear shaft

The diameter of gear shafts by which power is transmitted is not to be less than the value given by the formula in **203**. In this case, P and n in this formula represent respectively the output and the number of revolutions of the shaft at the maximum continuous output. For the tensile strength exceeding 1,000N/mm^2 in the pinion shafts, T is to

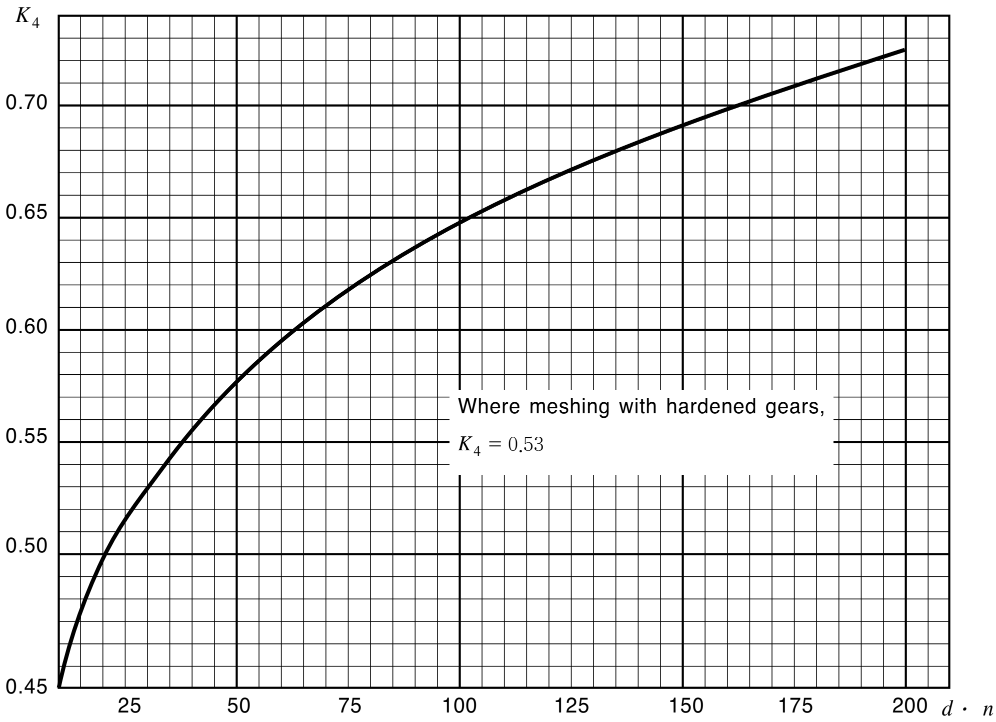


Fig. 5.3.4 K_4 Values

Table 5.3.8 Values of C

Arrangement of pinions	C
When one pinion is gearing, or when two pinions which are arranged at an angle less than 120° each other are gearing	1.16
When two pinions which are arranged at an angle more than 120° each other are gearing	1.10

be taken as 1,000N/mm^2. However, the diameter between the wheel shaft bearings is not to be less than the above values that multiplied by coefficient given in **Table 5.3.8**.

2. Pinion shaft

The diameter of pinion shaft is to have sufficient rigidity against the bending force generated by meshing of gears.

405. Flexible shaft

The diameter of flexible shaft is not to be less than that given by the following formula:

$$d_f = 100\sqrt[3]{\frac{P}{n}\cdot\frac{440}{S}} \quad (mm)$$

$$\left[d_f = 100\sqrt[3]{\frac{0.735P}{n}\cdot\frac{45}{S}} \quad (mm) \right]$$

where:

P = Output shared by flexible shaft at the maximum continuous output ($kW\,[PS]$).

n = Number of revolution per minute of flexible shaft at the maximum continuous output (rpm).

S = Specified minimum tensile strength of shaft material ($N/mm^2\,[kgf/mm^2]$).

406. Shaft couplings

1. Shaft couplings and coupling bolts

The dimensions of couplings and coupling bolts are applied to the related requirements in **207**. In case where they support heavy materials in cantilever style, they are to be designed so as to have sufficient strength to resist the weight.

2. Flexible couplings

The flexible couplings are to have sufficient strength against the torque to be transmitted to the shaft, and the constructions and materials are to be type approved by the Society.

407. Tests and inspections

1. Finishing accuracy

The parts undergone the surface hardening process, in general, are to be checked by the hardness tests and suitable non-destructive tests. The finishing accuracy of gears is to be measured minutely.

2. Dynamical balancing test

In the case of gears where the value given by the following formula exceeds 50, dynamic balancing tests are to be carried out, except for the case where specially approved by the Society to omit such test.

$$\frac{D \cdot n}{1{,}000}$$

where:

D = Pitch circle diameter of the gear (cm).
n = Number of revolution of the gear (rpm).

3. Contact marking of teeth

The contact marking of the teeth of all gearing is to be verified under appropriate loads by coating suitable paint thinly and uniformly. And, in the case of propulsion gears where the total face width (in the case of double helical gears, the central gap is included) exceeds 300 mm or where the ratio between the total face width and pitch circle diameter of the pinion exceeds 2, the contact marking of the teeth is to be verified at sea trial by coating with copper sulphate or suitable paint on teeth flank thinly and uniformly. ⚓

CHAPTER 4
TORSIONAL VIBRATION OF SHAFTINGS

SECTION 1
General

101. Application

The requirements of this Chapter apply to power transmision systems for propulsion and propulsion shafting systems, shafting systems to transmit power from main engines to generators, crankshafts of diesel engines used as main engines and shafting systems of generators driven by diesel engines.

102. Data to be submitted

1. For the shafting of ships, the calculation sheets for the torsional vibration are to be submitted in accordance with **Ch 1, 202.** and are to include the following particulars:
   (1) Natural frequencies and modes for one node and two nodes vibration, also more nodes vibration if necessary.
   (2) Estimated vibratory stresses for shafting system within 120% of the maximum continuous revolutions including non-resonant conditions.
   (3) Estimated vibratory torques for shafting system, gearings and flexible couplings.
2. Notwithstanding the requirements specified in **Par 1**, submission of the torsional vibration calculation sheets may be omitted in the following cases provided that approval of the Society is obtained:
   (1) In case where the shafting system is of the same types as previously approved one.
   (2) In case where there is a slight alternation in specifications of the vibration system, and the frequency and torsional vibration stress can be deduced with satisfactory accuracy on the basis of the previous result of calculations or measurements.
   (3) In case where the maximum continuous output of engine is 100 kW [135 PS] and below.

103. Measurements

For the shafting systems where the submission of the torsional vibration calculation sheets is required, measurements to confirm correctness of the estimated value are to be carried out. However, where the submission of the calculation sheets is omitted according to the requirement in **102. 2** and the Society considers that there is no critical vibration within the service speed range, the measurement of torsional vibration may be omitted.

SECTION 2
Allowable Limit of Vibration Stresses

201. Crankshafts

The torsional vibration stresses on the crankshafts of main propulsion diesel engines are to be in accordance with the following requirements.

1. For continuous operation, the torsional vibration stresses are not to exceed τ_1 given in followings.
   (1) For 4 cycle in-line diesel engines and 4 cycle vee type diesel engines with firing intervals of 45° or 60°, the value of τ_1 is given by the following formula:

$$\tau_1 = 45 - 24\lambda^2$$
$$\left[\tau_1 = 460 - 245\lambda^2\right] \quad (0 \leqq \lambda \leqq 1)$$

   (2) For 2 cycle diesel engines and 4 cycle vee type diesel engines other than shown in (1) above, the value of τ_1 is given by the following formula:

$$\tau_1 = 45 - 29\lambda^2$$
$$\left[\tau_1 = 460 - 295\lambda^2\right] \quad (0 \leqq \lambda \leqq 1)$$

   where:
   τ_1 = Allowable limit of torsional vibration stresses for continuous operation (N/mm^2 [kgf/cm^2]).
   λ = Ratio of the number of revolutions to the number of maximum continuous revolutions.
2. Within the range below and at 80 % of the maximum continuous revolutions, the torsional vibration

stresses not exceeding τ_2 given in the following formula may be accepted, only for transient operation by passing through rapidly the range where the stresses exceed τ_1:

$$\tau_2 = 2\tau_1 \quad (0 \leqq \lambda \leqq 0.8)$$

where:

τ_2 = Allowable limit of torsional vibration stresses for transient operation (N/mm^2 [kgf/cm^2]).

3. The torsional vibration stresses are not to exceed τ_3 given in the followings, within the range from the maximum continuous revolutions to 115 %.

(1) For 4 cycle in-line diesel engines and 4 cycle vee type diesel engines with firing intervals of 45° or 60°, the value of τ_3 is given by the following formula:

$$\tau_3 = 21 + 237(\lambda - 0.8)\sqrt{\lambda - 1}$$
$$\left[\tau_3 = 215 + 2420(\lambda - 0.8)\sqrt{\lambda - 1}\right]$$
$$(1.0 < \lambda \leqq 1.15)$$

(2) For 2 cycle diesel engines and 4 cycle vee type diesel engines other than shown in (1) above, the value of τ_3 is given by the following formula:

$$\tau_3 = 16 + 237(\lambda - 0.8)\sqrt{\lambda - 1}$$
$$\left[\tau_3 = 165 + 2420(\lambda - 0.8)\sqrt{\lambda - 1}\right]$$
$$(1.0 < \lambda \leqq 1.15)$$

where:

τ_3 = Allowable limit of torsional vibration stresses in the range over the maximum continuous revolutions (N/mm^2 [kgf/cm^2]).

λ = As specified in **Par 1**.

4. In case where the specified minimum tensile strength of the shaft material exceeds 440 N/mm^2 [45 kgf/mm^2], or its yield strength exceeds 225 N/mm^2 [23 kgf/mm^2], the values of τ_1, τ_2 and τ_3 given in **Pars 1** to **3** may be increased by multiplying the factor f_m given in the following formula:

(1) For τ_1 and τ_3

$$f_m = 1 + \frac{2}{3}\left(\frac{T_s}{440} - 1\right)$$
$$\left[f_m = 1 + \frac{2}{3}\left(\frac{T_s}{45} - 1\right)\right]$$

(2) For τ_2

$$f_m = \frac{Y}{225} \qquad \left[f_m = \frac{Y}{23}\right]$$

where:

f_m = Correction factor for allowable limit of torsional vibration stresses concerning the shaft material.

T_s = Specified minimum tensile strength of shaft material (N/mm^2 [kgf/mm^2]). However, in case where the specified minimum tensile strength exceeds 590 N/mm^2 [60 kgf/mm^2] for carbon steel forgings, or 835 N/mm^2 [85 kgf/mm^2] for low alloy steel forgings, the value of T_s for calculating f_m is to be as deemed appropriate by the Society.

Y = Specified minimum yield stress of the shaft material (N/mm^2 [kgf/mm^2]).

202. Intermediate shafts, thrust shafts, propeller shafts and stern tube shafts

1. For ships equipped with main propulsion diesel engine, the torsional vibration stresses on the intermediate shafts, thrust shafts, propeller shafts and stern tube shafts are to be in accordance with the following requirements (1) and (2).

(1) For continuous operation, the torsional vibration stresses are not to exceed τ_1 given in the following formulae:

$$\tau_1 = \frac{T_s + 160}{18} \cdot C_k \cdot C_d (3 - 2\lambda^2)$$
$$\left[\tau_1 = \frac{T_s + 16.3}{0.18} \cdot C_k \cdot C_d (3 - 2\lambda^2)\right]$$
$$(0 \leqq \lambda \leqq 0.9)$$

$$\tau_1 = 1.38 \cdot \frac{T_s + 160}{18} \cdot C_k \cdot C_d$$
$$\left[\tau_1 = 1.38 \cdot \frac{T_s + 16.3}{0.18} \cdot C_k \cdot C_d\right]$$
$$(0.9 < \lambda \leqq 1.05)$$

where:

τ_1 = Allowable limit of torsional vibration stresses for continuous operation (N/mm^2 [kgf/cm^2]).

λ = As specified in **201. 1**.

T_s = Specified minimum tensile strength of shaft material (N/mm^2 [kgf/mm^2]). However, the value of T_s for using in the formulae is not to exceed 590 N/mm^2 [60 kgf/mm^2] for carbon steel forgings and 785 N/mm^2 [80 kgf/mm^2] for low alloy steel forgings in intermediate shafts and thrust shafts, and 590 N/mm^2 [60 kgf/mm^2] in propeller shafts and stern tube shafts. Where propeller shafts and stern tube shafts are made of the approved corrosion resistant materials or other materials having effective means against corrosion by seawater, the value of T_s for using in the formulae is to be as deemed appropriate by the Society.

C_k = Coefficient concerning to the type and shape

Table 5.4.1 Values of C_k

Intermediate shaft			Thrust shafts external to engines		Propeller shaft and stern tube shaft
Integral coupling flanges	Shrink fit coupling flanges	Keyways	On both sides of thrust collar	In way of axial bearing where a roller bearing is used as a thrust bearing	—
1.0	1.0	0.6	0.85	0.85	0.55
NOTE: The value of C_k other than above is to be determined by the Society in each case.					

of the shaft, given in **Table 5.4.1**.

C_d = Coefficient concerning to the shaft size and determined by the following formula:

$$C_d = 0.35 + 0.93d^{-0.2}$$

d = Diameter of the shaft (mm)

(2) Within the range below 80 % of the maximum continuous revolutions, the torsional vibration stresses not exceeding τ_2 given in the following formula may be accepted, only for transient operation by passing through rapidly the range where the stresses exceed τ_1.

$$\tau_2 = \frac{1.7\tau_1}{\sqrt{C_k}}$$

where:

τ_2 = Allowable limit of torsional vibration stresses for transient operation (N/mm^2 [kgf/cm^2]).

τ_1, C_k = As specified in (1).

2. For main propulsion system formed by steam turbines, gas turbines, diesel engines having slide couplings or electric propulsion systems having geared power transmission, allowable limits of the torsional vibration stresses on the intermediate shafts, thrust shafts, propeller shafts and stern tube shafts are to be as deemed appropriate by the Society.

203. Shafting system of generators

1. The torsional vibration stresses on the crank shafts of diesel engines to drive generators are to be in accordance with the following requirements (1) and (2).

(1) The torsional vibration stresses are not to exceed τ_1 given in the followings, within the range from 90% to 110% of the maximum continuous revolutions.

(a) For 4 cycle in-line diesel engines and 4 cycle vee type diesel engines with firing intervals of 45° or 60°, the value of τ_1 is given by the following formula:

$$\tau_1 = 21\, N/mm^2 \left[\tau_1 = 215\, kgf/cm^2\right]$$

(b) For 2 cycle diesel engines and 4 cycle vee type diesel engines other than shown in (a) above, the value of τ_1 is given by the following formula:

$$\tau_1 = 16\, N/mm^2 \left[\tau_1 = 165\, kgf/cm^2\right]$$

(2) Within the range below and at 90 % of the maximum continuous revolutions, the torsional vibration stresses not exceeding τ_2 given in the following formula may be accepted, only for transient operation by passing through rapidly the range where the stresses exceed τ_1.

$$\tau_2 = 90\, N/mm^2 \left[\tau_2 = 920\, kgf/cm^2\right]$$

2. The torsional vibration stresses on the generator shafts driven by diesel engines are to be in accordance with the following requirements (1) and (2).

(1) The torsional vibration stresses are not to exceed τ_1 given in the following, within the range from 90 % to 110 % of the maximum continuous revolutions.

$$\tau_1 = 31\, N/mm^2 \left[\tau_1 = 315\, kgf/cm^2\right]$$

(2) Within the range below and at 90 % of the maximum continuous revolutions, the torsional vibration stresses not exceeding τ_2 given in the following formula may be accepted, only for transient operation by passing through rapidly the range where the stresses exceed τ_1.

$$\tau_2 = 118\, N/mm^2 \left[\tau_2 = 1{,}200\, kgf/cm^2\right]$$

3. In case where the specified minimum tensile strength of the shaft material exceeds 440 N/mm^2 [45 kgf/mm^2], or its yield strength exceeds 225 N/mm^2 [23 kgf/mm^2], the values of τ_1 and τ_2 given in **Pars 1** and **2** may be increased by multiplying the factor f_m given in **201. 4**.

204. Avoidance of major criticals

The major criticals of one node vibration in in-line diesel engine, e.g. the n th and $n/2$ th order for 4 cycle and the n th order for 2 cycle (n denotes the number of cylinders), are not to exist within the following speed range except when an approval is specifically obtained by the Society:

For main propulsion shafting system	$0.8 \leqq \lambda \leqq 1.1$
For generator shafting system	$0.9 \leqq \lambda \leqq 1.1$

where

λ = Ratio of the number of revolutions at the major critical to the maximum continuous revolutions.

205. Detailed evaluation for strength

Special consideration will be given to the allowable limit of torsional vibration stresses not complying with the requirements in **201.** to **203.** provided that detailed data and calculations are submitted to the Society and considered appropriate.

206. Barred speed range for avoiding continuous operation

1. In case where the torsional vibration stresses exceed the allowable limit τ_1 specified in **201.** to **203.** the barred speed ranges are to be imposed between the following speed limits. The barred speed ranges are to be marked with red zone on the engine tachometer, so that the engine is not to be run continuously.

$$\frac{16N_c}{18-\lambda} \leq N \leq \frac{(18-\lambda)N_c}{16}$$

where:

N = The number of revolutions to be barred (rpm).
N_c = The number of revolutions at the resonant critical (rpm).
λ = Ratio of the number of revolutions at the resonant critical to the maximum continuous revolutions.

2. In case where there are problems such as chattering or generation of heat caused by excessive alternating torque arising from the torsional vibration in the gears and flexible couplings, the requirement for those speed ranges is to comply with preceding **Par 1.** However, excessive alternating torque is not to be occurred in the speed range specified in **204.**

3. In case where the range in which the stresses exceed the allowable limit τ_1 specified in **201.** to **203.** is verified by measurements, such range may be taken as the barred speed range for avoiding continuous operation, notwithstanding the required range specified in the preceding **Par 1**, having regard to the tachometer accuracy. ⚓

CHAPTER 5
BOILERS AND PRESSURE VESSELS

SECTION 1
Boilers

101. Application

1. The requirements in this Section apply to boilers and their accessories intended for marine service, provided that the followings are excluded from the scope.

(1) Steam boilers with design pressure not exceeding 0.1 MPa and heating surface not exceeding 1 m^2.

(2) Hot water boilers with design pressure not exceeding 0.1 MPa and heating surface not exceeding 8 m^2.

2. In cases where boilers are of unconventional construction and the requirements of this Section are unsuitable to be applied, the manufacturer is to submit the detailed plans, data and strength calculations for the construction to the Society for its approval.

102. Materials

1. The materials used in the construction of the pressure parts of boilers are to comply with the following requirements.

(1) All materials used for boilers are to comply with the requirements in **Pt 2, Ch 1**.

(2) The materials of fittings for boilers and piping systems are to comply with the requirements in **Pt 2. Ch 1**. However, the Society may accept to use the materials which meet Korean Industrial Standards or equivalent.

(3) In case where heat treatment, such as hot working or stress relieving, is carried out on steel plates during the manufacturing process of boilers, the manufacturer is to inform of such intention with an order for the materials. What are expected of the manufacturer of steel plates in this case, are prescribed in **Pt 2, Ch 1, 302.3**.

(4) Appropriate heat treatments are to be carried out on the cold-formed steel plates, where it is considered that the cold-forming affects the safety of boiler.

2. Cast steel materials may be used in the boilers where the thickness does not exceed 50 mm and the maximum working temperature does not exceed 350°C.

3. Steel tubes

(1) Tubes used for boilers, which are subjected to the internal pressure and come in contact with fire or combustion gas, are to be either seamless steel tubes or electric resistance welded steel tubes.

(2) $RSTH$33 as electric resistance welded steel tubes may be used for a boiler which has the design pressure of 2 MPa or below, at the places where wall temperatures are estimated to be 350°C or below.

(3) $RSTH$35 and $RSTH$42 as electric resistance welded steel tubes may be used for a boiler which has the design pressure of 3 MPa or below, at the place where wall temperatures are estimated to be 400°C or below.

4. Pipe fittings for boiler

(1) Nozzles, flanges or distance pieces attached directly to boiler drums are to be made of steel.

(2) Valve boxes or other pipe fittings which are connected to a boiler and are subjected to its pressure, are to be made of steel except for the following cases :

(a) The copper alloy castings may be used in cases where the maximum working temperature does not exceed 200°C.

(b) The grey iron castings may be used for pipe fittings except for blow-off valve in cases where the maximum working temperature and the design pressure do not exceed 220°C and 1 MPa respectively.

(c) Special cast iron may be used in cases where the castings are made by the specifically approved manufacturers, and the maximum working temperature and the design pressure do not exceed 230°C and 2.5 MPa respectively.

103. Type of joint

Longitudinal and circumferential joints of boilers are to be of the approved double welded butt joints. However, for cylindrical shells of small diameter, where the inside welding is considered difficult, the joints may be of the single welded butt joint subject to the approval by the Society.

104. Welding method for each part

The welding methods to be adopted for each part are to be as those shown in **Fig. 5.5.1** or the equivalent. The definitions of representative symbols are stated at the end of the figures. (Unit:mm)

105. Efficiencies of joints

The values of efficiencies of joints for the shells of boilers are to be as follows in relation to their application and type of joints.

(1) For seamless shells : J = 1.00
(2) For welded shells :
  (a) Double welded butt joints : J = 1.00
  (b) Other cases : J = 0.90

106. Ligament efficiency

1. The efficiency of longitudinal ligament (hereinafter referred to as "longitudinal efficiency") along the row of tube holes drilled in a cylindrical shell, having a row parallel or nearly parallel to the shell axis, or having several parallel rows with sufficient distance to each other, is to be determined by the following formulae:

(1) In case where the pitch of tube holes is uniform (see **Fig. 5.5.2**(a))

$$J = \frac{P-d}{P}$$

where :

J = Efficiency of ligament.
P = Pitch of tube holes (mm).
d = Diameter of tube holes (mm).

(2) In case where the pitch of tube holes is irregular (see **Fig. 5.5.2**(b))

$$J = \frac{L-nd}{L}$$

where :

J, d = As specified in (1).
L = Total length between centres corresponding to n consecutive ligaments (mm).
n = Number of tube holes in length L.

2. The efficiency of circumferential ligament (hereinafter referred to as "circumferential efficiency") at the part of tube holes drilled in the circumferential direction of the shell is to be calculated in a similar manner to that prescribed in **Par 1** and is to be at least 0.50 times the efficiency of longitudinal ligaments. In this case, the pitches of tube holes in the circumferential direction are to be measured either on the flat plate before rolling or along the median line of plate thickness after rolling.

3. The efficiency of ligament at the part of tube holes drilled in the diagonal direction of the shell is to be determined by the following formula.

(1) Where tube holes drilled in the diagonal direction of the shell as shown in **Figs. 5.5.2** (c) and (d) : The value calculated by the following formula or longitudinal efficiency, whichever is lower, is to be used as the lowest efficiency of ligaments. (see **Fig. 5.5.3**)

$$J = \frac{2}{A+B+\sqrt{(A-B)^2+4C^2}}$$

$$A = \frac{\cos^2\alpha + 1}{2\left(1-\dfrac{d\cos\alpha}{a}\right)}$$

$$B = \frac{1}{2}\left(1-\frac{d\cos\alpha}{a}\right)(\sin^2\alpha+1)$$

$$C = \frac{\sin\alpha\cdot\cos\alpha}{2\left(1-\dfrac{d\cos\alpha}{a}\right)}$$

$$\cos\alpha = \frac{a}{\sqrt{a^2+b^2}}$$

$$\sin\alpha = \frac{b}{\sqrt{a^2+b^2}}$$

where :

J = Efficiency of ligament.
α = As given in **Figs. 5.5.2** (c), (d) and (e).
a, b = As given in **Figs. 5.5.2** (c), (d) and (e) (mm).
d = Diameter of tube holes (mm).

(2) For the above requirements in (1), where the tube holes are arranged in a regular staggered spacing as shown in **Fig. 5.5.2** (e) :
The value calculated by above formula, twice the circumferential efficiency or longitudinal efficiency, whichever is the lowest, is to be used as the lowest efficiency of ligament. (see **Fig. 5.5.4**)

4. Where the efficiency of tube plate cannot be obtained by the above requirements due to the special pattern of tube holes, the manufacturer may submit to the Society for its approval an alternative method of calculating the efficiency.

Fig. 5.5.1 Examples of Welded Joints

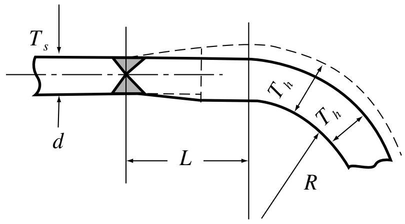
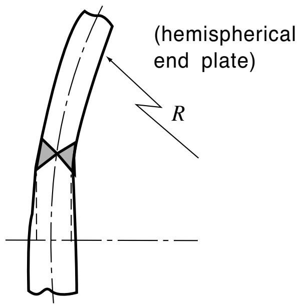
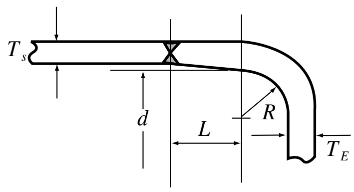
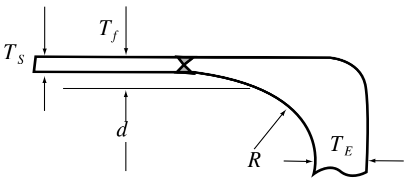
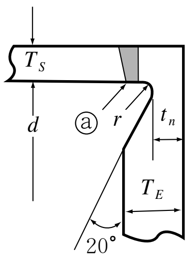
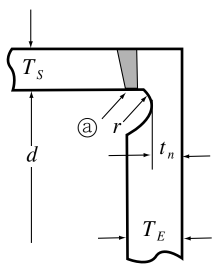
Welding part	Symbol	Welding mode	Remark
(1) Welding joint between formed end plate and shell plate	1 A		L ≧ 3 T_h (but, need not be more than 38 mm.). Where T_h ≦ 1.25 T_s , the above mentioned value may be reduced.
	1 B		
(2) Welding joint between flat end plate or cover plate and shell plate	2 A		(1) L = see **Table 5.5.4** (2) R ≧ 3 T_E
	2 B		(1) T_f ≧ 2 T_s (2) R ≧ 3T_f
	2 C		(1) r ≧ 0.2 T_E (but not less than 5mm) (2) t_n ≧ 1.25 T_{ro} (3) In welding the part ⓐ, such welding process as should have a good penetration to the root is to be employed. (4) End plates or cover plates are to be made of forged steel.
	2 D		Same as above

Fig. 5.5.1 Examples of Welded Joints (Continued)

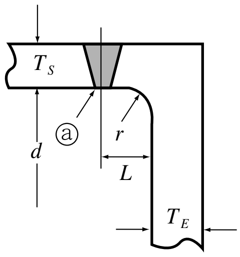
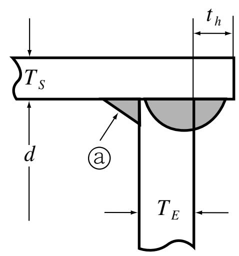
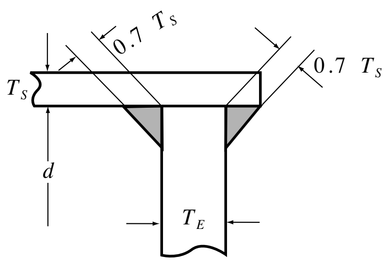
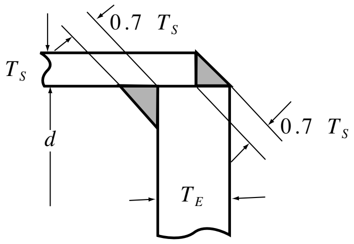
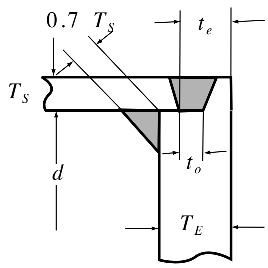
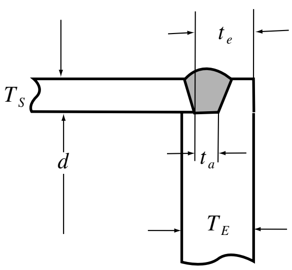
Welding part	Symbol	Welding mode	Remark
(2) Welding joint between flat end plate or cover plate and shell plate	2 E		(1) $r \geqq 0.3\ T_E$ (2) $L \geqq T_E$ (3) For the part ⓐ, the same is required as above. (4) End plates or cover plates are to be made of forged steel.
	2 F		(1) $T_S \geqq 1.25\ T_{ro}$ (2) $t_h \geqq T_S$ (3) Where the welding of part ⓐ is considered difficult, the backing strip is to be used or the welding process which should have a good penetration to the root is to be employed.
	2 G		$T_S \geqq 1.25\ T_{ro}$
	2 H		
	2 I		(1) $T_s \geqq 1.25\ T_{ro}$ (2) $t_o \geqq T_S$ (but need not be over 6.5 mm.) (3) $t_e \geqq 1.25\ T_S$
	2 J		(1) Tube headers only. (2) $T_S \geqq 1.25\ T_{ro}$ (circular only) (3) t_e is not to be less than 2 T_{ro}, or 1.25 T_S, whichever is the larger. (4) $t_a \geqq T_S$ (but need not be over 6.5 mm.)

Fig. 5.5.1 Examples of Welded Joints (continued)

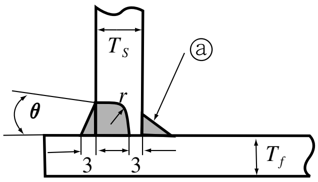
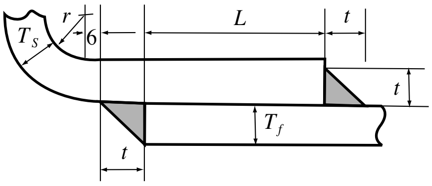
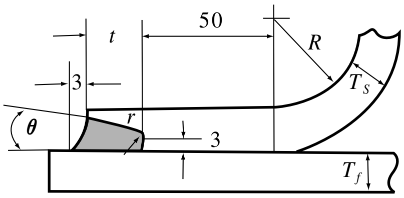
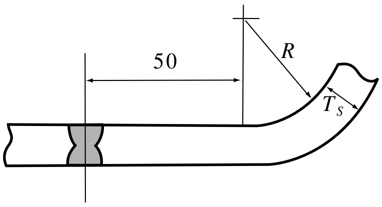
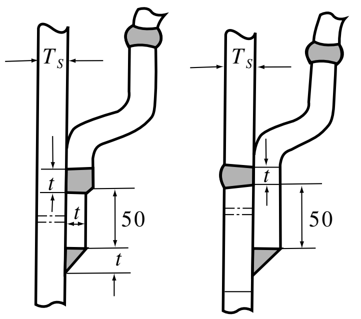
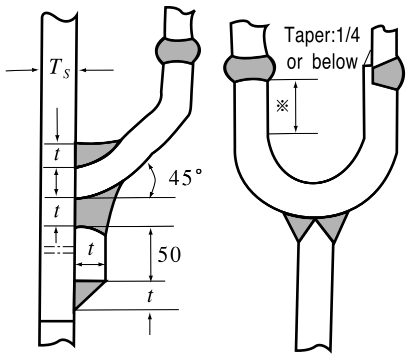
Welding part	Symbol	Welding mode	Remark
(3) Welding joint between flue or furnace and shell or end plate	3 A		(1) To be applied for welding of boiler front. (2) Light fillet welding is to be employed for part ⓐ, (throat depth 4 ~ 6 mm) (3) θ is to be 10°~20° (4) 5 ≦ r ≦ 10
	3 B		(1) To be applied for welding of boiler front. (2) t ≧ T_f (3) L ≧ 2 T_s
	3 C		(1) To be applied for welding of boiler front. (2) t ≧ T_S − 3 (3) θ is to be 10°~20° (4) 5 ≦ r ≦ 10
	3 D		To be applied for welding of boiler rear.
(4) Welding joint between furnace ogee ring and shell plate	4 A 4 B	4A 4B 	(1) t ≧ T_s (2) The welded surface is not to be lower than the plate surface.
	4 C 4 D	4C 4D 	

Fig. 5.5.1 Examples of Welded Joints (Continued)

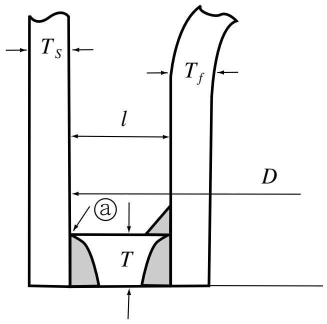
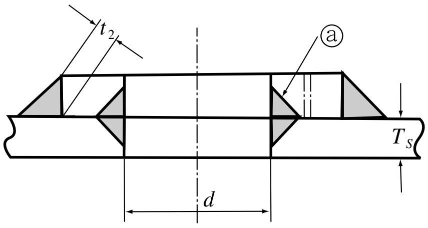
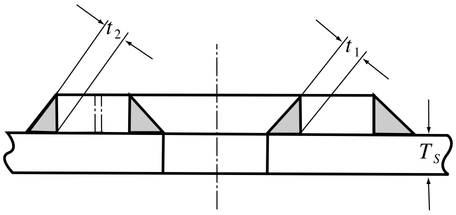
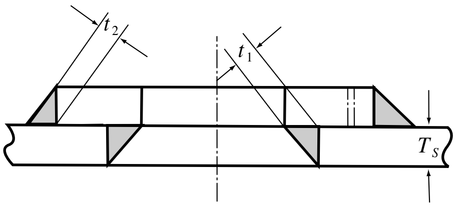
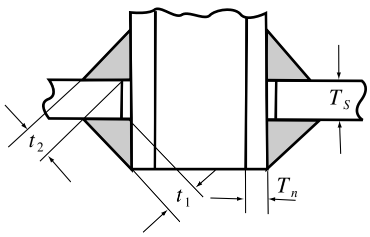
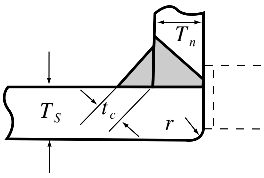
<table>
<tr><th>Welding part</th><th>Symbol</th><th>Welding mode</th><th>Remark</th></tr>
<tr><td></td><td>4 E</td><td>
</td><td>(1) $T \geq 1.265\sqrt{D \cdot P}$
Where :
D = Inside diameter of shell (mm).
P = Design pressure (MPa).
T = Thickness of foundation ring (mm).
(2) Where D ≦ 750 : l ≧ 50
Where D 〉 750 : l ≧ 60
(3) In welding the part ⓐ, such welding process as should have a good penetration to the root is to be employed.</td></tr>
<tr><td rowspan="3">(5) Welding joint between washer or reinforcement ring and shell or end plate</td><td>5 A</td><td>
</td><td>(1) In case of d 〈 60, to be applied.
(2) t_2 ≧ 0.7 t_m where t_m is the thickness of the smaller one of the plates to be welded together, but need not be over 20mm
(3) The seal welding is to be employed for part ⓐ</td></tr>
<tr><td>5 B</td><td>
</td><td rowspan="2">(1) $t_1 + t_2 \geqq 1.25\ t_m$
(2) $t_1,\ t_2 \geqq \frac{1}{3}\ t_m$
(but the minimum is 6.5 mm)</td></tr>
<tr><td>5 C</td><td>
</td></tr>
<tr><td rowspan="2">(6) Welding joint between nozzle and shell or end plate</td><td>6 A</td><td>
</td><td rowspan="2">(1) t_c ≧ 6.5 or 0.7 t_m, whichever is the smaller.
(2) $t_1 + t_2 \geqq 1.25\ t_m$
(3) $t_1,\ t_2 \geqq \frac{1}{3}\ t_m$
(but the minimum is 6.5mm)
(4) $t_w \geqq 0.7\ t_m$</td></tr>
<tr><td>6 B</td><td>
</td></tr>
</table>

Fig. 5.5.1 Examples of Welded Joints (Continued)

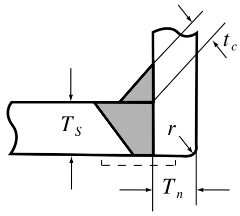
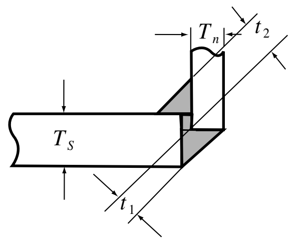
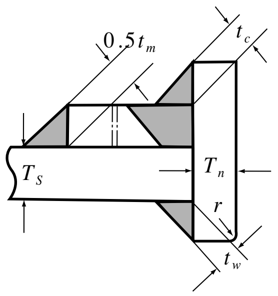
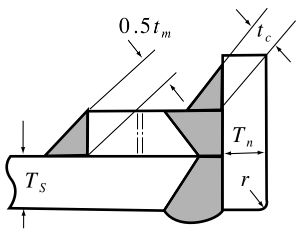
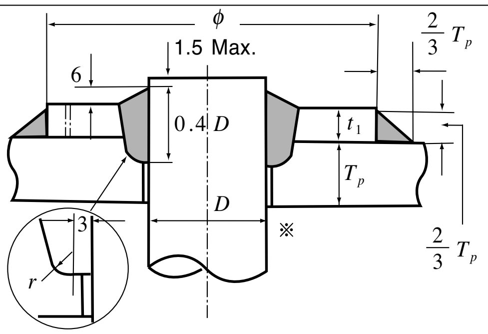
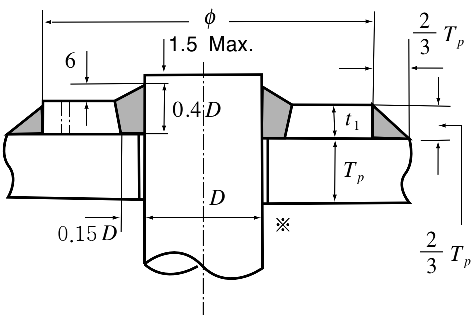
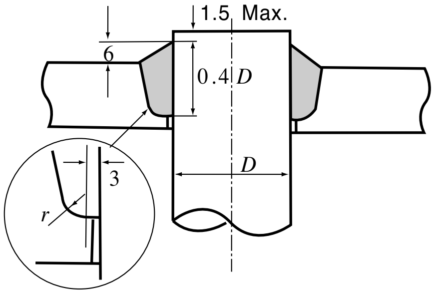
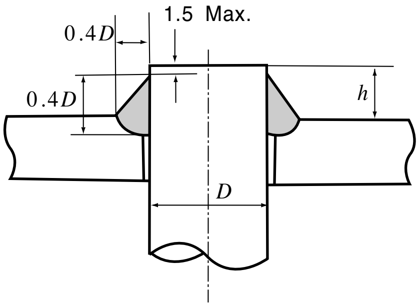
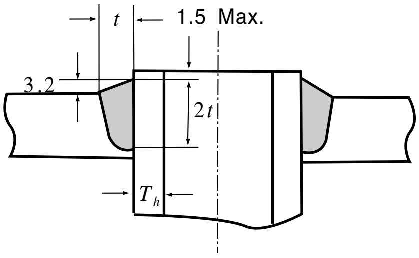
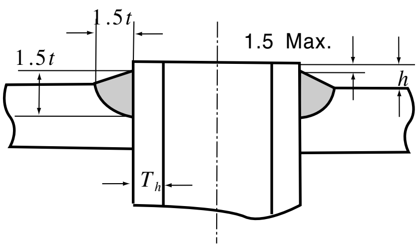
Welding part	Symbol	Welding mode	Remark
(6) Welding joint between nozzle and shell or end plate	6 C		(1) $t_c \geqq$ 6.5 or 0.7 t_m, whichever is the smaller. (2) $t_1 + t_2 \geqq 1.25\ t_m$ (3) $t_1,\ t_2 \geqq \frac{1}{3}\ t_m$ (but the minimum is 6.5mm) (4) $t_w \geqq 0.7\ t_m$
	6 D		
	6 E		
	6 F		
(7) Welding joint between stay, stay tube or tube and tube plate or end plate	7 A		(1) $\phi \geqq \frac{2}{3}\ p$, p means the pitch of stay (same in the following) (2) $t_1 \geqq \frac{2}{3}\ T_p$ (3) For the part marked ※, the light fillet welding (throat depth 4 ~ 6 mm) or caulking from the plate side is to be done to fill up the gap
	7 B		(1) $\frac{2}{3}\ p > \phi \geqq 3.5\ D$ (2) $t_1 \geqq \frac{2}{3}\ T_p$ (3) The part marked with ※ is to be treated as mentioned above.

Fig. 5.5.1 Examples of Welded Joints (Continued)

<table>
<tr><th>Welding part</th><th>Symbol</th><th>Welding mode</th><th>Remark</th></tr>
<tr><td rowspan="4">(7) Welding joint between stay, stay tube or tube and tube plate or end plate</td><td>7 C</td><td>
</td><td></td></tr>
<tr><td>7 D</td><td>
</td><td>On the side exposed to flame, $h \leqq 10$</td></tr>
<tr><td>7 E</td><td>
</td><td>(1) $t \geqq T_k$
(2) To be welded after expanding the tube, and after the welding the tube is to be further expanded slightly.</td></tr>
<tr><td>7 F</td><td>
</td><td>(1) $t \geqq T_k$
(2) To be welded after expanding the tube, and after the welding the tube is to be further expanded slightly.
(3) On the side exposed to flame, $h \leqq 10$.</td></tr>
</table>

NOTES :

T_s = Actual thickness of shell plate
T_h = Actual thickness of formed end plate
T_E = Actual thickness of flat end plate or cover plate
T_{ro} = Required thickness of seamless shell
T_p = Actual thickness of tube plate or flat end plate (formed end plate)
T_f = Actual thickness of flue or furnace plate, actual thickness of the flange on a forged head at the large end.
T_n = Actual thickness of nozzle
T_k = Actual thickness of stay tube or tube.
t_m = Smaller value of thickness of plates to be welded, however, the maximum value being 20 mm.

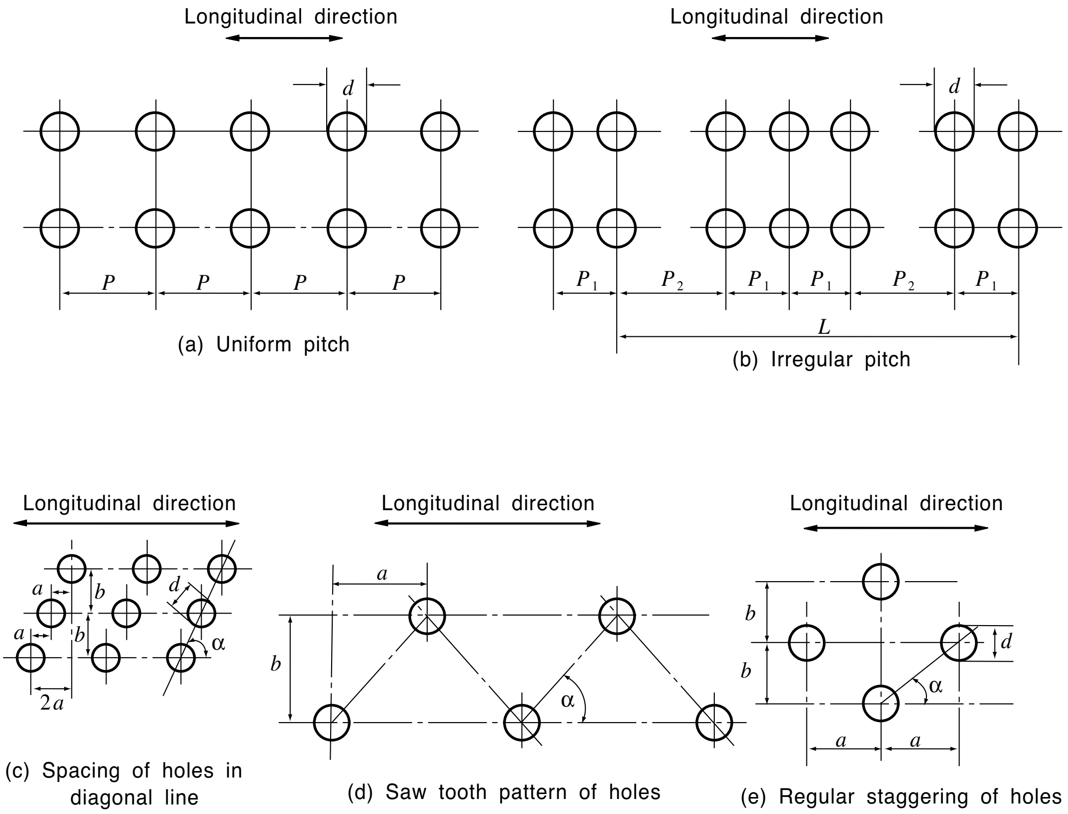


Fig. 5.5.2 Tube Holes

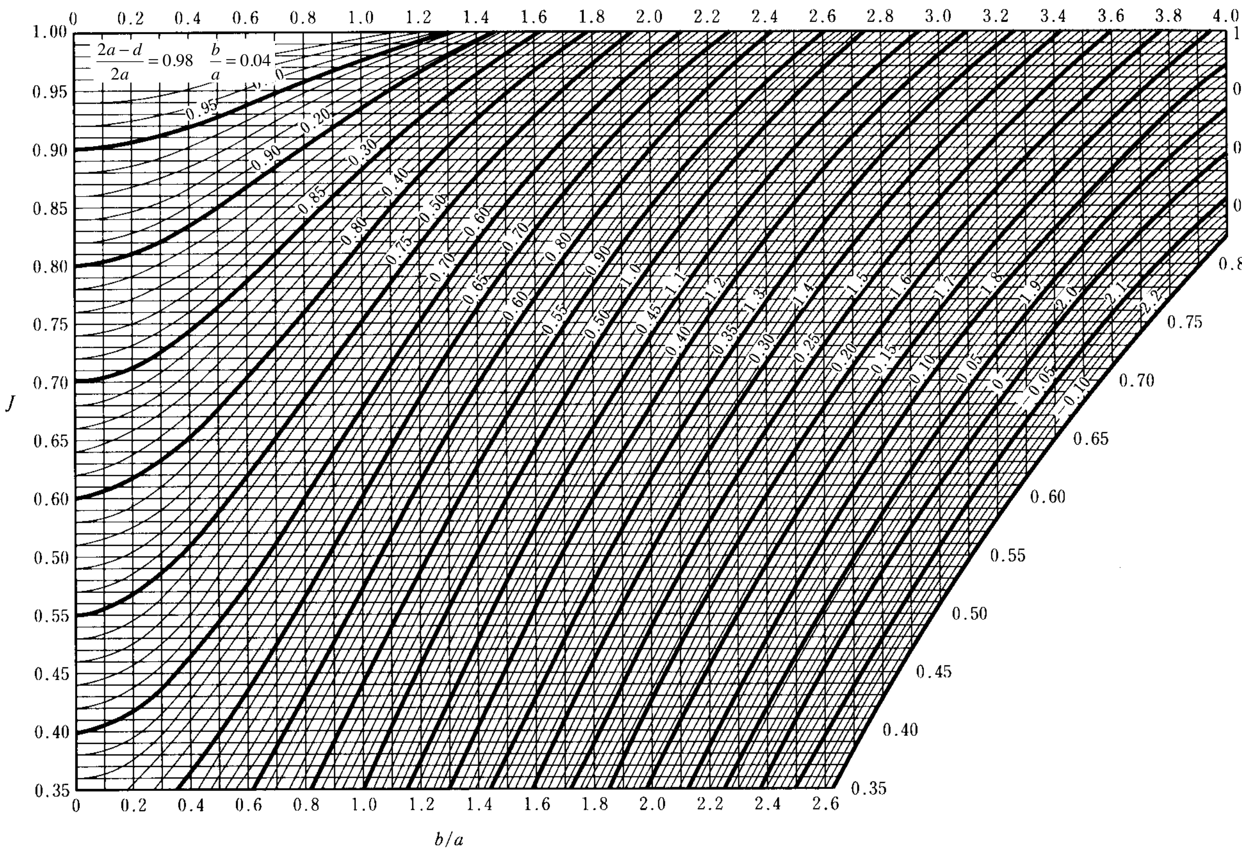


Fig. 5.5.3 The Efficiency of Ligament at the Part of Tube Holes Drilled in the Circumferential Direction

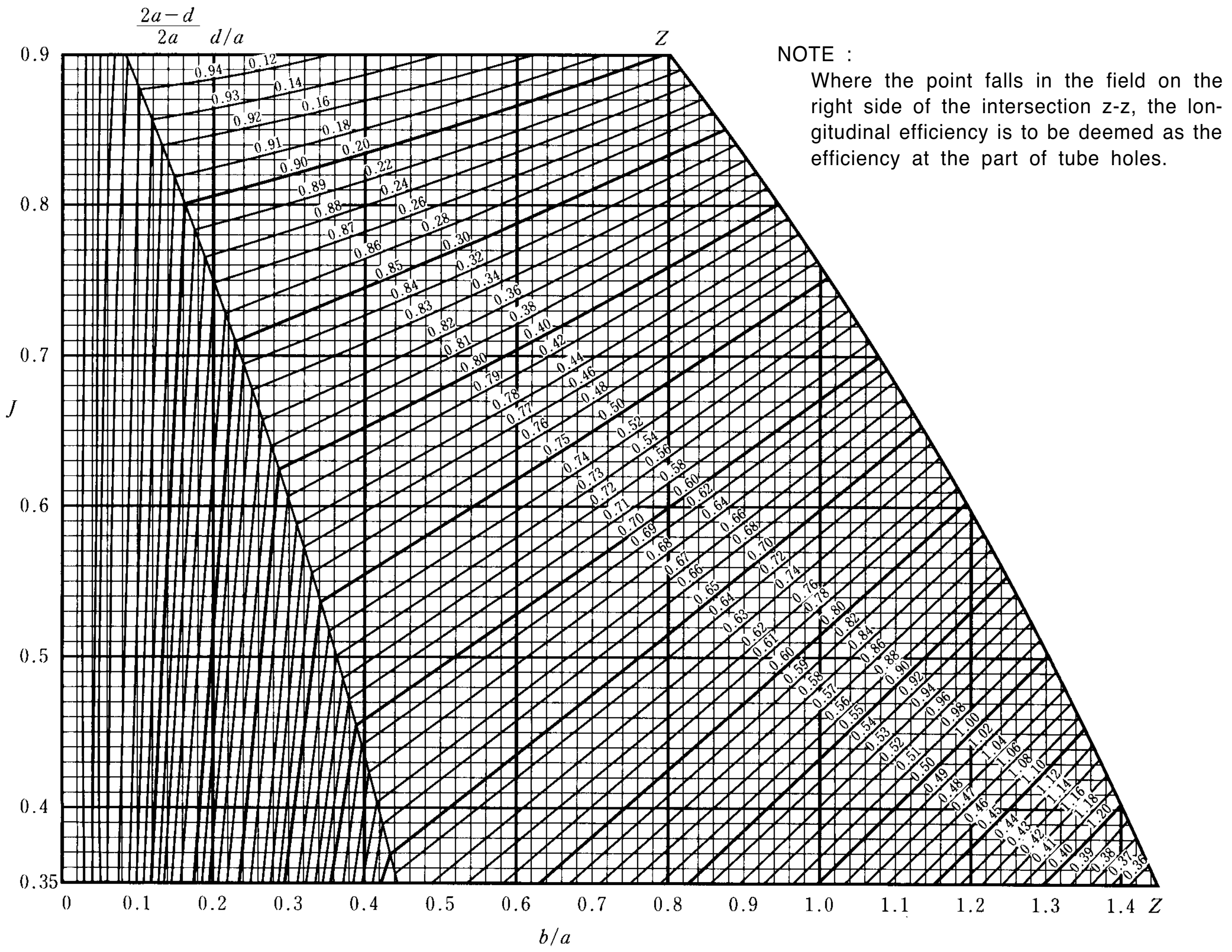


Fig. 5.5.4 The Efficiency of Ligament at the Part of Tube Holes Drilled in the Diagonal Direction

107. Allowable stress

1. The metal temperature at the heating surface, used to evaluate the allowable stress is to be taken as not less than the planned maximum temperature of the internal fluid increased by the temperature indicated in **Table 5.5.1**.

Table 5.5.1 Increase of Material Temperature

Heating surface in general	Heated by contact	25°C
	Heated by radiation	50°C
Heating surface of superheater	Heated by contact	35°C
	Heated by radiation	50°C
Heating surface of economizer	–	25°C

2. The allowable stresses which are used for the calculation of strength in this Section are to be as follows.

(1) The allowable stress of carbon steel (including carbon manganese steel, hereinafter the same being referred in this Section) and low alloy steels excluding cast steels is not to be greater than obtained from the following formulae, whichever is the smallest. The allowable stress at each metal temperature may also be in accordance with the values given in **Table 5.5.2** instead of the following formulae.

$$f=\frac{R_{20}}{2.7},\quad f=\frac{f_R}{1.6},\quad f=\frac{E_T}{1.6},\quad f=\frac{S_C}{1.0}$$

where :

R_{20} = Specified minimum tensile strength at room temperature ($N/mm^2[kgf/mm^2]$).

f_R = Average stress to produce rupture in 100,000 *hours* at the design temperature (N/mm^2 $[kgf/mm^2]$).

E_t = Specified minimum yield stress or 0.2 percent proof stress ($N/mm^2[kgf/mm^2]$).

S_c = Average stress to produce an elongation (creep) of 1% in 100,000 *hours* at metal temperature ($N/mm^2[kgf/mm^2]$).

(2) The allowable stress of cast steels is to be 80% of the value obtained by the formula in (1) or the value given in **Table 5.5.2**.

(3) The allowable stress of materials other than those specified in (1) and (2) will be considered

Table 5.5.2 Allowable Stress (*f*)

Kind of materials		Allowable stress (f) N/mm^2 [kgf/mm^2][(1)]											
		250°C and below	300°C C	350°C	375°C	400°C	425°C	450°C	475°C	500°C	525°C	550°C	575°
Steel plates for boiler	*RSP* 42	110 [11.2]	104 [10.6]	103 [10.5]	96 [9.8]	88 [9.0]	76 [7.7]	57 [5.8]	39 [4.0]				
	RSP 46	122 [12.4]	117 [11.9]	113 [11.5]	106 [10.8]	95 [9.7]	80 [8.2]	58 [5.9]	39 [4.0]				
	RSP 49	124 [12.6]	122 [12.4]	121 [12.3]	114 [11.6]	102 [10.4]	84 [8.6]	58 [5.9]	39 [4.0]				
	RSP 46 *A*	122 [12.4]	117 [11.9]	113 [11.5]	113 [11.5]	113 [11.5]	108 [11.0]	101 [10.3]	90 [9.2]	69 [7.0]	48 [4.9]		
	RSP 49 *A*	124 [12.6]	122 [12.4]	121 [12.3]	121 [12.3]	121 [12.3]	117 [11.9]	106 [10.8]	91 [9.3]	69 [7.0]	48 [4.9]		
	RSP 56 *A*	157 [16.0]	147 [15.0]	137 [14.0]	137 [14.0]	137 [14.0]	131 [13.4]	119 [12.1]	99 [10.1]	69 [7.0]	48 [4.9]		
Steels for header	*RBH*-1	105 [10.7]	104 [10.6]	103 [10.5]	97 [9.9]	88 [9.0]	76 [7.7]	57 [5.8]	39 [4.0]				
	RBH-2	117 [11.9]	115 [11.7]	113 [11.5]	106 [10.8]	95 [9.7]	80 [8.2]	58 [5.9]	39 [4.0]				
	RBH-3	102 [10.4]	99 [10.1]	96 [9.8]	96 [9.8]	96 [9.8]	93 [9.5]	91 [9.3]	87 [8.9]	67 [6.8]			
	RBH-4	106 [10.8]	104 [10.6]	103 [10.5]	103 [10.5]	103 [10.5]	102 [10.4]	98 [10.0]	92 [9.4]	74 [7.5]			
	RBH-5	106 [10.8]	104 [10.6]	103 [10.5]	103 [10.5]	103 [10.5]	102 [10.4]	98 [10.0]	92 [9.4]	81 [8.3]	64 [6.5]		
	RBH-6	106 [10.8]	104 [10.6]	103 [10.5]	103 [10.5]	103 [10.5]	102 [10.4]	98 [10.0]	92 [9.4]	81 [8.3]	64 [6.5]		
Steel tubes for boiler[(2)]	*RSTH* 33	86 [8.8]	84 [8.6]	81 [8.3]	78 [7.0]	74 [7.5]							
	RSTH 35	88 [9.0]	87 [8.9]	86 [8.8]	82 [8.4]	76 [7.7]	66 [6.7]	53 [5.4]					
	RSTH 42	113 [11.5]	104 [10.6]	103 [10.5]	97 [9.9]	88 [9.0]	76 [7.7]	57 [5.8]					
	RSTH 12	102 [10.4]	99 [10.1]	96 [9.8]	96 [9.8]	96 [9.8]	94 [9.6]	91 [9.3]	87 [8.9]	69 [7.0]			
	RSTH 22	106 [10.8]	104 [10.6]	103 [10.5]	103 [10.5]	103 [10.5]	102 [10.4]	98 [10.0]	92 [9.4]	81 [8.3]	64 [6.5]	44 [4.5]	
	RSTH 23	106 [10.8]	104 [10.6]	103 [10.5]	103 [10.5]	103 [10.5]	102 [10.4]	98 [10.0]	92 [9.4]	81 [8.3]	64 [6.5]	47 [4.8]	34 [3.5]
	RSTH 24	106 [10.8]	104 [10.6]	103 [10.5]	103 [10.5]	103 [10.5]	102 [10.4]	98 [10.0]	92 [9.4]	81 [8.3]	64 [6.5]	48 [4.9]	34 [3.7]
Forged Steel[(3)]		1/4 of specified minimum tensile strength of material (where 350°C and below)											
Cast steel[(3)]		1/5 of specified minimum tensile strength of material (where 350°C and below)											

NOTES :
(1) In case where the temperature of a material is between those indicated in the Table, the value of allowable stress is to be determined by interpolation.
(2) For the electric-resistance welded steel tubes, the values of f are to be 85% of these values.
(3) Materials specified in **Pt 2, Ch 1**.

in each case by the Society taking account of the mechanical properties of the materials.

108. General construction and strength

1. Because the formulae of this Section do not take into account such additional stresses as load from boiler fittings, localized stress, repeated load, thermal stress and so on, some measures such as increasing the size, etc. are to be taken, in case those effects are considered to exist.

2. Economizer, exhaust-gas economizer and their accessories, and fittings on feed water pipes are to be designed to stand a pressure 1.25 times the design pressure of the boiler. Where, however, it is difficult to comply with the above, they may be designed basing upon the maximum working pressure of the feed water pump or the boiler water circulating pump concerned.

3. Where part of the boiler drum and tube header is of the construction exposed to flames or high temperature gas, the part is to be suitably insulated with non-combustible material and sheathed with steel or other non-combustive material. In case where a part of the flue is composed of the end plate at the vapour space of the cylindrical boiler, the exposure of that part of flame is to be avoided by preparing an intercepting plate.

109. Shell plates and end plates

1. The thickness of shell plates or end plates is not to be less than the required thickness prescribed in **Table 5.5.3** and further is not to be less than 6mm. The thickness of the formed end plate except for the full hemispherical end plate is not to be less than the thickness (calculated by using the efficiency equal to 1.00) of the shell to which the end plate is attached.

2. The required thickness of the end plate having openings for which reinforcement is required is to comply with the followings :

Table 5.5.3 Thickness of Shell Plates and End Plates

Shell plates and end plates		Thickness (mm)
Shell plates	Cylindrical	$T=\frac{PD_1}{2fJ-1.2P}+1.0$
	Spherical	$T=\frac{PR_1}{2fJ-0.2P}+1.0$
End plates	Dished(1)	$T=\frac{PR_2E}{2fJ-0.2P}+1.0$
	Semi-spherical	$T=\frac{PR_2}{2fJ-0.2P}+1.0$
	Semi-ellipsoidal(2)	$T=\frac{PD_2}{2fJ-0.2P}+1.0$

P = Design pressure (MPa).
J = Minimum value of the efficiencies prescribed in **105.** and **106**.
f = Allowable stress prescribed in **107.2**. (N/mm^2).
D_1 = Inside diameter of shell (mm).
D_2 = Inside length of the major axis (mm).
R_1 = Inside radius of shell (mm).
R_2 = Inside crown radius (mm).

$$E=\frac{1}{4}\left(3+\sqrt{\frac{R_2}{r}}\right)$$

r = Inside knuckle radius (mm).

NOTES :
(1) The inside crown radius of dished end plate is not to be greater than the outside diameter of the flanged part of the end plate. The inside knuckle radius of end plate is not to be less than 6% of the outside diameter of the flanged part of the end plate or 3 times the thickness of the end plate, whichever is greater.
(2) Half the minor axis inside the semi-ellipsoidal end plate is not to be less than 1/2 of half the inside major axis of the end plate.

(1) In case where the openings are reinforced in accordance with the requirements in **115.2** the required thickness is to be calculated by the previous paragraph.

(2) Where an end plate has a flanged-in manhole or access opening with a maximum diameter exceeding 150 mm, and the flanged-in reinforcement complies with the requirements in **115.6**, the thickness is to be calculated as follows :

(a) Dished or hemispherical end plates : The thickness is to be increased by not less than 15% (if the calculated value is less than 3 mm, the value is to be taken to 3 mm) of the required thickness calculated by the formula in **Table 5.5.3**. In this case, where the inside crown radius of the end plate is smaller than 0.80 times the inside diameter of the shell, the value of the inside crown radius in the formula is to be 0.80 times the inside diameter of the shell. In calculating the thickness of the end plate having two manholes in accordance with this (a), the distance between the two manholes is not to be less than 1/4 of the outside diameter of the end plate.

(b) Semi-ellipsoidal end plates : The same requirements in **Table 5.5.3** are to be applied. However, in this case R_1 is to be 0.80 times the inside diameter of shell and E to be 1.77.

3. The required thickness of end plates subject to pressure on the convex sides is not to be less than that obtained from the formula for end plates subject to pressure on the concave sides provided that the value of design pressure P, in the formula is taken as 1.67 times P.

110. Flat end plates or cover plates without stay or other supports

The required thickness of flat end plates and cover plates without stay or other supports is not to be less than that obtained by the following formula :

$$T = C_1 C_2 d\sqrt{\frac{P}{f}} + 1.0 \quad (mm)$$

where :

P, f = As specified in **Table 5.5.3**.

d = Inside diameter of end plate at flange part in case of circular type (mm).
= Inside length of the shortest of the spans in case of non-circular type (mm).

C_2 = 1.00 for circular type
$= \sqrt{3.4 - \frac{2.4d}{b}}$ for non-circular type, but need not exceed 1.6.

b = Inside length of the greatest of the spans perpendicular to d in case of noncircular end plates (mm).

C_1 = Constant determined by the fixing method and given in **Table 5.5.4**.

111. Flat plates or tube plates with stay or other supports

1. The required thickness of tube plates and flat plates is not to be less than 10 mm for tube plates and 6 mm for flat plates, regardless of the following paragraphs.

2. The required thickness of flat plates supported by stays or stay tubes, arranged regularly is not to be less than that obtained by the following formula :

$$T = Cd\sqrt{\frac{P}{f}} + 1.0 \quad (mm)$$

where :

P = Design pressure (MPa).

f = Allowable stress prescribed in **107.2**. (N/mm^2).

d = $\sqrt{a^2 + b^2}$

a = Horizontal pitch of stays or stay tubes (mm).

b = Vertical pitch of stays or stay tubes (mm).

C = Constant determined by the fixing methods of stays or stay tubes and given in **Table 5.5.5**. In case where various fixing methods are used, the value C is to be the mean of the constants for the respective methods.

Table 5.5.4 Constant C_1

Fixing method	C_1
In case 2A in **Fig. 5.5.1**	1) In case L is not restricted (circular or non-circular), C_1=0.50
	2) Where $L \geqq (1.1 - 0.8 \times T_S^2 / T_E^2)\sqrt{d \cdot T_E}$ (circular only), C_1=0.39
In case 2B in **Fig. 5.5.1**	Circular or non-circular, C_1=0.50
In case 2C, 2D, 2E, 2G, 2H in **Fig. 5.5.1**	Circular, C_1 =0.55. Non-circular, C_1 =0.70
In case 2F, 2J in **Fig. 5.5.1**	Circular or non-circular, C_1=0.70
In case 2I in **Fig. 5.5.1**	Circular only, C_1=0.55

3. At tube nests of tube plates supported by stay tubes arranged regularly, the required thickness of tube plates is not to be less than that obtained by the following formula ;

$$T = Cd\sqrt{\frac{P}{f}} + 1.0 \quad (mm)$$

where :

P, f = As specified in **Par 2**.
d = Average length of four sides of the quadrilateral composed by four centre points of stay tubes at the corresponding parts (mm).
C = Constants determined by **Table 5.5.6**.

4. For the calculation of the required thickness of the flat plate in case where points of supports of stays or stay tubes are irregularly pitched, draw a maximum circle that passes through at least three points of supports with no point inside and the diameter d_1 of the circle is to be used as d in the formula in **Par 2**, or $\sqrt{a^2+b^2}$ is to be used as d in the formula in **Par 3**.

5. In case where the above formulae are applied, the commencement of curvature of the flange or the inside plain ends welded on shell or furnaces are to be regarded as points of supports, and the value of constant C in **Par 2** is determined by **Table 5.5.7**.

112. Tube plates of vertical boiler

For vertical boilers where the smoke tubes are arranged horizontally, the required thickness of tube plate at the tube nests is not to be less than that obtained from the following formula or than that given by **111.3**, whichever is greater. However, for the outer row of tube arranged vertically, stay tubes are to be arranged alternately.

$$T = \frac{PD}{1.97fJ} + 1.0 \quad (mm)$$

where :

P, f = As specified in **111.2**.
D = Twice the distance between the axis of shell and the centre of the outer row of tube holes (mm).

$$J = \frac{P_i - d}{P_i}$$

P_i = Vertical pitch of smoke tubes (mm).

Table 5.5.5 Constant C

Fixing method of stay or stay tube	C	
	In case the plates are exposed to flame	In case the plates are not exposed to flame
In case the stays are inserted into the plate as 7A in **Fig. 5.5.1**	0.38	0.35
In case the stays are inserted into the plate as 7B in **Fig. 5.5.1**	0.40	0.37
In case the stays are inserted into the plate as 7C in **Fig. 5.5.1**	0.44	0.41
In case the stays are inserted into the plate as 7D in **Fig. 5.5.1**	0.53	0.50
In case the stay tubes are inserted into the plate as 7E in **Fig. 5.5.1**	0.45	0.42
In case the stay tubes are inserted into the plate as 7F in **Fig. 5.5.1**	0.52	0.49

Table 5.5.6 Constant C

Fixing methods of stay or stay tubes	C	
	In case the plates are exposed to flame	In case the plates are not exposed to flame
In case the stay tubes are inserted into the plate as 7E in **Fig. 5.5.1**	0.54	0.51
In case the stay tubes are inserted into the plate as 7F in **Fig. 5.5.1**	0.61	0.57

Table 5.5.7 Constant C

Item	In case exposed to flame	In case not exposed to flame
The commencement of curvature. However, when the inner radius of the curvature is greater than 2.5 times the thickness of the plate, the points located at a distance of 3.5 times the thickness of plate from outer surface of the flange may be considered as a commencement of the curvature.	0.39	0.36
The inside plain ends welded on shell or furnaces	0.47	0.43

d = Diameter of tube holes (mm).

113. Tube plates of boilers with wet combustion chamber

The required thickness of rear tube plate in boiler with wet combustion chamber subjected to compression due to the pressure on the top plate is not to be less than that obtained by the following formula or than that obtained from **111.3**, whichever is the greater.

$$T = \frac{PW}{183J} \quad (mm)$$

where :

P = Design pressure (MPa).
W = Breadth at the top of combustion chamber (Inside distance between rear tube plate and back chamber plate) (mm).

$$J = \frac{P_i - d}{P_i}$$

P_i = Horizontal pitch of smoke tube (mm).
d = Inside diameter of ordinary smoke tube (mm).

114. Manholes, mud holes and peep holes

1. Manholes or mud holes are to be provided for boilers in a location where they do not come in the way on inspecting and cleaning of each portion of the boiler. The clear opening of manholes is to be not less than 300 mm by 400 mm. A mudhole opening in a boiler shell is not to be less than 60 mm by 90 mm. Where, due to size or interior arrangement of a boiler, it is impractical to provide a manhole or other suitable opening for direct access, there are to be two or more suitable openings through which the interior can be inspected.

2. The manhole cover of internal type is to be provided with a spigot which has a clearance of not more than 1.5 mm all round.

3. The minor axis of the oval opening to be provided on the shell plate is to be preferably parallel to the longitudinal direction of the drum.

4. For the vertical boilers having cross tubes, a mud hole or some other proper attachment is to be provided for the purpose of cleaning the tube interior. Where, however, the diameter of the cross tubes is large, there are to be peep holes in the shell opposite to one end of each tube sufficiently large to permit the tube to be examined and cleaned in the easiest accessible position.

5. The caps of the peep holes of headers are to be rigid in construction, and the repetition of covering and uncovering is not to impair safety. In case where the cap is bolted, it is to be of such construction that the breakage of the bolts does not cause danger.

115. Reinforcement of openings

1. Openings in the shell are to be reinforced in accordance with the following Paragraph except single openings having a maximum diameter of not larger than 1/4 of the inside diameter of the shell and of not lager than 60mm and the shell plate having margin in thickness for which no reinforcement is needed.

2. For openings in shell plates and formed end plates, reinforcement is to be provided in such a manner that the area of its cross section through the centre of the opening and normal to the surface of the opening is not less than that calculated by the following formula:

$$A = dT_r \quad (mm^2)$$

where :

d = Maximum diameter of the finished opening in the longitudinal cross section for the shell plate or in the cross section for the end plate (mm).
T_r = Required thickness for a seamless shell or for a blank end plate (mm), except that, where the opening and its reinforcement are entirely within the spherical portion of a dished end plate, T_r is the thickness required for a seamless hemispherical end having the equal radius to the spherical portion of the head plate, and where the opening and its reinforcement are in semi-ellipsoidal end plate and are located entirely within a circle the centre of which coincides with the centre of the end plate and the diameter of which is equal to 80% of the shell inside diameter, T_r is the thickness required for a seamless hemispherical head plate of a radius equal to 90% of the shell inside diameter.

3. Where the flat head plates or cover plates prescribed in **110**. have openings with a diameter not exceeding one-half of the end plate diameter or the shortest span, the end plates are to have a total cross-sectional area of reinforcement not less than that given by the following formula :

$$A = 0.5dT_r \quad (mm^2)$$

where :

d = Maximum diameter of holes (mm).
T_r = Required thickness calculated from the formula prescribed in **110**. (mm).

4. Effective limits of reinforcement

Reinforcement is to be provided within its effective limits. The limits of reinforcement are designated as the boundaries which are surrounded by two lines parallel to the centre line of the opening expressed by L and two lines vertical to inner and outer surfaces of the plate containing the centre of the opening expressed by H. The values of L and H may be taken as follows : (Also see **Fig. 5.5.5**)

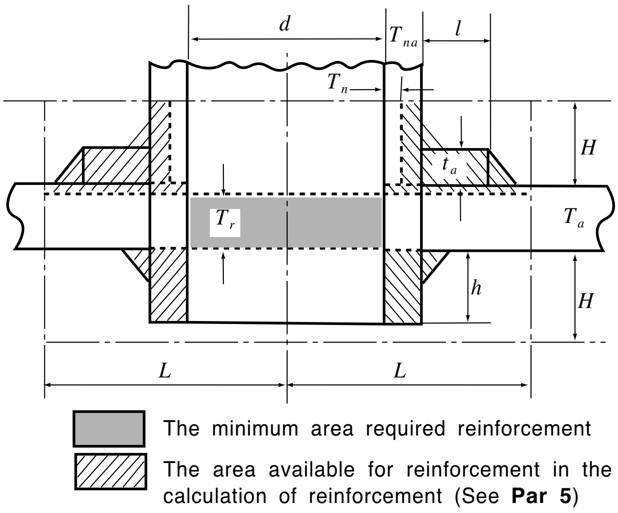


Fig. 5.5.5 Reinforcement of Holes

where :

L = d or $(d/2+T_a+T_{na})$, whichever is greater (mm).

H = 2.5 T_a or (2.5 T_{na} + t_a), whichever is smaller (mm).

d = Diameter of opening in the cross section where reinforcement is intended (mm).

T_a = Actual thickness of the shell or end plate (mm).

T_{na} = Actual thickness of stand pipe (mm).

t_a = Actual thickness of reinforcement plate (mm).

5. The area available for reinforcement

The area available for reinforcement in the shell or end plate may be obtained as follows :

The total of these areas in each case is not to be less than the required sectional area A of reinforcement given in **Par 2** or **Par 3**. Where the opening requiring reinforcement passes through a joint in the shell or end plate, the actual area of the reinforcement is to be such that the efficiency of the joint is fully taken into account

$$A_1 = (T_a - T_r)(2L - d) \quad (mm^2)$$
$$A_2 = 2KH(T_{na} - T_n) \quad (mm^2)$$
$$A_3 = 2khT_{na} \quad (mm^2)$$
$$A_4 = 2Kt_a l \quad (mm^2)$$

A_5 = Total section area of weld metal in one side (mm^2).

$$A \leqq A_1 + A_2 + A_3 + A_4 + A_5$$

where :

T_a, T_{na}, t_a, d, L, H = As specified in **Par 4**.

T_r = As specified in **Par 2 or 3**.

T_n = Thickness of stand pipe provided as calculated from the formula in **Ch 6, 102. 6** minus corrosion allowance (mm).

h = Length of stand pipe within the effective limit where provided inside of the shell or end plate (mm).

l = Length of reinforcement in one side appearing in the cross section (mm).

$$K = \frac{\text{Allowable stress of reinforcing material or stand pipe}}{\text{Allowable stress of shell or end plate}}$$

(Provided that $K \leqq 1.0$)

6. Where the end plate is bent around the manhole to form a flange, the depth of flange is not to be less than that obtained by the following formula :

Where the thickness of end plate is not more than 38 mm :

$$h = 3T_r \quad (mm)$$

Where the thickness of end plate exceeds 38 mm :

$$h = T_r + 76 \quad (mm)$$

where :

h = Depth of flange measured along the major axis of opening from the outer surface of end plate (mm).

T_r = The required thickness of end plate (mm).

116. Flues, furnaces, ogee rings and cross tubes

1. The thickness of flues is not to be less than that given by the following Paragraph and in no case is to be less than 5 mm and more than 22 mm.

2. The thickness of corrugated furnace plates is not to be less than that obtained by the following formula :

$$T = \frac{PD}{C} + 1.0 \quad (mm)$$

where :

P = Design pressure (MPa).

D = Minimum outside diameter measured at corrugated part of furnace (mm).

C = Constant determined by **Table 5.5.8**.

Table 5.5.8 Constant C

Furnaces	C
Morison, Deighton, Fox and similar furnaces	107
Leeds forge bulb furnaces	104

3. The required thickness of plain cylindrical furnace or cylindrical bottom of combustion chambers which are not reinforced by stays or other means is not to be less than that obtained by the following formulae, whichever is greater.

$$T_1 = \sqrt{\frac{PD(L+610)}{10,500}} + 1.0 \quad (mm)$$

$$T_2 = \frac{1}{325}\left(\frac{PD}{0.35} + L\right) + 1.0 \quad (mm)$$

where :

P = Design pressure (MPa).
D = External diameter of furnace or combustion chamber bottom (mm).
L = Length of furnace or depth of combustion chamber bottom (mm).
The length of furnace, however, is measured from commencement of curvature where the furnace plates are flanged and jointed to other plates, reinforcing rings, etc.

4. The required thickness of a hemispherical furnace without stays or other means is not to be less than that obtained by the following formula :

$$T = \frac{PR}{62} + 1.0 \quad (mm)$$

where :

P = Design pressure (MPa).
R = Outside radius of hemispherical furnace (mm).

5. The required thickness of furnace supported by stays or other means or cylindrical steel plates exposed to flame is to be determined in accordance with the following requirements, choosing the value whichever is greater.

(1) The sum of the thickness calculated by the formula in **Par 3** and that given by the formula in **111. 2** using 0.50 times the design pressure specified.

(2) The sum of the thickness calculated by the formula in **111.2** and that given by the formula in **Par 3** using 0.50 times the design pressure specified, whichever is the greater.

6. Ogee rings

Where ogee rings are used to connect the furnace bottom of vertical boiler to shell and to sustain the whole load of the furnace, the required thickness of ogee rings is not to be less than that obtained by the following formula :

$$T = \frac{\sqrt{PD(D-D_0)}}{1,010} + 1.0 \quad (mm)$$

where :

P = Design pressure (MPa).
D = Inside diameter of boiler shell (mm).
D_o = Outside diameter of the lower part of the furnace at the joint with ogee ring (mm).

7. Cross tubes

In cross tube boilers, the required thickness of cross tubes is not to be less than that obtained by the following formula. In no case, however, the thickness of cross tubes is to be less than 9.5 mm.

$$T = \frac{PD}{45} + 6.5 \quad (mm)$$

where :

P = Design pressure (MPa).
D = Inside diameter of cross tubes (mm).

117. Stays, stay tubes and girders

1. The required diameter of stays or stay tubes is not to be less than that obtained by the following formula. However, the thickness of stay tube is not to be less than 6.0mm for those in bounding rows of tube nests, nor 4.5mm for others.

$$d = C_1 k \sqrt{PA} + C_2 \quad (mm)$$

where :

P = Design pressure (MPa).
A = Area of plate supported by one stay or stay tube (mm^2).

$$k = \frac{1}{\sqrt{1-z^2}}$$

$$z = \frac{\text{inside diameter}}{\text{Outside diameter}}, \text{ for stay tube}$$
$= 0$, for stays

C_1, C_2 = Constants determined by **Table 5.5.9.**

2. Where stays are fitted diagonally, the required diameter of the stay is not to be less than that obtained from the formula in **Par 1** with the value of C_1 substituted by C_3 given in the following formula :

$$C_3 = C_1 \sqrt{\frac{L}{H}}$$

where :

L = Length of diagonal stay (mm).

Table 5.5.9 Constant C_1 and C_2

Description	C_1	C_2
Longitudinal stays without screws	0.127	3
Screwed stays	0.139	3
Stay tubes	0.158	0

H = Length of line, drawn perpendicular to boiler head or surface supported, to center of palm of diagonal stay (mm).

3. The required thickness of girders, or sum of the thickness in case of double plate construction supporting top plates of combustion chambers is not to be less than that obtained by the following formula :

$$T = \frac{PWP_i(W-a)}{CH^2S} \quad (mm)$$

where :

P = Design pressure (MPa).
W = Width of combustion chamber at upper part (the inside distance between rear tube plate and back plate of combustion chamber) (mm).
P_i = Pitch of girders (mm).
a = Spacing of stay bolts supporting girder (mm). For the welding type, a is to be 0.
S = Specified minimum tensile strength of the girder material (N/mm^2)
H = Depth of girder at centre (mm).
C = Constants determined by **Table 5.5.10**.

4. For top and side plates of combustion chambers in boiler with wet combustion chamber, the distance between outer row of the nearest stay to tube plate or back plate and the commencement of curvature of tube plate or back plate is to be not more than the value of "a" calculated by substituting design pressure in the formula of **111.2**.

5. Where the outer radius of curvature at the flange part joining the top and side plates of combustion chambers is less than one-half the allowable pitch, P_i , of the girder calculated by substituting design pressure in the formula in **Par 3**, the distance measured from the inside surface of side plate to the centre of girder adjacent to the side plate is not to be greater than the allowable pitch, P_i , of the girder. Where this radius is greater than one-half the value of P_i , the distance from the beginning point of the curvature at the flange part to the centre of the girder is not to be greater than one-half the value of P_i .

118. Headers

1. The required thickness of cylindrical headers is not to be less than that obtained by the formula in

Table 5.5.10 Constant C

Description		C
Bolt type	The number (n) of stay bolts in each girder is odd	$25 \times \frac{n}{n+1}$
	The number (n) of stay bolts in each girder is even	$25 \times \frac{n+1}{n+2}$
Welding type		31

Table 5.5.3.

2. The required thickness of square headers is not to be less than that obtained by the following formula :

$$T = \frac{Pl_2}{4f}\left(1+\sqrt{1+\frac{8fl_1^2}{CPl_2^2}}\right)+1.0 \quad (mm)$$

where :

P = Design pressure (MPa).
f = Allowable stress prescribed in **107.2** (N/mm^2).
l_1 = Inside breadth measured between supports of flat surface for the strength calculation (mm).
l_2 = Inside breadth of another side adjacent to l_1 (mm).
C = 2.0, where holes are not arranged in succession.
1.0 + J, where holes are arranged in succession.
J = Longitudinal efficiency of openings arranged in succession choosing the least value obtained in accordance with **106**.

3. Where the shape and dimension of the openings provided on headers are irregular, the minimum shell thickness of headers is to be specially considered by the Society.

4. Thickness of part of peep holes of tube header

The peep holes of tube headers are to be well machined so that they may be effectively covered. In this case, the thickness of the tube headers may be 1.0 mm less than that calculated by the formula in **Par 2**, but is not to be less than 9 mm.

119. Stand pipes

The thickness of stand pipes welded to shell is not to be less than either the value of 1/25 of the outside diameter of the stand pipes plus 2.5 mm or the value calculated by the formula in **Ch 6, 102.6**. However, it need not exceed the required thickness of the shell at the part where the stand pipe is attached.

120. Boiler tubes

1. The thickness of the boiler tubes is not to be less than that given by the formula in **Par 2**, and not to be less than 2 mm for the tubes less than 30 mm in outside diameter and not to be less than 2.5 mm for the tubes more than 30 mm in outside diameter. For tubes to be expanded or bent, their thickness is to be increased to compensate for thickness reduction due to expansion or bending.

2. The required thickness of smoke tubes for boilers is to be calculated by the following formula (1). And, the required thickness of water tubes, evaporating tubes, and superheater tubes subjected to the internal pressure of boilers is to be calculated by the following formula (2).

(1) $$T = \frac{Pd}{70} + 2.0 \quad (mm)$$

(2) $$T = \frac{Pd}{2f + P} + 1.5 \quad (mm)$$

where :

P = Design pressure (MPa).
d = Outside diameter of tube (mm).
f = Allowable stress prescribed in **107.2** (N/mm^2).

3. Tube holes

Tube holes in the tube plates of drums are to be formed in such a way that the tubes can be effectively tightened in them. Where the tubes are practically normal to the tube plates, the parallel seating of the holes is not to be less than 10 mm in depth. Where the tube ends are not normal to the tube plate, the depth of the holes perpendicular to the tube plate is not to be less than 10 mm for tubes not exceeding 60 mm in outside diameter, and not to be less than 13 mm for tubes exceeding 60 mm in outside diameter.

4. Fixing

All tubes are to be tightly attached to the tube plate by expanding or other suitable methods and the ends are to project through the tube plate not less than 6 mm, except where being attached by welding. Both ends of tubes are to be fixed to tube plates in such a manner that they will never fall off. When fixing them simply with the tube end expanded in a flare shape, the taper is to be 30° or more.

121. Bolting methods of cover plates

Bolting methods of attaching unstayed cover plates are to follow the examples in **Fig. 5.5.6** or other methods with the equivalent effectiveness, and the required thickness of unstayed cover plates is not to be less than that obtained by the following formulae.

(1) In case where a full-face gasket is used : (**Fig. 5.5.6 A**)

$$T = d\sqrt{\frac{C_1 P}{f}} + 1.0 \quad (mm)$$

(2) In case where it is necessary to consider a moment due to gasket reaction : (**Fig. 5.5.6 B**)
For circular plate :

$$T = d\sqrt{\frac{C_1 P}{f} + \frac{1.78\,Wl}{f d^3}} + 1.0 \quad (mm)$$

For non-circular plate :

$$T = d\sqrt{\frac{C_1 C_2 P}{f} + \frac{6\,Wl}{f L d^2}} + 1.0 \quad (mm)$$

where :

P = Design pressure (MPa).
f = Allowable stress given in **107.2** (N/mm^2).
d = Diameter of circular plate or the shortest span of non-circular plate measured as indicated in **Fig. 5.5.6** (mm).
b = Longest span of non-circular plate measured perpendicular to the shortest span d (mm).
C_1 = Constant depending on attaching methods given in **Fig. 5.5.6**.
C_2 = 3.4 – 2.4 d/b, but need not exceed 2.5.
W = Total bolt load (N).
L = Length of non-circular curve through the centres of bolts (mm).
l = Arm length due to gasket reaction, equal to radial distance from the centre line of bolts to the line of gasket reaction (mm).

122. Boiler mountings

1. The requirements in this Section apply to the fittings attached to boilers, such as valves, except where otherwise specified, and the requirements in **Ch 6** and **Pt 6, Ch 2** also apply respectively to the portions of boiler fittings that have close relation with piping systems and to the boilers that employ automatic and/or remote control.

2. Valves having nominal diameter not less than 50 mm are to be of the outside-screw and yoke-rising-spindle type closing to the right hand with the bolted bonnet. Valves are to be fitted with an indicator to show whether the valve is opened or closed, except for the rising stem type.

3. All valves and cocks attached directly to a boiler are to be attached to the boiler with flange or by welding. Where stand pipes or distance pieces are used between the shell and mountings, they are to be as short as practicable. Where the thickness of boiler plate is 12 mm or above, or where a special stand for screwing is welded to the plate, the valves or cocks may be effectively attached to the boiler by pipe thread having a nominal diameter of 32 mm and under. Where valves or cocks are attached to the boiler by stud bolts, the depth of threaded part inside the bolt holes is not to be less than diameter of bolt. The holes, however, are not to penetrate the whole thickness of the boiler plate.

123. Safety valves of boilers

1. (1) All boilers are to be fitted with not less than 2 spring loaded safety valves. But, the boilers with heating surface of less than 10 m^2 or with automatically controlled device with the design pressure of 1 MPa or below may have one safety valve, provided they are equipped with a pressure controlling device and a device which cuts off fuel automatically with pressure not more than the design pressure.

(2) Safety valve with spring pilot valve may be used in lieu of spring loaded safety valve. The safety valve with spring pilot valve is to operate satisfactorily with the steam pressure.

(3) In case where boiler is provided with a superheater, at least one safety valve is to be fitted up at the outlet of the superheater.

2. Total area of safety valve

The total area of safety valve seats is not to be less than the required area given by the following formula. And, the seat diameter of safety valves is to be 25 mm or over, unless it is specially approved. But, the safety valves of the boiler having a superheater are to comply with **Par 4**.

(1) For saturated steam

$$A = \frac{KW}{10.5P + 1.0} \quad (mm^2)$$

where :

W = Designed maximum evaporating capacity (kg/hr).

P = Set pressure of safety valve (MPa).

K = Values given by **Table 5.5.11**.

(2) For superheated steam

The area is to be the value calculated by the formula in (1), multiplied by

$$1 + \frac{\text{Degree of superheat}}{556}$$

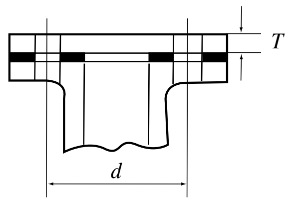
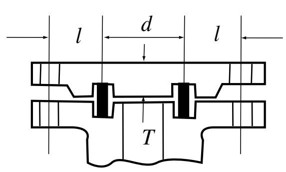
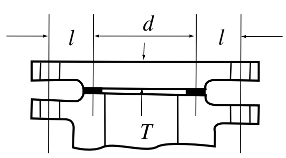
Symbol	Attaching method	Type and dimension	C_1	Remark
A	Bolted with full-face gasket		0.25 for circular and non-circular plates	—
B	Bolted	 	0.3 for circular and non-circular plates	W is mean value of the bolt load required for watertightness and the allowable bolt load in actual use.

Fig. 5.5.6 Examples of Bolting Methods of Cover Plates, etc.

3. Area of steam passages

(1) The required areas of steam passages of the ordinary type safety valve at the chest inlet and outlet are not to be less than 0.5 times and 1.1 times the required valve seat area respectively.

(2) The required areas of steam passages of the high lift type safety valve at the chest inlet and outlet are not to be less than the same and 2 times the required valve seat area respectively.

(3) The required areas of steam passages of the improved high lift type safety valve at the chest inlet and outlet are not to be less than 1.1 times and 2 times the steam passage area when the valve lift is 1/7 of the valve seat diameter respectively.

(4) The area of steam passage at the valve seat for the full bore safety valve is not to be less than 1.05 times the area at the throat, when the valve is open. Further, the areas of steam passages at the valve inlet and the nozzle are not to be less than 1.7 times the area at the throat, and the minimum steam passage area at the outlet is not to be less than 2 times the area at the valve seat when the valve is open.

4. Safety valve of superheater

(1) Where a superheater is considered as an integral part of a boiler with no intervening valve between the superheater and the boiler, the area of superheater safety valve seats may be included in determining the required total area of safety valve seats for the boiler as a whole, but is not to be credited of more than 25% of the total capacity required in **Par 2**.

(2) The discharge capacity of the superheater safety valve is to be such that when main steam supply at normal load is shut down in an emergency, the superheater does not receive damages. In cases where this purpose cannot be achieved, the installation is to be provided so that a part of the fuel supply to the boiler is automatically shut down in emergency.

5. (1) One or more safety valves are to be fitted at the inlet and the outlet respectively of the independent reheater or the independent superheater, and the total discharge capacity is not to be less than the maximum passing steam quantity. The total discharge capacity of the safety valve provided at its outlet is not to be less than the quantity necessary to keep the steam temperatures of the independent reheater or independent superheater not more than the designed point. However, for the independent superheater connected directly to the boiler which is designed with the same design pressure as that of the boiler, one or more safety valves are to be fitted at its outlet, and the total discharge capacity is not to be less than the quantity necessary to keep the steam temperature of the independent superheater not more than the designed point.

(2) For the economizer and exhaust gas economizer equipped with a cutoff device from the boiler, one or more relief valves that are capable of discharging the quantity not lower than that calculated from the maximum absorbable energy are to be fitted.

124. Construction and tests of safety valves

1. The safety valves are to be so constructed that the springs and valves cannot be overloaded from outside and that in case of fracture of the springs they cannot lift out of their cages.

2. The valve springs are to be so set that the amount of contraction in length is not less than one-tenth

Table 5.5.11 Values of K

Type of safety valves	K	Remarks
Ordinary type ($15 < D/L \leqq 24$)	20.8	F : Diameter of throat (mm). L : Lift (mm). D : Inside diameter of valve seat (mm).
High lift type ($7 < D/L \leqq 15$)	10.0	
Improved high lift type ($D/L \leqq 7$)	5.0	
Full bore type ($D \geqq 1.15F$)	3.34	

NOTES :
1. Where K is less than the above values, K is to be approved by the Society.
2. For full bore valve, A is required nozzle throat area.
3. For any boiler with an exhaust gas economizer which is so designed that it may be additionally heated while in use, the required area of the safety valves is to be calculated after the maximum evaporation of the boiler is added with the evaporation of the exhaust gas economizer.

the diameter of the valves, and the spring is to be such that the amount of permanent set will not exceed 1 % of the free length after it is fully compressed at cold state for 10 *minutes*.

3. Boiler safety valves are to be provided with easing gears in case of emergency and their handles are to be operated from easily accessible place.

4. Safety valves are to be attached directly to boiler shells by flanges and the chests are to be of such type that they are not used in common with those of other valves. However, superheater safety valves may be fitted to the stand pipes or distance pieces attached at the outlet.

5. Waste steam pipe

(1) The waste steam pipe of the safety valve is to be of such construction that back pressure does not interfere with operation of the valve. The inside diameter of the waste steam pipe is not to be less than the diameter of the valve outlet, and is to be designed at the pressure 1/4 or more of the setting pressure of the safety valve.

(2) Where a common waste steam pipe is provided for two or more safety valves the cross sectional area of the common pipe is not to be less than the aggregate area of required outlet area of each safety valve. The waste steam pipes of boiler safety valves are to be separated from pipe lines containing drains such as waste steam pipes of relief valves for exhaust gas economizer or steam blow-out pipes to the atmosphere.

6. Drain

Draining hole having sufficient size is to be provided to the safety valve chest at the lowest part of the discharge side. Pipes for draining are to be led to a safety place clear of the boiler. No valves or cocks are to be fitted to these pipes.

7. Setting

The safety valve or relief valve is to be set in accordance with the following requirements at the completion of manufacturing at the factory and after the installation in the ship. And the valve is to operate satisfactorily while relieving at its setting pressure.

(1) The safety valve of the boiler drum is to be set to relieve steam automatically at a pressure not exceeding the design pressure. The range of pressure settings of all the drum safety valves is not to exceed 10% of the highest pressure to which any safety valve is set. In no case is the relief pressure to be greater than the design pressure of the steam piping or that of the machinery connected to the boiler plus the pressure drop in the steam piping.

(2) Where a superheater is fitted, the superheater safety valve is to be set to relieve at a pressure no greater than the design pressure of the steam piping or the design pressure of the machinery connected to the superheater plus pressure drop in the steam piping. In no case is the superheater safety valve to be set at a pressure greater than the design pressure of the superheater. The superheater safety valve is to be set to relieve steam automatically at a pressure not greater than the value which is obtained by subtracting the setting pressure of the safety valve or valves at the boiler drum by the value of 0.035 MPa plus the steam pressure drop in the superheater at the rated load.

(3) The relieving pressure of the safety valve at the outlet of the superheater is to be set lower than that at the inlet.

(4) The relieving pressure of the relief valve provided to the economizer or exhaust gas economizer is to be set at a pressure not exceeding the design pressure.

8. Accumulation test

The accumulation test of the boiler is to be conducted in the methods specified below. However, in case the data on the evaporation of the boiler submitted to the Society has been approved, the accumulation test prescribed in (1) may be omitted.

(1) When the safety valve blows under the maximum firing condition of the boiler with the stop valves closed except for the valves for steam supply to the machinery necessary to the operation of the boiler, the accumulation of pressure in the boiler drum is not to exceed 110 % of the design pressure. In this case, however, the feed water necessary to maintain a safe water level may be supplied.

(2) For the oil burning boiler with superheater, where the accumulation test might endanger the superheater with possible overheating, the operation test of the installation by merely shutting down quickly the main steam supply under the maximum output of the boiler, as specified in **123.4** (2).

9. In case the calculated discharge capacity of the safety valve does not comply with the requirement of **123.2** on account of the reduction of the design pressure for the boiler, it may be accepted provided the accumulation test required by (1) of the preceding Paragraph has been carried out with satisfactory results.

125. Low water level safety device

Boiler is to be fitted with a low water level safety device which is capable of shutting off automatically the oil supply to the burners when the water level falls to a predetermined level higher than the critical level. The water level detector for this device is to be independent of water level detector for the feed water control system. For forced circulation boilers or once-through boilers, the safety device may be omitted, provided that the boiler is fitted with safety device specified in **129.2**.

126. Steam stop valves

1. Main and auxiliary steam stop valves are to be fitted to the boiler shells at all steam outlets of boilers. Where a superheater is fitted as an integral part of a boiler, superheater steam stop valve is to be fitted at the superheater outlet side in order to prevent damage to the superheater.
2. Where the steam discharge pipes of two or more boilers are connected to each other, two stop valves are to be fitted between the boiler and the connecting part and the stop valve adjoining to the boiler is to be of the non-return type.
3. Where the diameter of steam stop valves exceeds 150 mm, by-pass is to be arranged as far as practicable.

127. Feed water connection and valves

1. Main boilers for steam propulsive engines and essential auxiliary boilers are to be provided with two feed openings.
2. A feed stop valve attached directly to the boiler is to be fitted to each opening of **Par 1** and a screw down check valve is to be provided as close to the stop valve as practicable. An approved feed water regulator may, however, be fitted between the check and stop valves.
3. Where the boiler has an economizer which is recognized as integral part of the boiler, the stop valves may be provided at the economizer inlet. In this case a screw-down check valve is to be provided as close to the stop valve as practicable.
4. The part of the drum shell where feed water is discharged into the boiler is to be so arranged that a remarkable thermal stress may not occur due to direct contact of the feed water to the shell plate. This requirement is also to be applied to the parts of the boiler drum having desuperheater where the superheated steam pipes are penetrated through the drum.
5. Feed water discharge in the drum is to be distributed as far apart as practicable so that it may not impinge directly on the heating surfaces of the boiler at high temperature.

128. Blowoff valves and blowoff piping

1. Design

The design pressure of blowoff piping is not to be less than 1.25 times the design pressure of the boiler.

2. Blowoff valves

The boiler is to be provided with a blowoff valve mounted directly on its drum so that the boiler water may be discharged from the bottom of its water space ; its nominal diameter is not to be less than 25 mm but not more than 65 mm, except that for boilers with heating surface of 10 m^2 or less, the blowoff valve may be 20 mm in nominal diameter. Blowoff valves are to be of such construction that they are free from accumulation of scale and other sediments.

3. Blowoff pipe

Where two or more boilers are installed and the blow off pipe of each boiler is connected to each other, screw-down check valves are to be fitted in each pipe line. Where the blowoff pipes are exposed to flame or high temperature gases, they are to be protected by thermal insulation materials.

129. Water level indicator

1. Each boiler is to be provided with at least two independently operating water level indicators, one of which is to be a glass gauge and the other is to comply with either of the following requirements :
   (1) Glass water level gauge located where the water level is easily read by the operator in his working area.
   (2) Remote water level indicator, but, for the boiler whose design pressure is 1 MPa or under, this may be replaced with a level alarm device. In this case, remote water level indicator or detector for high and low water level alarm device is to be independent of the detector for the low water level safety device required in **125**.
2. For forced circulation or once-through boilers, where **Par 1** is not applicable for the indication of water level, a suitable level detector and the low water level safety device which are comprised of two detectors so designed to prevent the overheating of any part of the boiler by lack of water supply is to be provided. In cases the water space in the boiler is long in the transverse direction of the ship, or an excessive difference in water level is feared to occur, the level indicators prescribed in **Par 1** or the above requirement are to be provided on both ends of the water space.
3. The lowest visible part of the glass water gauge

is to be at least 50 *mm* above the lowest permissible water level. The visible range of the remote level indicator is to be such that it covers all the possible water levels as related to the water level control in the boiler.

4. Each water gauge is to be fitted with shut-off valve or cock on the top and bottom, and drain valve at the bottom. Where top and bottom shut-offs of the watergauge are cocks, and where the water gauge or the water column is connected by the pipe to the boiler drum, the stop valves are to be fitted to the boiler drum.

5. The water column to which the water gauge is attached is to be strongly supported so that it may maintain its correct position. The inside diameter of the water column is to be 45 *mm* or over and the draining device with nominal diameter 20 *mm* or over is to be attached to the bottom of column. The connection pipes to be boiler drum are to be 15 *mm* or over for water gauge, and 25 *mm* or over for the water column in nominal diameter.

6. The connection pipes from the water column to the boiler are not to penetrate the flue, unless they are enclosed all through the flue and further the air passage of not less than 50 *mm* is provided around the pipes.

130. Pressure gauges and thermometers

1. Each boiler is to be provided with pressure gauges to the boiler drum and to the superheater outlet. These gauges are to be such that they have a scale 1.5 times and above the pressure at which the safety valves are set and are to be placed where they can easily be observed. In the scale of the pressure gauges, the approved working pressure and the working pressure at the superheater outlet are to be marked. A thermometer is to be provided at the outlet of superheater or reheater.

2. The pressure gauge is to be provided with a device to which a test pressure gauge for the indicator can be attached while the boiler is in operation, unless it is already equipped with a pressure gauge tester.

131. Boiler water take-out valve or cock.

Each boiler is to be provided with a boiler water takeout valve or cock in a convenient position. This valve or cock is to be directly attached to the boiler shell and not on the water gauge column.

132. Draught fans

The boilers are to be provided with draught fans with a capacity sufficient for the designed maximum steam evaporation of the boiler and for the stable combustion in the boiler within its service range. An alternative means which is available to ensure the normal navigation and cargo heating that is required continuously is to be provided, in the case of failure of the draught fan.

133. Safety devices and alarm devices

1. Fuel oil shut-off device

Each boiler is to be fitted with a safety device which is capable of shutting off automatically the fuel supply to all burners in the cases of the following :

(1) When automatic ignition fails.
(2) When the flame vanishes (in this case, the fuel oil supply is to be shut-off within 4 *seconds* after the extinguishing of flame).
(3) When the water level falls.
(4) When the combustion air supply stops.
(5) When the fuel oil supply pressure to the oil burners falls in the case of pressure atomizing, or when the steam pressure to the burners falls in steam atomizing.
(6) When considered necessary by the Society.

2. Alarm device

(1) Each boiler is to be provided with an alarm device which operates when the water level in the drum falls.
(2) In addition to the above, the main boilers are to be provided with alarm devices which operate in the following cases :
(a) When combustion air supply reduces, or when the draught fan stops.
(b) When the fuel oil supply pressure to the burner falls, in the case of pressure atomizing, or when the steam pressure to burner falls, in steam atomizing.
(c) When the water level in boiler drum reaches to a high level.
(d) When the steam temperature at the superheater outlet rises, if the superheater is provided.
(e) When the exhaust gas temperature at the outlet of the gas type air preheater or economizer rises.
(f) When the flame vanishes
(3) For auxiliary boiler supplying steam to the turbines driving main generators, alarm devices which operate when the water level in the boiler drum reaches to a high level are to be provided in addition to those alarm devices given in (1).

134. Boiler installation

1. Boilers are to be efficiently insulated as far as possible and so arranged that all exterior parts, after lagging is removed, may be readily inspected or repaired. Boilers are to be so installed as to minimize the effect of the following loads or external forces.

(1) Ship motion or vibrations caused by machinery installations.
(2) External forces caused by the piping and supporting members fitted on the boiler.
(3) Thermal expansions due to temperature fluctuation.

2. Distance between boilers and fuel oil tanks

The distance between boilers and fuel oil tanks is to be 610 *mm* or more at the rear ends of the boilers and 457 *mm* or more at the other parts in order to prevent the oil temperature in the tanks from reaching the flash point of the oil. However, at the cylindrical part of a cylindrical boiler or the casing corners of a water tube boiler, the distance may be reduced down to 230 *mm*.

3. Water tube boilers

Water tube boilers are to be so arranged as to prevent the fuel oil from leaking into the bilge wells out of boiler bottom.

4. Dampers

In case dampers are installed in the funnels or uptakes of boilers, their openings are not to be reduced to more than 2/3 of the flue area when closed. They are to be capable of locking in any open position and the degree of the opening is to be clearly indicated.

5. Boiler casings

The boiler casings, the joints of funnels, and the covers of openings are to be so arranged as to prevent waste gas from leaking into the engines or boiler rooms.

6. Valves and cocks

All valve and cocks attached to boilers are to be so arranged as to have proper space around each of them in order to give facilities for their handling and repairing.

135. Drainage of superheaters and reheaters

Drain valves or cocks are to be arranged in the positions proper for draining water completely from the superheaters or reheaters.

136. Tests and Inspections

1. Hydraulic tests

Boilers, valves and cocks attached directly to a boiler, and water level indicators are to be tested by the hydraulic pressure specified in **Table 5.5.12** after construction in the presence of the Surveyor.

2. Tests and inspections of boiler

For the tests and inspections of the safety valves and accumulation tests of boilers, the requirements in **124. 7** and **8** are to be applied. Where boilers are automatically operated or remote-controlled, the requirements in **Pt 6, Ch 2, Sec 1** are to be applied.

3. Hammering tests

Where welding is employed in constructing the parts subjected to pressure, the requirements in **404**. to **406**. are to be applied, and the hammering test is to be carried out under the pressure of those hydraulic test specified in **Par 1**. However, for those fully radiographed in accordance with the requirements in **404. 1** the hammering test need not be carried out. In the hammering test, both sides of the welded joint are to be hammered all along the joint length at the interval of about 150 *mm*. The weight of the hammer with the round head is to be at the rate of 0.45 *kg* per 2.5 *mm* of plate thickness, but is not to exceed 4.5 *kg*.

Table 5.5.12 Test Pressure

Item	Test pressure
Boiler, superheater, reheater and the equivalent	1.5 times the design pressure
Economizer, exhaust gas economizer	1.5 times the design pressure in accordance with **108.2**.
Valves and cocks attached directly to a boiler, superheater, reheater and the equivalent	2 times the design pressure of the boiler
Valves and cocks attached directly to a economizer and exhaust gas economizer	2 times the design pressure in accordance with **108.2**.
Blow-off valves	2.5 times the design pressure of the boiler
Water level indicators	2 times the design pressure of the boiler

SECTION 2 Thermal Oil Installations

201. General

The thermal oil installations heated by flame or combustion gas are to comply with the relevant requirements specified in **Sec 1** (in this case the term "boiler" is to be read as "thermal oil installation") as well as the requirements in this Section.

202. Safety devices

1. Temperature regulators are to be provided to control the temperature of the thermal oil within the predetermined range.

2. The master valve of the expansion tank is to be kept always open, and the burning system is to be interlocked in such a way that it does not start when the master valve is closed.

3. Safety valve or pressure relief pipe of sufficient capacity is to be provided.

4. The discharge pipes from the safety valve or the pressure relief pipe specified in **Par 3** are to have their open ends in the thermal oil tank with sufficient capacity.

5. The following safety devices are to be provided :

(1) Prepurging system for preventing explosion of the furnace gas.
(2) Fuel oil shut-off systems which operate in the following cases ;
(a) When the temperature of the thermal oil rises abnormally.
(b) When the flow rate of the thermal oil falls or when the pressure difference of the thermal oil between the inlet and outlet of the heater falls.
(c) When the level of the thermal oil in the expansion tank falls abnormally.

203. Pipings

1. Expansion tanks are to be provided with liquid level indicator.

2. Circulating pumps are also to be capable of being stopped from a suitable position other than a space in which thermal oil heaters are situated.

3. Circulating pumps are to be provided with a pressure measuring device at a suitable position on the delivery and suction sides.

4. The important thermal oil installation is to be provided with two thermal oil circulating pumps and two fuel oil burning pumps. However, where alternative means are available to ensure the normal navigation and cargo heating with these pumps being out of operation, only one pump will be accepted respectively.

5. The inlet and outlet valves of oil-fired thermal oil heaters and exhaust-fired thermal oil heaters are to be controllable from outside the compartment where they are situated. As an alternative, an arrangement for quick gravity drainage of the thermal oil contained in the system into a collecting tank is acceptable.

6. Heating of liquid cargoes with flash points below 60°C is to be arranged by means of a separate secondary system, located completely within the cargo area. However, a single circuit system may be accepted on the following conditions:

(1) System is arranged so that a positive pressure in the coil is to be at least 3m water column above the static head of the cargo when circulating pump is not in operation,
(2) The thermal oil system expansion tank is to be fitted with high and low level alarms,
(3) Means is to be provided in the thermal oil system expansion tank for detection of flammable cargo vapours. Portable equipment may be accepted.
(4) Valves for the individual heating coils are to be provided with locking arrangement to ensure that the coils are under static pressure at all times.

7. The other pipings for thermal oil installation are to be complied with **Ch 6, 201., 901. 2, 4, 6** (2) and **7**.

SECTION 3 Pressure Vessels

301. Application

1. The requirements in this Section apply to pressure vessels and their fittings intended for marine service, provided that pressure vessels belong to Class 3 (PV-3) which are not used for important purposes are excluded.

2. In cases where pressure vessels are of unconventional construction and the requirements of this Section are unsuitable to be applied, the manufacturer is to submit the detailed drawings, data and strength calculations for the construction to the Society for its approval.

3. The pressure vessels concerned in (1) to (3) are also to comply with the requirements in this Chapter except specially specified.

(1) Pressure vessels used for liquefied gas (**Pt 7, Ch 5**).
(2) Pressure vessels used for the refrigerating machinery (**Pt 9, Ch 1**).
(3) Other pressure vessels used for inflammable gas or liquid are to comply with the separate requirements to the Society about the property and working condition of gas and liquid.

302. Classification

1. Class 1 pressure vessels (Symbol PV-1)

(1) Steam generators whose design pressure exceed 0.35 MPa.

(2) Pressure vessels in which inflammable high pressure gas having the vapour pressure not less than 0.2 MPa at 38°C (hereinafter referred to as "inflammable high pressure gas") is contained. However, the requirements for "PV-2" may be applied to the pressure vessels with the capacity of 0.5 m^3 or under with respect to their materials, construction and welding.

(3) Pressure vessels whose shell plates exceed 38 mm in thickness, and/or whose design pressures exceed 4 MPa, and/or whose maximum working temperatures exceed 350°C. However, the pressure vessels in which the shell plates exceed 38 mm in thickness and/or the design pressure exceed 4 MPa are classified as "PV-2", provided that they are subject to hydraulic pressure at the atmospheric temperature.

(4) Pressure vessels contained ammonia or toxic gases.

2. Class 2 pressure vessels (Symbol PV-2)

(1) Steam generators whose design pressure do not exceed 0.35 MPa.

(2) Pressure vessels whose shell plate exceed 16mm in thickness, and/or whose design pressure exceed 1 MPa, and/or whose maximum working temperature exceed 150°C.

3. Class 3 pressure vessels (Symbol PV-3)

Pressure vessels not included in Class 1 and 2.

303. Materials

1. The materials used in the construction of the pressure parts of pressure vessels are to comply with following requirements.

(1) All materials used for Class 1 and Class 2 pressure vessels are to comply with the requirements in **Pt 2, Ch 1.** However, for the following Class 2 pressure vessels, the materials may be in accordance with the requirements in (2) below :

(a) Vessels of which design pressure is less than 0.7 MPa.

(b) Vessels whose design pressure and maximum working temperature are not more than 2 MPa and 150°C respectively, and whose internal capacity is not more than 0.5 m^3.

(2) The materials used for Class 3 pressure vessels are to be materials specified in the Korean Industrial Standards in accordance with the usage, or equivalent thereto.

(3) The materials of fittings for a pressure vessel are to comply with the requirements in **Pt 2, Ch 1**. However, the Society may accept to use valves and cocks made of materials which comply with Korean Industrial Standards or other recognized standards considering their size and the design pressure.

(4) In case where the heat treatment, such as hot working or stress relieving, is carried out on steel plates during the manufacturing process of pressure vessels, the manufacturer is to inform of such intention with an order for the materials. What are expected of the manufacturer of steel plates in this case, are prescribed in **Pt 2, Ch 1, 303.3**.

(5) Appropriate heat treatments are to be carried out on the cold-formed steel plates, where it is considered that the cold-forming affects the safety of pressure vessel.

2. Materials of cast steel and grey iron casting are to be used for the construction of pressure vessels, according to the following items.

(1) Cast steel may be used in pressure vessels.

(2) Grey iron castings may be used in the pressure vessels where the working temperature does not exceed 220°C and the design pressure does not exceed 1 MPa. However, grey iron castings are not to be used for the pressure vessels which contain inflammable or toxic liquid or gas.

(3) Special cast iron such as nodular graphite cast iron etc. may be used for the pressure vessels with the maximum working temperature not exceeding 350°C and the design pressure not exceeding 1.8 MPa where approved by the Society.

3. Electric resistance welded steel pipes may be used for pressure vessels whose design pressure is 2 MPa or below and working temperature 150°C or below, and which do not contain inflammable or toxic liquid or gas.

304. Type of joint

1. Class 1 pressure vessels

Longitudinal and circumferential joints of Class 1 pressure vessels are to be of the approved double welded butt joints. However, for cylindrical shells of small diameter, where the inside welding is considered difficult, the joints may be of the single welded butt joint subject to the approval by the Society.

2. Class 2 pressure vessels

(1) Longitudinal joints : They are to be the same as the case of Class 1 pressure vessels.

(2) Circumferential joints : They are to be of double welded butt joints or single welded butt joints with backing strip. However, for shell plates of

16 mm or under in thickness, they may be of single welded butt joints.

3. Class 3 pressure vessels

(1) Longitudinal joints : Double welded butt joints or single welded butt joints with backing strip are to be applied. However, for plates of 9 mm or below in thickness, both sides welded full fillet lap joints may be accepted, and for plates of 6 mm or below in thickness, single welded butt joints may be accepted.

(2) Circumferential joints : Single welded butt joints or one side welded full fillet lap joints may be accepted.

305. Welding method for each part

The welding methods are to be in accordance with **104**.

306. Efficiencies of joints

The values of efficiencies of joints for pressure vessels are to be as follows in relation to their application and type of joints.

(1) For seamless shells : J = 1.00

(2) For welded shells : J is to be as given in **Table 5.5.13**.

307. Allowable stress

1. The allowable stress of the materials used at room temperature is to be determined by the following items

(1) The allowable stress of carbon steel (including carbon manganese steel) and low alloy steels excluding cast steels is not to be taken to be greater than obtained from the following formulae, whichever is the smaller. For pressure vessels used for liquefied gas, the values of denominator for f_1 and f_2 are to be 3.0 and 2.0, respectively.

$$f_1 = \frac{R_{20}}{2.7}, \quad f_2 = \frac{E_{20}}{1.6}$$

where :

R_{20} = Specified minimum tensile strength at room temperature (N/mm^2 [kgf/mm^2]).

E_{20} = Specified minimum yield stress or 0.2% proof stress (N/mm^2 [kgf/mm^2]).

(2) The allowable stress of the electric resistance welded steel tubes except where they are used for the shell of pressure vessels is to be taken to the value specified in (1) when subjected to the ultrasonic testing or any other compatible flaw detection approved by the Society for the entire length of the weld, and other cases 85% of the value specified in (1).

(3) The allowable stress of cast steel is to be taken to the value obtained by (1) multiplied by the coefficients given in **Table 5.5.14**.

Table 5.5.14 Coefficients to be multiplied to Allowable Stress of Cast Steels

Type of test	Coefficient
When no radiographic test or any other alternative testing is carried out	0.7
When random radiographic test or alternative testing is carried out	0.8
When the above tests are carried out on all parts	0.9

(4) The allowable stress of cast iron is to be taken to 1/8 of the specified minimum tensile strength. However, the allowable stress of special cast iron approved by the Society may be taken to 1/6 of the specified minimum tensile strength.

Table 5.5.13 Efficiencies of Joints, J

Type of joint \ Kind of radiographic testing	Full radiographic testing carried out	Partial radiographic testing carried out	No radiographic testing carried out
Double-welded butt joint or the butt welded joint considered equivalent by the Society	1.00	0.85	0.75
Single-welded butt joint where the backing strip is left unremoved or the single-welded butt joint considered equivalent by the Society	0.90	0.80	0.70
Single welded butt joint without backing strip	—	—	0.60
Double-welded full fillet lap joint	—	—	0.55
Single fillet welded lap joint	—	—	0.45

(5) The allowable stress of austenitic steel is to be taken to the following f_1 or f_2, whichever is the smaller.

$$f_1 = \frac{R_{20}}{3.5}, \quad f_2 = \frac{E_{20}}{1.6}$$

where :

R_{20}, E_{20}, = As specified in (1).

(6) The allowable stress of aluminium alloy is to be taken to the following f_1 or f_2, whichever is the smaller.

$$f_1 = \frac{R_{20}}{4.0}, \quad f_2 = \frac{E_{20}}{1.5}$$

where :

R_{20}, E_{20} = As specified in (1).

2. For the allowable stress of materials used for pressure vessels for high temperature service, the requirements in **107**. or the value deemed appropriate by the Society apply.

3. The allowable tensile stress is to conform to the requirements in **Pars 1** and **2**. However, the allowable tensile stress of bolts is to comply with the following requirements :

(1) In case where bolts are used at room temperature, the value is to be taken to the following (a) or (b), whichever is the smaller. However, for bolts complying with the requirements in the recognized standards the value may be 1/3 of the proof load specified therein.

(a) $\dfrac{R_{20}}{5.0}$

(b) $\dfrac{E_{20}}{4.0}$

where :

R_{20}, E_{20} = As specified in (1).

(2) In case where bolts are used at high temperature, the value will be considered by the Society in each case.

4. The allowable bending stress is to comply with the following requirements :

(1) In case where the materials are used at room temperature, the requirements in **Par 1** are to be complied with. However, for cast iron or cast steel, the value is to be taken to 1.2 times thereof.

(2) In case where the materials are used at high temperature, the value will be considered by the Society in each case.

5. The allowable shearing stress for the mean primary shearing stress in the section subjected to shearing load is to be taken to 80 % of the allowable tensile stress.

6. The allowable compression stress in the cylindrical shell of pressure vessels used at room temperature subject to a load causing compression stress in longitudinal direction is to be taken to the following (1) or (2), whichever is the smaller :

(1) The value specified in **Par 1**.

(2) The allowable buckling stress by the following formula ;

$$\sigma_z = \frac{0.3ET_0}{D_m\left(1+0.004\dfrac{E}{E_{20}}\right)}$$

where :

σ_z = Allowable buckling stress (N/mm^2 [kgf/mm^2]).

E = Modulus of longitudinal elasticity at room temperature (N/mm^2 [kgf/mm^2]).

T_o = Net thickness of shell plate excluding corrosion allowance from the actual shell plate (mm).

D_m = Average shell diameter (mm).

7. The allowable stress for various stresses of carbon steel or carbon manganese steel used for the shell of pressure vessels formed by rotating unit when detailed calculations are carried out, may be as follows :

$P_m \leqq f$
$P_L \leqq 1.5f$
$P_b \leqq 1.5f$
$P_L + P_b \leqq 1.5f$
$P_m + P_b \leqq 1.5f$
$P_L + P_b + Q \leqq 3f$

where :

P_m = Equivalent primary general membrane stress (N/mm^2 [kgf/mm^2]).

P_L = Equivalent primary local membrane stress (N/mm^2 [kgf/mm^2]).

P_b = Equivalent primary bending stress (N/mm^2 [kgf/mm^2]).

Q = Equivalent secondary stress (N/mm^2 [kgf/mm^2]).

308. General construction and strength

1. Because the formulae of this Section do not take into account such additional stresses as load from fittings, localized stress, repeated load, thermal stress and so on, some measures such as increasing the size, etc. are to be taken, in case those effects are considered to exist.

2. In the provisions in this Section, the design pressure of the pressure vessels used for refrigerating machinery, inflammable high pressure gases or of those subjected to delivery pressure of the boiler feed pump is not to be less than the values given below ;

(1) For pressure vessels used for refrigerating machinery, **Pt 9, Ch 1, 403. 3** is to be applied depending on types of the refrigerants.

(2) Design pressure of pressure vessels used for liquefied gases, storaged under pressurized condition at atmospheric temperature or near it, is not to be less than the following, whichever is the greatest :

(a) Vapour pressure of the gas at 45°C.

(b) Maximum working pressure to be expected.

(c) 0.7 MPa.

(3) For pressure vessels subjected to delivery pressure of boiler feed water pump, the allowable pressure is to be 1.25 times the design pressure of the boiler. Where, however, this is not applicable, the maximum working pressure of the feed water pump may be taken.

309. Shell plates and end plates

1. The thickness of shell plates or end plates is not to be less than the required thickness prescribed in **Table 5.5.15** and further is not to be less than 5mm for pressure vessel. However, the thickness of formed end plates, except for full hemispherical ones, is not to be less than the thickness of the shell plate (required thickness of seamless shell) to which the end plate is attached.

2. The required thickness of the end plate having openings for which reinforcement is required is to comply with the followings :

(1) In case where the openings are reinforced in accordance with the requirements in **115. 2** the required thickness is to be calculated by **Table 5.5.15**.

(2) Where an end plate has a flanged-in manhole or access opening with a maximum diameter of which exceeds 150 mm and flanged-in reinforcement of which complies with the requirements in **115.6**, the thickness is to be calculated as follows :

(a) Dished or hemi-spherical end plates : The thickness is to be increased by not less than 15% of the required thickness by **Table 5.5.15** using the design pressure or 3 mm, whichever is greater. In this case, where the inside crown radius of the end plate is smaller than 0.80 times the inside diameter of the shell, the value of the inside crown radius in the formula is to be 0.80 times the inside diameter of the shell. In calculating the thickness of the end plate having two manholes in accordance with above paragraph, the distance between the two manholes is not to be less than 1/4 of the outside diameter of the head plate.

(b) Semi-ellipsoidal end plates : The requirements in **Table 5.5.15** are to be applied. However, in this case R_2 is to be 0.80 times the inside diameter of shell and E to be 1.77.

3. The required thickness of end plates subject to pressure on the convex sides is not to be less than that obtained from the formula for end plates subject to pressure on the concave sides provided that the value of design pressure P in the formula is taken as 1.67 times P.

310. Flat end plates or cover plates without stay or other supports

The required thickness of flat end plates or cover plates without stay or other supports is to be in accordance with **110**.

311. Flat plates or tube plates with stay or other supports

The required thickness of flat plates or tube plates with stay or other supports is to be in accordance with **111.**

312. Thickness of cover plates

The required thickness of cover plates is to be in accordance with **121**.

313. Manholes, mud holes and peep holes

1. Manholes or mud holes are to be provided for pressure vessels in a location where they do not come in the way on inspecting and cleaning of each portion of the pressure vessels. The construction, dimensions and materials of the manholes or mud holes are to comply with the following requirements. Pressure vessels over 900 mm inside diameter of shell are to be provided with a manhole or at least two mudholes. The size of the manhole is not to be less than 300 mm by 400 mm. The size of the mudholes is not to be less than 75 mm by 100 mm, and 100 mm by 150 mm where the internal diameter of shell exceeds 750 mm.

2. The construction of holes and covers is to be in accordance with **114. 2** and **3**.

314. Reinforcement of openings

Openings in the shell and end plate are to be reinforced in accordance with **115**.

315. Stand pipes

The thickness of stand pipes welded to shell is to be in accordance with **119**.

Table 5.5.15 The Thickness of Shell Plates and End Plates

Shell plates and end plates		The required thickness (mm)
Shell plates	Cylindrical	$T = \dfrac{PD_1}{2fJ - 1.2P} + 1.0$
	Spherical	$T = \dfrac{PR_1}{2fJ - 0.2P} + 1.0$
End plates	Dished(1)	$T = \dfrac{PR_2E}{2fJ - 0.2P} + 1.0$
	Semi-spherical	$T = \dfrac{PR_2}{2fJ - 0.2P} + 1.0$
	Semi-ellipsoidal(2)	$T = \dfrac{PD_2}{2fJ - 0.2P} + 1.0$

P = Design pressure (MPa).
J = Minimum value of the efficiencies prescribed in **306**.
f = Allowable stress prescribed in **307.** (N/mm^2).
D_1 = Inside diameter of shell (mm).
D_2 = Inside length of the major axis (mm).
R_1 = Radius of shell (mm).
R_2 = Inside crown radius (mm).

$$E = \frac{1}{4}\left(3 + \sqrt{\frac{R_2}{r}}\right)$$

r = Inside knuckle radius (mm).

NOTES :
(1) The inside crown radius of dished end plate is not to be greater than the outside diameter of the flanged part of the end plate. The inside knuckle radius of the plate is not to be less than 6% of the outside diameter of the flanged part of the end plate or 3 times the thickness of the end plate, whichever is greater.
(2) Half the minor axis inside the semi-ellipsoidal end plate is not to be less than 1/2 of half the inside major axis of the end plate.

316. Required thickness of tubes for heat exchangers

The materials of the tubes for heat exchangers are to be suitable for their purposes, and the required thickness is to be calculated by the following formula.

$$t = \frac{PD_0}{2fJ} + a \quad (mm)$$

where ;

P = Design pressure (MPa).
f = As given in **307. 1, Table 5.6.6.** or **Table 5.6.7**.
D_o = Outside diameter of tube (mm).
a = 1.5 mm for steel tube and 0.1 T for copper or copper alloy tube.
T = Actual thickness of tube (mm).
J = Efficiencies of joints mentioned below :
1.0 for seamless tubes
0.85 for electric resistance welded tubes.

317. Relief valves on pressure vessels

1. For pressure vessels in which pressure may exceed the design pressure under working condition and a pressure vessel where an additional hazard may be created by exposure of the pressure vessel to a fire or other unexpected source of external heat, a pressure relieving device is to be provided to prevent the pressure from exceeding the design pressure. However, if an air reservoir is provided with a fusible plug with melting point of approximately 100°C to release the pressure automatically in the case of a fire, the pressure relieving device may be omitted.

2. A heat exchanger or other similar pressure vessels, where internal pressure may exceed the design pressure due to internal failure or other, is to be provided with a suitable relief valve.

3. A steam generator which comes under PV-1 is to be provided with a safety valve prescribed in **123**. and **124**.

4. There is to be no stop valve between a pressure vessel and a relief valve or other relieving devices, except where approved by the Society.

5. A rupture disc may be installed between a pressure vessel and a relief valve or at a discharge line of the relief valve. In this case, the bursting pressure of the rupture disc is not to exceed the setting pressure of the relief valve. In addition, the discharge capacity of the rupture disc is to be the same as the relief valve or larger.

318. Arrangement of pressure vessels

Pressure vessels and their fittings are to be arranged at places convenient for operation, repair and inspection.

319. Tests and inspections

1. Hydraulic tests

Pressure vessels and valves and cocks attached directly to a pressure vessel are to be tested by the hydraulic pressure specified in **Table 5.5.16** after construction in the presence of the Surveyor.

Table 5.5.16 Hydraulic Test Pressure

Item	Test pressure
Pressure vessels	1.5 times the design pressure
Heat exchangers and other special vessels not applicable to the above	To be determined in each case
Valves and cocks attached directly to a pressure vessels	2 times the design pressure of the pressure vessel

2. Airtight tests

The pressure vessels subjected to the pressure of the primary refrigerant of the refrigerating machinery are to be subjected to a airtight test at the design pressure at the completion of the hydrostatic test prescribed in **Par 1**. The airtight tests to be conducted on the pressure vessels for inflammable high pressure gases are to be in accordance with the provisions in **Pt 7, Ch 5, 410. 10**.

3. Hammering tests

Where welding is employed in constructing the part subjected to pressure, the requirements in **404**. to **406.** are to be applied, and the hammering test is to be carried out under the pressure of those hydraulic test specified in **Par 1**. However, for those fully radiographed in accordance with the requirements in **404. 1**, the hammering test needs not be carried out. In the hammering test, both sides of the welded joint are to be hammered all along the joint length at the interval of about 150 mm. The weight of the hammer with the round head is to be at the rate of 0.45 kg per 2.5 mm of plate thickness, but is not to exceed 4.5 kg.

SECTION 4
Welding for Boilers and Pressure Vessels

401. General

1. The manufacturers of welded boiler, Class 1 and Class 2 pressure vessels are to submit to the Society for approval the detailed construction drawings and welding procedures as specified in **Ch 1, 207. 1** (7) (quality of materials, welding method, specification of welding materials, type of edge preparation, heat treatment, test methods are to be shown) before the commencement of the work. Unless specially specified otherwise, the following requirements are also to be applied to welded construction.

2. Welding procedure qualification test

The manufacturers are to submit the detailed data in connection with the welding work for examination of the Society and also conduct the welding procedure qualification tests specified by the Society if they plan to construct boilers or pressure vessels with welded structure for the first time, or if they adopt a new welding method, and if they change types of base metals, types of welding materials, or types of joints. But, for minor changes in the welding process, the test may be omitted if approved by the Surveyor.

3. General requisites for welded construction

General requisites for welded construction are as follows :

(1) Welding method and welding materials : Welding is to be carried out in accordance with the previously approved welding plans using approved electrodes, approved automatic welding materials or other equivalent materials.
(2) Welders : All important weldings are to be carried out by welders holding Socity's qualification.
(3) Base materials: Unless specially approved otherwise, the base materials used are conform to the requirements of **Pt 2, Ch 1** and the carbon content is not to exceed 0.35 %.

402. Welding workmanship

1. V-out

The dimension and shape of the edges to be joined is to be such that the welding can be carried out without failure. The welded joint portion is to be designed so as not to be subjected to direct bending stress.

2. Plates of unequal thickness

Where plates of unequal thickness are to be jointed in a longitudinal butt weld of a shell, the thicker plate is as a rule to be reduced by machining both surfaces to the thickness of thinner plate with an inclination of not more than 1/4 so as to coincide the centre lines of both plates. Where the reduction in thickness is made on one surface, the distance between the centre line of weld and the commencement of the inclination is to be at least equal to the thickness of the thinner plate.

3. Joints

Details of welded joints of essential members are to be as required in **104.** or other equivalent methods with equal effectiveness.

4. Application

The details of welding workmanship are to conform to the requirements of **Pt 2, Ch 2, Sec 3** as far as practicable in addition to the requirements specified in the following Articles.

5. Misalignment

The butting edges of the plates are to be in line within a limit of the following misalignment:

(1) Longitudinal joints
1 mm for plates of 20 mm and under in thickness.
5 % of plate thickness for plates of over 20 mm but less than 60 mm in thickness.
3 mm for plates of 60 mm and over in thickness.

(2) Circumferential joints
1.5 mm for plates of 15 mm and under in thickness. 10 % of the plate thickness for plates of over 15 mm but less than 60 mm in thickness.
6 mm for plates of 60 mm and over in thickness.

6. Deformation

Deformation of all boilers and pressure vessels of cylindrical type is to be measured on completion of the welding or after heat treating if heat treatment is required. The difference between the maximum and minimum in inside diameter of any section of the shell is to be within a limit of 1 % of the designed diameter and there is to be no flat part on welded line.

403. Heat treatment

1. Boilers and Class 1 pressure vessels

Boilers and Class 1 pressure vessels are to be heat-treated after the joints of shells, end plates and all fitting such as stand pipes or reinforcements, are welded in place. But, for fusion-welded corrugated furnace, heat treatment may be dispensed with because the heating necessary for forming the corrugation after welding is considered to be sufficient stress relieving.

2. Class 2 pressure vessels

Class 2 pressure vessels corresponding to the followings are to be subjected to stress relieving heat treatment.

(1) The thickness of shell plates exceeds 30 mm.
(2) The thickness of shell plates is not less than 16 mm and is greater than the value of T_n determined by the following formula :

$$T_n = \frac{D}{120} + 10$$

where:

D = The inside diameter of the shell (mm).

3. Omission of stress relief

In case corresponding to the followings stress relieving may be omitted.

(1) In case where the material having a superior notch toughness is specially used and approved by the Society.
(2) Subsequent stress relieving is not necessary to the pressure vessels which have been carried out stress relieving, even if fillet weld is applied as described below:
(a) Seal welding not feared to induce a remarkable strain.
(b) Intermittent welding for attaching fittings provided that the welds do not exceed 6 mm in throat thickness and 50 mm in length, and have an interval of 50 mm or larger.
(3) The stress relieving for following parts may be omitted in case where the thickness of the welded part is not more than 19 mm for carbon steel or carbon manganese steel, or not more than 13 mm for alloy steel.
(a) welded joint between tubes, tubes and tube flanges, and tubes and headers
(b) Circumferential joints of headers
(c) Welded parts specially approved by the Society

4. Furnace

Heat treatment is to be carried in a furnace capable of readily adjusting the temperature and of maintaining the adjusted temperature. At least 2 thermometers are to be provided to measure or record the temperature in the furnace.

5. Procedure of post weld heat treatment

The welds of boilers and Class 1 pressure vessels using carbon steel, carbon manganese steel and low alloy steel as the base metal are to be heated to a stress relieving temperature, maintained at that temperature for a period of at least one hour per 25 mm of thickness and allowed to cool down slowly to a temperature of 400°C or below in the furnace and thereafter in a still atmosphere. The stress relieving temperature is in general to be taken as 625°C ± 25°C but to be suitably adjusted to the material used.

6. Area of heat treatment

Where the heat treatment of a boiler and a pressure vessel cannot be accomplished at one time due to an insufficient size of the furnace, it may be carried out twice or more times, but in this case, care is to be taken to assure that sufficient area between each heat treated section is overlapped in the process of heat treatment. This provision may also be applied when a structure in sections heat-treated is welded together, in which case the joints between the sections are to be heat treated to an entire bend with width of at least six times the plate thickness on each side of the seams.

7. Local heat treatment

Stress-relieving heat treatment for reinforcements or other welded connections on heat treated boilers and pressure vessels may be carried out locally by heating a circular area around such connections provided that any part of the welded edge thereof is not less than 12 times the thickness of the plate from the nearest adjacent welded joint or other element that would tend to resist the free expansion of the heated area. The width of area to be heated measured from the welded seam is to be at least 6 times the thickness of the plate. However, where the plate thickness is not greater than 20 mm, this width is not to be less than 125 mm.

8. Special heat treatment

Where the heat treatment is carried out on special materials and by special procedures, the requirements are to be specially considered by the Society according to the type of base metal and welding materials, and welding procedures. In case of need, another effectiveness test of heat treatment could be required by the Society.

404. Radiographic examination

1. Fully radiographed

For boilers and pressure vessels whose joint efficiency has been determined subject to a fully radiographic examination specified in **306.**, the entire length of both longitudinal and circumferential welded joints is to be subjected to radiographic examination (hereinafter referred to as "fully radiographed").

2. Spot radiographed

For pressure vessels whose joint efficiency has been determined subject to spot radiographic examination specified in **306.**, the radiographic examination is to be carried out in accordance with the following requirements (hereinafter referred to as "spot radiographed"):

(1) The length which is not less than 20 % of the longitudinal joints (minimum 300 mm) and the intersecting part of the circumferential joints with the longitudinal joints which were welded by the same method and by the same welder, are to be spot radiographed.
(2) The locations to be spot radiographed are to be chosen by the Surveyor.

3. Reinforcement of welding

The reinforcement of the welding at the joints on which the radiographic examination is to be carried out is to be machined down to a plane surface to enable the examination. In this case, the height of reinforcement is not to exceed the following values:

(1) Double welded butt joints:

Thickness of base plate t (mm)	Height of reinforcement (mm)
$t \leq 12$	1.5
$12 < t \leq 25$	2.5
$25 < t$	3.0

(2) Single welded butt joints: 1.5 mm and under, regardless of the plate thickness.

4. Radiograph film

The radiographic technique employed is to be such as to detect as small as 2 % of the welding depth, and the thickness of the penetrameter corresponding to 2 % of the thickness of the base metal is to be clearly shown on the radiograph film. Each radiograph film is to be marked clearly as to the relative position of the weld seams to the radiograph position, and the following items are to be included in the report of radiographic examination:

(1) Thickness of material (flush or reinforced).
(2) Distance from radiation source to weld surface.
(3) Distance from film to weld surface.
(4) Type of penetrameter used.

5. Re-radiographed

The radiograph films are to be submitted to the Surveyor. There are to be no defects, such as crack, long cavity, slag inclusion, etc. If there are defects, the area is to be chipped off and to be rewelded and radiographed again. When spot radiographed is used, additional radiographic examination is to be carried out on both sides of the original spot in accordance with the indication of the Surveyor.

405. Welding workmanship approval tests for boilers and Class 1 pressure vessels

1. Test plates

Where the boilers and Class 1 pressure vessels are to be welded the approval test is to be in accordance with the following requirements , and test plates of sufficient size are to be prepared in order to make test specimens specified by the requirements in **Par 2**.

(1) The test plate is to be attached to the shell in such a manner that the centre of weld coincide with that of the longitudinal joint of the shell and that the welding is carried out continuously from the welding of the longitudinal joint of the shell. The test plates are to be adequately supported during welding in order to minimize any deformation.

(2) The test plate for the circumferential joints of shells are to be made separately under the same welding conditions as the circumferential joint. However, test plates for the circumferential joints are not required except where the shell has no longitudinal joints or welding procedure for the circumferential joints is very much different from that for the longitudinal joints.

(3) The material for the test plates is in general to be taken from a part of the structure.

2. Mechanical tests

Mechanical tests for test plate are to be in accordance with the followings.

(1) The kind, number and dimension of test specimens are to be as shown in **Table 5.5.17.** However, the impact tests are to be carried out, where stress relieving was omitted in accordance with **403. 3** (1) or alloy steel was used.

(2) Face bend and root bend test are to be conducted for the test plate not more than 19 mm in thickness and side bend test is to be conducted for the test plate exceeds 19 mm.

3. Tensile test for welded joints

The tensile strength is not to be less than the minimum tensile strength specified for the base metal. However, if the test specimen breaks at the base metal but the specimen shows no sign of defect in the welded joint, and tensile strength is not less than 95 % of the specified minimum tensile strength for the base metal, the test may be considered to be satisfactory.

4. Guide bend test

The test specimen is to be put on the guide bend jig shown in **Fig. 2.2.1** of **Pt 2**, **Ch 2**, so as to coincide with the centre line of the weld at the centre of the jig. For the side bend test, the test specimen is to be bent with one of both sides in tension, and for the root bend test, with the narrow side of the weld in tension. In all cases, the test specimens are to be bent in the jig through an angle of 180 *degrees* with internal radius of 20 mm. Cracks exceeding 3 mm in length or any other defect are not to be observed on the outer surface of the weld; however, any crack at corners of the test piece may not be considered as a failure.

5. Impact test

The impact test specimen is to be sampled from the welded joint portions such that its longitudinal axis is at right angle to the weld line and its surface is 5 mm inside from the surface of the plate. The notch on the test specimen is to coincide with the centre of the weld line and to be on the surface at right angle to the plate surface. The mean value of absorbed energy of three test specimens is not to be smaller than the standard value approved by the Society.

Table 5.5.17 Test Specimen

Kind of test specimen	Number of test specimen	Dimension of test specimen
Tensile test for joint	1	As specified in **Table 2.2.1** of **Pt 2**, **Ch 2** ($R2A$ Type)
Guide bend test	1	As specified in **Table 2.2.2** of **Pt 2**, **Ch 2**
Charpy impact test	3	As specified in **Table 2.1.3** of **Pt 2**, **Ch 1** ($R4$)
Macro-etching test	1	–

6. Macro-etching test

Cracks, lack of fusion, incomplete penetration or any other defect are not to be observed.

406. Welding workmanship approval tests for Class 2 pressure vessels

In case the important parts of Class 2 pressure vessels are welded, the workmanship tests prescribed for Class 1 pressure vessels are to be carried out. The guide bend test of the requirements in **405. 2,** however, are not necessary.

407. Retests and modification

1. Retest

If the result of any test does not conform to the requirements, two additional test specimens may be taken from the same test plate for each failure. In the case of retests, both of the test specimens are to conform to the requirements. Retest is allowed in the following cases:

(1) In case the results of tensile and impact tests are not less than 90% of the value specified in the requirements.
(2) In case guide bend test fails to meet the requirements from the cause due to defects found in the part excepting the welded parts.

2. Modification of test

The workmanship tests for pressure vessels may be modified at the discretion of the Surveyor taking account of their past performances. ⚓

CHAPTER 6
AUXILIARIES AND PIPING ARRANGEMENT

Section

SECTION 1
General

101. General

1. Application

(1) The requirements in this Chapter apply to the design, fabrication and tests of pipes, valves, pipe fittings and auxiliaries.

(2) The requirements in this Chapter may be modified for ships having special limitation for their service and usage and for small ships.

2. Related requirements

In addition to complying with the requirements in this Chapter, those are to be applied respectively such as follows:
For steering gears, **Pt 5, Ch 7**; For windlasses and mooring winches, **Pt 5, Ch 8**: For pumping arrangements of oil tankers, **Pt 7, Ch 1**, **Secs 10** and **11**; For drainage of ore holds of ore carriers, **Pt 7, Ch 2**; For cargo handling facilities and piping systems of liquefied gas carriers and chemical carriers, **Pt 7, Ch 5** and **Ch 6**, respectively; For piping systems of ships to be registered as those strengthened for navigation in ice, **Pt 3, Ch 20**; For automatic and remote control systems, **Pt 6, Ch 2**.

3. Definition

(1) Design pressure is the maximum working pressure of a medium inside pipes and is not to be less than the following pressures given in (a) to (h).

(a) For pipings fitted with a relief valve or other overpressure protective device, the pressure based on the set pressure of the relief valve or overpressure protective device. However, for steam pipings connected to the boiler or pipings fitted to pressure vessel, the design pressure of the boiler or the pressure vessel.

(b) For pipings on the discharge side of the pumps, the pressure based on the delivery pressure of the pump against a shut valve. However, for pumps having a relief valve or overpressure protective device, the pressure based on its set pressure.

(c) For feed water pipings on the discharge from the feed water pumps to feed water check valves, the pressure of the 1.25 times the design pressure of the boiler or the pump pressure against a shut valve, whichever is the greater.

(d) For pipings without relief valves on the low pressure side of pressure reducing valves, the pressure as the design pressure on the high-pressure side of the pressure reducing valve.

(e) For boiler blow-off pipings, the pressure of 1.25 times the design pressure of the boiler.

(f) For refrigerating machinery pipings, the pressure prescribed in **Pt 9, Ch 1, 403. 3**.

(g) For pipes containing fuel oil, the design pressure is to comply with the following requirements.

(i) Where the working pressure is not more than 0.7 MPa and the working temperature is not more than 60°C : 0.3 MPa or max. working pressure, whichever is greater

(ii) Where the working pressure is not more than 0.7 MPa and the working temperature exceeds 60°C : 0.3 MPa or max. working pressure, whichever is greater

(iii) Where the working pressure exceeds 0.7 MPa and the working temperature is not more than 60°C : max. working pressure

(iv) Where the working pressure exceeds 0.7 MPa and the working temperature exceeds 60°C : 1.4 MPa or max. working pressure, whichever is greater

(h) Where it is impracticable to adopt the above values, the design pressure is to be specially considered by the Society in each case.

(2) The design temperature in this Chapter is the

Table 5.6.1 Classes of Piping Systems

Service \ Class of piping	Class I	Class II	Class III
Steam Thermal oil	P > 1.6 or T > 300 P > 1.6 or T > 300	Any pressure-temperature combination not belong to Class I or III	$P \leq$ 0.7 and $T \leq$ 170 $P \leq$ 0.7 and $T \leq$ 150
Fuel oil Lubricating oil Flammable hydraulic oil	P > 1.6 or T > 150	Any pressure-temperature combination not belong to Class I or III	$P \leq$ 0.7 and $T \leq$ 60
Other media(3)	P > 4.0 or T > 300	Any pressure-temperature combination not belong to Class I or III	$P \leq$ 1.6 and $T \leq$ 200

NOTES;
1. Cargo oil pipes belong to Class III.
2. P = Design pressure(MPa). T = Design temperature (°C).
3. Including water, air, gases, non-flammable hydraulic oil.
4. Open ended pipes(drains, overflows, vents, exhaust gas lines, boiler escape pipes) belong to Class III.
5. Piping systems for $R717(NH_3)$ used as a primary refrigerant belonging to Class I, and for $R12(CCl_2F_2)$, $R22(CHClF_2)$, $R404a(C_2HF_5/CF_3CH_3/CF_3CH_2F)$ and $R502(CHClF_2/CClF_2CF_3)$ used as a primary refrigerant belonging to Class III.

highest working temperature of the medium. However, for piping systems intended for lower temperature services than the room temperature, the design temperature is the lowest working temperature of the medium.

4. Classes of piping systems

(1) For the purpose of testing, type of joint to be adopted, heat treatment and welding procedure, piping systems are subdivided into three classes as indicated in **Table 5.6.1** depending upon the service, design pressure and design temperature of the medium.

(2) Piping systems for other media than specified in **Table 5.6.1** are to be specially considered by the Society depending upon the nature of the mediums and their service conditions.

5. Materials for auxiliaries

The materials used for essential parts of auxiliary machinery are to be complied with the recognized atandards, unless the Society specially considers necessary.

6. Incinerators of waste oil and waste substance, gas bottles and piping systems of gas welding equipment are to be specially considered by the Society in each case.

102. Pipes

1. Materials

Materials for pipes are to be suitable for the medium and service for which the pipes are intended and are to be of the materials complying with the following requirements.

(1) The materials for pipes belonging to Class I or Class II are, as a rule, to be manufactured and tested in accordance with the appropriate requirements of **Pt 2, Ch 1**.

(2) The materials for pipes belonging to Class III piping systems are to be manufactured and tested in accordance with the recognized standards.

2. Service limitations for steel pipes

(1) Grade 1 and Grade 2 specified in **Pt 2, Ch 1, 402**. are not to be used for pipes whose design temperature exceeds 350°C. However, they may be used up to 400°C if the value of the allowable stress is guaranteed.

(2) Grade 3, RST 338 and RST 342 are not to be used for the pipes whose design temperature exceeds 450°C and Grade 3, RST 349 is not to be used for pipes whose design temperature exceeds 425°C.

(3) Grade 4, RST 412 is not to be used for pipes whose design temperature exceeds 500°C and Grade 4, RST 422, RST 423 and RST 424 are not to be used for pipes whose design temperature exceeds 550°C.

(4) Carbon steel pipes for ordinary piping (Korean Industrial Standard D 3507, SPP) may be used for Class II and Class III piping systems having a design pressure up to 1 MPa with a design temperature up to 230°C.

3. Service limitations for copper and copper alloy pipes

(1) Copper and copper alloy pipes are to be seamless drawn pipes or pipes fabricated by the procedure approved by the Society.

(2) Copper pipes for Classes I and II are to be seamless.

(3) The design temperature of the pipes is not to exceed 200°C for phosphorous-deoxidized copper and brass, and 300°C for cupro-nickel in **Table 5.6.7.**

(4) Copper and copper alloy pipes which are considered inappropriate by the Society are not to be used for piping system.

4. Service limitations for cast iron pipes

Table 5.6.2 Minimum Wall Thickness for Steel Pipes (*mm*)

Nominal diameter (*mm*)	Pipes in general	1. Air, overflow and sounding pipes for structural tanks 2. Over board scupper pipes	Bilge, ballast and general sea water pipes	1. Bilge pipes, overflow pipes, air pipes, sounding pipes and fresh water pipes passing through ballast or fuel oil tanks 2. Ballast pipes passing through fuel oil tanks 3. Fuel oil pipes passing through ballast tank 4. Air pipes on exposed deck	Overboard scupper pipes to be omitted the nonreturn valve	1. Ballast piping passing through cargo tanks[(1)] 2. Cargo oil pipes passing through segregated ballast tanks[(2)]
6	1.6					
8	1.8					
10	1.8					
15	2.0		3.2			
20	2.0		3.2			
25	2.0		3.2			
32	2.0	4.5	3.6	6.3		
40	2.3	4.5	3.6	6.3		
50	2.3	4.5	4.0	6.3		6.3
65	2.6	4.5	4.5	6.3	7.0	6.3
80	2.9	4.5	4.5	7.1	7.6	7.1
90	2.9	4.5	4.5	7.1	8.0	7.1
100	3.2	4.5	4.5	8.0	8.6	8.6
125	3.6	4.5	4.5	8.0	8.8	9.5
150	4.0	4.5	4.5	8.8	10.0	11.0
175	4.5	5.3	5.3	8.8	10.0	11.8
200	4.5	5.8	5.8	8.8	12.5	12.5
225	5.0	6.2	6.2	8.8	12.5	12.5
250	5.0	6.3	6.3	8.8	12.5	12.5
300	5.6	6.3	6.3	8.8	12.5	12.5
350	5.6	6.3	6.3	8.8		12.5
400	6.3	6.3	6.3	8.8		12.5
450	6.3	6.3	6.3	8.8		12.5

NOTES:

1. Diameter and thickness according to other national or international standards recognized by the Society may be accepted.
2. Where pipes and any integral pipe joints are protected against corrosion by means of coating, lining, etc., the thickness may be reduced by an amount up to not more than 1*mm*.
3. For sounding pipes, except those for flammable cargoes, the minimum wall thickness in air, overflow and sounding pipes for structural tanks is intended to apply only to the part outside the tank.
4. The minimum thicknesses listed in this table are the nominal wall thickness. No allowance needs to be made for negative tolerance or for reduction in thickness due to bending.
5. For threaded pipes, where allowed, the minimum wall thickness is to be measured at the bottom of the thread.
6. (1) and (2) in this Table apply to the pipes passing through dangerous zone and the minimum wall thickness of following pipes is not to be less than 16*mm*;
   (a) Overboard discharge pipes(bilge and ballast pipes) passing through cargo oil tanks.
   (b) In case where ballast pipes passing through cargo oil tanks are led to ballast tank located forward of the collision bulkhead.
7. The minimum wall thickness for pipes larger than 450*mm* nominal size is to be in accordance with a national or international standard recognized by the Society and in any case not less than the minimum wall thickness of the appropriate column indicated for 450*mm* pipe size.

Table 5.6.3 Minimum Wall Thickness for Steel Pipes for CO_2 fire extinguishing (mm)

Nominal diameter (mm)	Fire extinguishing CO_2 pipes	
	From bottles to distribution station	From distribution station to nozzle
15	3.2	2.6
20	3.2	2.6
25	4.0	3.2
32	4.0	3.2
40	4.0	3.2
50	4.5	3.6
65	5.0	3.6
80	5.6	4.0
90	6.3	4.0
100	7.1	4.5
125	8.0	5.0
150	8.8	5.6

NOTES :
1. Pipes are to be galvanized at least inside, except those fitted in the engine room where galvanizing may not be required at the discretion of the Society.
2. For threaded pipes, where allowed, the minimum wall thickness is to be measured at the bottom of the thread.
3. The external diameters and thicknesses have been selected from ISO Recommendations R336 for smooth welded and seamless steel pipes. Diameter and thickness according to other national or international standards may be accepted.
4. For larger diameters specified in this table, the minimum wall thickness will be subject to special consideration by the Society.
5. The minimum thicknesses listed in this table are the nominal wall thickness. No allowance needs to be made for negative tolerance or for reduction in thickness due to bending.

Spheroidal or nodular graphite iron castings according to **Pt 2, Ch 1** may be accepted for bilge, ballast and cargo oil piping.

5. Use of Special Materials

(1) Such special materials as rubber hoses, plastic pipes, vinyl pipes, aluminium alloys, etc, notwithstanding the provision in **Pars 2, 3** and **4** above, may be used where approved by the Society taking into account safety against fire and flooding as well as their service conditions.

(2) Hose assemblies may be installed between two points where flexibility is required. In general, hose is to be limited to the length necessary to provide for flexibility and for proper operation of machinery. Hose clamps and similar types of attachments for flexible pipes are not permitted.

6. Required wall thickness of pipes

(1) The minimum wall thickness of steel pipes is not to be less than the greater of the minimum wall thickness calculated by **Par 7** or the minimum wall thickness shown in **Table 5.6.2** and **5.6.3.**

(2) The minimum wall thickness of copper and copper alloy pipes is not to be less than the greater of the minimum wall thickness calculated by **Par 7** or the minimum wall thickness shown in **Table 5.6.4**.

(3) The minimum wall thickness of austenitic stainless steel pipes is not to be less than the greater of the minimum wall thickness calculated by **Par 7** or the minimum wall thickness shown in **Table 5.6.5.**

7. Minimum calculated wall thickness of pipes

(1) The minimum calculated wall thickness of straight pipes subject to internal pressure is to be determined by the following formula:

$$t = (t_0 + c)\frac{100}{100 - a} \quad (mm)$$

Table 5.6.4 Minimum Wall Thickness for Copper and Copper Alloy Pipes (mm)

External diameter (mm)	Copper pipes	Copper alloy pipes
8 ~ 10	1.0	0.8
12 ~ 22	1.2	1.0
25 ~ 44.5	1.5	1.2
50 ~ 76.1	2.0	1.5
88.9 ~ 108	2.5	2.0
133 ~ 159	3.0	2.5
193.7 ~ 267	3.5	3.0
273 ~ 457.2	4.0	3.5
(470)	4.0	3.5
508	4.5	4.0

NOTES :
Diameter and thickness according to national or international standards recognized by the Society may be accepted.

Table 5.6.5 Minimum Wall Thickness for Austenitic Stainless Steel Pipes (*mm*)

External diameter	Minimum wall thickness
10.2 ~ 17.2	1.0
21.3 ~ 48.3	1.6
60.3 ~ 88.9	2.0
114.3 ~ 168.3	2.3
219.1	2.6
273.0	2.9
323.9 ~ 406.4	3.6
over 406.4	4.0
NOTES : Diameters and thicknesses according to national or international standards recognized by the Society may be accepted.	

where:

t_o = Strength thickness specified in (3) (*mm*).

c = Corrosion allowance specified in **Tables 5.6.6** and **5.6.7** (*mm*).

a = Negative manufacturing tolerance (%).

(2) Where pipes are bent, the minimum calculated wall thickness, t_b, before bending is to be determined by the following formula.

$$t_b = (t_0 + c + b)\frac{100}{100 - a} \quad (mm)$$

where:

b = Bending allowance specified in (4) (*mm*).

t_o, c, a = As defined in (1).

(3) The strength thickness is to be determined by the following formula:

$$t_0 = \frac{PD}{2fJ + P} \quad (mm)$$

where:

P = Design pressure (MPa).

D = Outer diameter of pipe (*mm*).

f = Allowable stress specified in (5). (N/mm^2).

J = Efficiency factor

Seamless pipes ---------------------------1.00

Electric resistance welded pipes-----0.85

(1.0 may be adopted for those which are considered as equivalent to seamless pipes.)

For other welded pipes and forge butt welded pipes, the Society will consider an efficiency factor value depending upon the welding procedure.

(4) The bending allowance, b, is not be less than calculated by the following formula, except where it can be demonstrated that the minimum wall thickness at any point after bending is not to be less than the minimum calculated wall thickness of straight pipe:

$$b = \frac{1}{2.5} \cdot \frac{D}{R} t_0 \quad (mm)$$

where:

D = Outer diameter of pipe (*mm*).

R = Radius of curvature of a pipe bend at the centre line of the pipe (*mm*).

Table 5.6.6 Corrosion Allowance for Steel Pipes (*mm*)

Piping service	C
Superheated steam systems	0.3
Saturated steam systems	0.8
Steam coil systems in cargo tanks	2.0
Steam coil systems in fuel oil tanks	1.0
Feed water for boilers in open circuit systems	1.5
Feed water for boilers in closed circuit systems	0.5
Blow-off (for boilers) systems	1.5
Compressed air systems	1.0
Lubricating and hydraulic oil systems	0.3
Fuel oil systems	1.0
Cargo oil systems	2.0
Refrigerating plants	0.3
Fresh water systems	0.8
Sea water systems in general	3.0
NOTES: 1. For pipes passing through tanks, an additional corrosion allowance is to be considered according to the figures given in the Table, and depending on the external medium, in order to account for the external corrosion. 2. Where pipes and any integral pipe joints are protected against corrosion by means of coating, lining, etc., the corrosion allowance may be reduced by not more than 50%. 3. In the case of use of special alloy steel with sufficient corrosion resistance, the corrosion allowance may be reduced to zero. 4. For other systems than specified in this Table, the corrosion allowance is to be specially considered by the Society in each case. 5. For sea water steel pipes whose nominal diameter is 25*mm* or below, the corrosion allowance may be reduced to 1.5*mm*.	

Table 5.6.7 Corrosion Allowance for Copper and Copper Alloy Pipes (*mm*)

Pipe material	c
Phosphorus-deoxidized copper seamless pipes and brass seamless pipes specified in **Table 5.6.7**	0.8
Copper nickel seamless pipes specified in **Table 5.6.7**	0.5
NOTE: For media without corrosive action in respect of the material employed, the corrosion allowance may be reduced to zero.	

However, $R \geqq 2D$

t_o = Strength thickness specified in (3) (mm).

(5) Allowable stress

(a) The alowable stress for carbon steel and alloy steel pipes is in general to be chosen as the lowest of the following values:

$$f = \frac{E_T}{1.6}, \quad f = \frac{R_{20}}{2.7}, \quad f = \frac{f_R}{1.6}$$

where:

E_T = Specified minimum yield stress or 0.2 percent proof stress (N/mm^2 [kgf/mm^2]).

R_{20} = Specified minimum tensile strength at room temperature (N/mm^2 [kgf/mm^2]).

f_R = Average stress to produce rupture in 100,000 hours at the design temperature (N/mm^2 [kgf/mm^2]).

(b) For steel pipes for pressure piping prescribed in **Pt 2, Ch 1** the allowable stresses may be obtained from **Table 5.6.8**.

(c) The allowable stresses for copper and copper alloy pipes are to be obtained from **Table 5.6.9**.

103. Valves and fitting

1. Materials

Materials for valves and pipe fittings are to be suitable for the medium and service for which the pipes are intended and are to be of the materials complying with the following requirements.

(1) The materials of valves and fittings belonging to Class I and Class II piping systems, shipside valves and fittings, and valves on the collision bulkhead are, as a rule, to comply with the relevant requirement of **Pt 2, Ch1.** However, the Society may accept to use valves and fittings made of materials which meet Korean Industrial Standards or equivalent.

(2) The materials for valves, cocks and pipe fittings belonging to Class III piping systems are to be

Table 5.6.8 Allowable Stress of Steel Pipes for Pressure Piping (N/mm^2 [kgf/mm^2])

Material	Symbols \ Design Temperature °C	100 or less	150	200	250	300	350	375	400	425	450	475	500	525	550
Grade 1	RST 138	123 [12.5]	114 [11.6]	105 [10.7]	96 [9.8]	87 [8.9]	78 [8.0]								
	RST 142	138 [14.1]	129 [13.1]	118 [12.0]	107 [10.9]	96 [9.8]	90 [9.2]								
Grade 2	RST 238	123 [12.5]	114 [11.6]	105 [10.7]	96 [9.8]	87 [8.9]	78 [8.0]								
	RST 242	138 [14.1]	129 [13.1]	118 [12.0]	107 [10.9]	96 [9.8]	90 [9.2]								
	RST 249	156 [15.9]	145 [14.8]	133 [13.6]	122 [12.4]	117 [11.9]	113 [11.5]								
Grade 3	RST 338	123 [12.5]	114 [11.6]	105 [10.7]	96 [9.8]	87 [8.9]	78 [8.0]	75 [7.6]	70 [7.1]	63 [6.4]	56 [5.7]				
	RST 342	138 [14.1]	129 [13.1]	118 [12.0]	107 [10.9]	96 [9.8]	90 [9.2]	87 [8.9]	84 [8.6]	71 [7.2]	57 [5.8]				
	RST 349	156 [15.9]	145 [14.8]	133 [13.6]	122 [12.4]	117 [11.9]	113 [11.5]	105 [10.7]	96 [9.8]	77 [7.9]					
Grade 4	RST 412	119 [12.1]	112 [11.4]	105 [10.7]	97 [9.9]	89 [9.1]	85 [8.7]	83 [8.5]	80 [8.2]	77 [7.9]	73 [7.4]	70 [7.1]	65 [6.6]		
	RST 422	121 [12.3]	116 [11.8]	111 [11.3]	105 [10.7]	99 [10.1]	93 [9.5]	91 [9.3]	89 [9.1]	85 [8.7]	80 [8.2]	76 [7.7]	71 [7.2]	55 [5.6]	38 [3.9]
	RST 423	121 [12.3]	116 [11.8]	111 [11.3]	105 [10.7]	99 [10.1]	93 [9.5]	91 [9.3]	89 [9.1]	85 [8.7]	80 [8.2]	76 [7.7]	71 [7.2]	57 [5.8]	40 [4.1]
	RST 424	121 [12.3]	116 [11.8]	111 [11.3]	105 [10.7]	99 [10.1]	93 [9.5]	91 [9.3]	89 [9.1]	85 [8.7]	80 [8.2]	76 [7.7]	71 [7.2]	57 [5.8]	41 [4.2]

NOTE:
Intermediate values are to be determined by interpolation.

Table 5.6.9 Allowable Stress of Copper and Copper Alloy Pipes (N/mm^2 [kgf/mm^2])

Kind of Materials \ Design Temp. °C		50 or below	75	100	125	150	175	200	225	250	275	300
Phosphorous-deoxidized copper seamless pipes	C1201 C1220	47 [4.8]	35 [3.6]	33 [3.4]	33 [3.4]	32 [3.3]	27 [2.8]	21 [2.1]				
Brass seamless pipes for condenser and heat exchanger	C4430	69 [7.0]	69 [7.0]	69 [7.0]	69 [7.0]	69 [7.0]	68 [6.9]	25 [2.5]				
	C6870 C6871 C6872	82 [8.4]	81 [8.3]	81 [8.3]	80 [8.2]	80 [8.2]	45 [4.6]	23 [2.3]				
Copper nickel seamless pipes for condenser and heat exchanger	C7060	69 [7.0]	67 [6.8]	66 [6.7]	64 [6.5]	62 [6.3]	60 [6.1]	59 [6.0]	56 [5.7]	55 [5.6]	48 [4.9]	41 [4.2]
	C7100	74 [7.5]	73 [7.4]	73 [7.4]	72 [7.3]	71 [7.2]	69 [7.0]	68 [6.9]	66 [6.7]	64 [6.5]	61 [6.2]	58 [5.9]
	C7150	82 [8.4]	79 [8.1]	77 [7.9]	76 [7.7]	75 [7.6]	73 [7.4]	71 [7.2]	70 [7.1]	68 [6.9]	67 [6.8]	66 [6.7]

NOTES:
1. Intermediate values are to be determined by interpolation.
2. Kind of materials are to be in compliance with *KS D* 5301.
3. Allowable stress for materials not specified in the Table will be specially considered by the Society in each case.

manufactured and tested in accordance with the requirements of acceptable Korean Industrial Standards.

2. Service limitations for carbon and low alloy steel

Carbon steel castings and steel forgings are not to be used for valves and pipe fittings in the piping system whose design temperature exceeds 425°C. Low alloy steel castings and low alloy steel forgings are not to be used for valves and pipe fittings in the piping system whose design temperature exceeds 550°C.

3. Service limitations for copper alloy

Copper alloy castings may be used for valves and pipe fittings intended for the design temperature up to 200°C. Special bronze suitable for high temperature service may be accepted up to 260°C subject to the approval by the Society.

4. Service limitations for cast iron for valves and pipe fittings

(1) Cast iron products with an elongation of 12% or above are not to be used for valves and pipe fittings in the piping system whose design temperature exceeds 350°C.

(2) Cast iron products with an elongation of less than 12% are not to be used for the following piping system.

(a) Ship-side valves and fittings.
(b) Valves fitted on the collision bulkhead.
(c) Valves fitted on the external wall of fuel tanks and subjected to the static head of internal fluid unless the valves are mechanically protected to the Society's satisfaction.
(d) Valves and pipe fittings for boiler blow-off piping.
(e) valves fitted on shore connection for cargo pipings of inflammable liquid.
(f) Valves and pipe fittings for piping liable to be subjected to water hammer, excessive strain or vibration.
(g) Valves and pipe fittings whose design temperature exceeds 220°C.
(h) Valves and pipe fittings used for pipes of Class II (except steam pipes).
(i) Valves and pipe fittings for clean ballast lines to forward tanks through cargo oil tanks.
(j) Valves and pipe fittings used for cargo oil pipelines exceeding design pressure of 1.6 MPa.

(3) Cast iron products are not to be used for valves and pipe fittings in the piping system belonging to Class I, unless specially approved by the Society.

5. Construction of valves and pipe fittings

Valves, pipe fittings, gaskets and packings are to be suitable for the condition of use and to have a construction specified in Korean Industrial Standards or equivalent construction thereto. The dimensions of flanges and relative bolts are to be chosen in accordance with Korean Industrial Standards or equivalent. For special applications, when the temperature, the pressure and the size of the flange have values above certain limits, to be fixed, the complete calculation of bolts and flanges is to be carried out.

104. Type of connection

1. Direct connection of pipe lengths

(1) Direct connection of pipe lengths is to be made by direct welding, flanges, threaded joints or mechanical joints, and is to be of a recognised standard or of a design proven to be suitable for the intended purpose and acceptable to the Society.

(2) The expression "mechanical joints" means devices intended for direct connection of pipe lengths other than by welding, flanges or threaded joints described in **Pars 2, 3** and **4** below.

2. Welded connections

(1) Butt welded joints

(a) Butt welded joints are to be of full penetration type generally with or without special provision for a high quality of root side. The expression "special provision for a high quality of root side" means that butt welds were accomplished as double welded or by use of a backing ring or inert gas back-up on first pass, or other similar methods accepted by the Society.

(b) Butt welded joints with special provision for a high quality of root side may be used for piping of any Class, any outside diameter.

(c) Butt welded joints without special provision for a high quality of root side may be used for piping systems of Class II and III irrespective of outside diameter.

(2) Slip-on sleeve and socket welded joints

(a) Slip-on sleeve and socket welded joints are to have sleeves, sockets and weldments of adequate dimensions conforming to the Society Rules or recognized Standard.

(b) Slip-on sleeve and socket welded joints may be used in Class III systems, any outside diameter.

(c) In particular cases, slip-on sleeve and socket welded joints may be allowed by the Society for piping systems of Class I and II having nominal diameter 80A and below (outside diameter $\leq$88.9mm) except for piping systems conveying toxic media or services where fatigue, severe erosion or crevice corrosion is expected to occur.

3. Flange connections

(1) The dimensions and configuration of flanges and bolts are to be chosen in accordance with recognized standards.

(2) Gaskets are to be suitable for the media being conveyed under design pressure and temperature conditions and their dimensions and configuration are to be in accordance with recognised standards.

(3) For non-standard flanges, the dimensions of flanges and bolts are to be subject to special consideration.

(4) Typical Examples of flange attachments are shown in **Table 5.6.1.** However, other types of flange attachments may be considered by the Society in each particular case.

(5) Flange attachments are to be in accordance with national or international standards that are applicable to the piping system and are to recognize the boundary fluids, design pressure and temperature conditions, external or cyclic loading and location.

4. Slip-on threaded joints

(1) Slip-on threaded joints having pipe threads where pressure-tight joints are made on the threads with parallel or tapered threads, are to comply with requirements of a recognized national or international standard.

(2) Slip-on threaded joints may be used for outside diameters as stated below except for piping systems conveying toxic or flammable media or services where fatigue, severe erosion or crevice corrosion is expected to occur.

(a) Threaded joints in CO_2 systems are to be allowed only inside protected spaces and in CO_2 cylinder rooms.

(b) Threaded joints for direct connectors of pipe lengths with tapered thread are to be allowed for:

(i) Class I, outside diameter not more than 33.7mm.

(ii) Class II and Class III, outside diameter not more than 60.3mm.

(c) Threaded joints with parallel thread are to be allowed for Class III, outside diameter not more than 60.3mm.

(d) In particular cases, sizes in excess of those mentioned above may be accepted by the Society if in compliance with a recognized national and/or international standard.

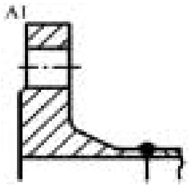
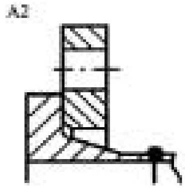
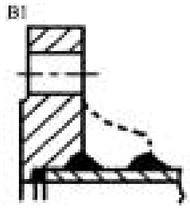
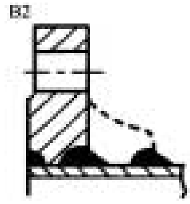
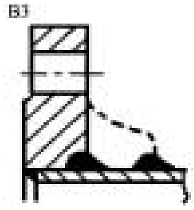
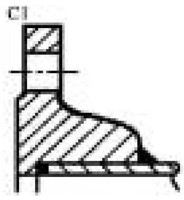
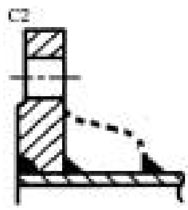
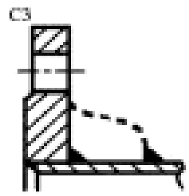
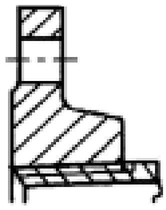
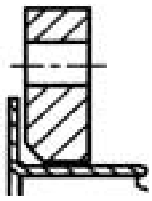
5. Mechanical joints

These requirements are applicable to pipe unions, compression couplings, slip-on joints as shown in **Table 5.6.10.** Similar joints complying with these requirements may be acceptable.

(1) Mechanical joints including pipe unions, compression couplings, slip-on joints and similar joints are to be of approved type for the service conditions and the intended application.

(2) Where the application of mechanical joints results in reduction in pipe wall thickness, this is to be taken into account in determining the minimum wall thickness of the pipe to withstand the design pressure.

(3) Construction of mechanical joints is to prevent the possibility of tightness failure affected by pressure pulsation, piping vibration, temperature variation and other similar adverse effects occurring during operation on board.

Type of flange	Examples of attachments		
Type A			
Type B			
Type C			
Type D			
Type E			

NOTE :
For type D, the pipe and flange are to be screwed with a tapered thread and the diameter of the screw portion of the pipe over the thread is not to be appreciably less than the outside diameter of the unthreaded pipe. For certain types of thread, after the flange has been screwed hard home, the pipe is to be expanded into the flange.

Fig. 5.6.1 Examples of Flange Attachments

(4) Material of mechanical joints is to be compatible with the piping material and internal and external media.

(5) Mechanical joints are to be tested where applicable, to a burst pressure of 4 times the design pressure. For design pressures above 20MPa, the required burst pressure will be specially considered by the Society.

(6) Mechanical joints are to be of fire resistant type as required by **Table 5.6.10.**

(7) Mechanical joints, which in the event of damage could cause fire or flooding, are not to be used in piping sections directly connected to the sea openings or tanks containing flammable fluids.

(8) The mechanical joints are to be designed to withstand internal and external pressure as applicable and where used in suction lines are to be capable of operating under vacuum.

(9) The number of mechanical joints in oil systems is to be kept to a minimum.

(10) Piping in which a mechanical joint is fitted is to be adequately adjusted, aligned and supported. Supports or hangers are not to be used

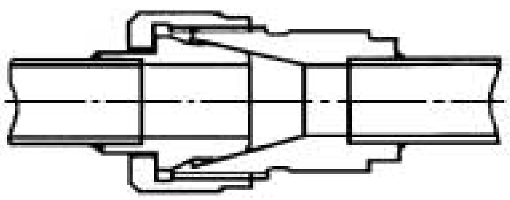
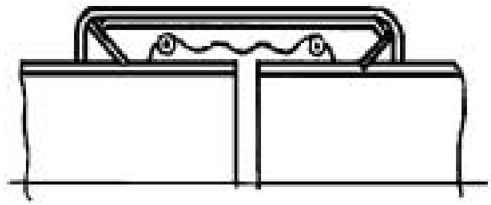
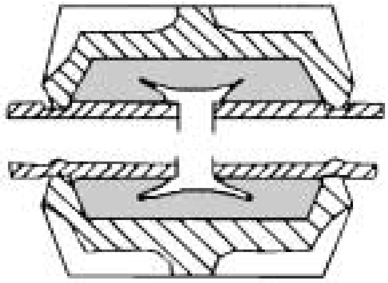
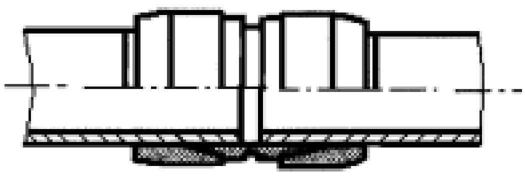
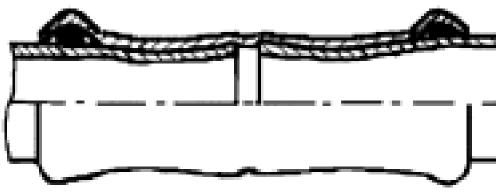
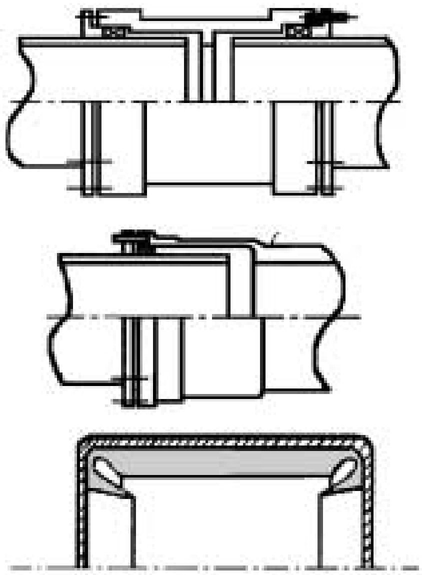
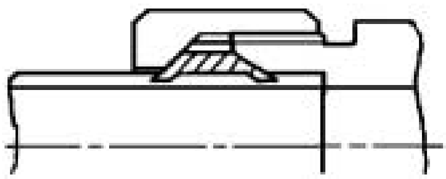
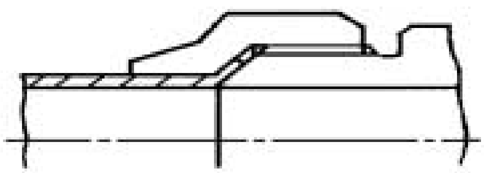
Type of mechanical joints	Examples of mechanical joints	Type of mechanical joints	Examples of mechanical joints
Pipe union		Slip-on joints	
Welded and brazed types		Grip types	
Compression couplings		Mechine grooved type	
Swage type			
Press type		Slip type	
Bite type			
Flared type			

Fig. 5.6.2 Examples of Mechanical Joints

to force alignment of piping at the point of connection.

(11) Slip-on joints are not to be used in pipelines in cargo holds, tanks, and other spaces which are not easily accessible. Application of these joints inside tanks may be permitted only for the same media that is in the tanks. Unrestrained slip-on joints are to be used only in cases where compensation of lateral pipe deformation is necessary. Usage of these joints as the main means of pipe connection is not permitted.

(12) Typical Application of mechanical joints and their acceptable use for each service is indicated in **Table 5.6.10;** dependence upon the Class of piping, pipe dimensions, working pressure and temperature is indicated in **Table 5.6.11.** In particular cases, sizes in excess of those mentioned above may be accepted by the Society if in compliance with a recognized national and/or international standard.

105. Welding of pipes and pipe fittings

1. Scope and documentation

(1) The following requirements apply to the fabrication of Classes I and II piping systems operating at ambient or high temperature and made of steel of the types given below. At the discretion of the Society, these requirements may be applied also to the Class III piping systems

Table 5.6.10 Application of Mechanical Joints
The following table indicates systems where the various kinds of joints may be accepted. However, in all cases, acceptance of the joint type is to be subject to approval for the intended application, and subject to conditions of the approval and applicable Rules.

Systems		Kind of connections		
		Pipe Unions	Compression Couplings[6)]	Slip-on joints
Flammable fluids (Flash point ≤ 60℃)				
1	Cargo oil lines	○	○	○[5)]
2	Crude oil washing lines	○	○	○[5)]
3	Vent lines	○	○	○[5)]
Inert gas				
4	Water seal effluent lines	○	○	○
5	Scrubber effluent lines	○	○	○
6	Main lines	○	○	○[2),5)]
7	Distributions lines	○	○	○[5)]
Flammable fluids (Flash point 〉 60℃)				
8	Cargo oil lines	○	○	○[5)]
9	Fuel oil lines	○	○	○[2),3)]
10	Lubricating oil lines	○	○	○[2),3)]
11	Hydraulic oil	○	○	○[2),3)]
12	Thermal oil	○	○	○[2),3)]
Sea water				
13	Bilge lines	○	○	○[1)]
14	Fire main and water spray	○	○	○[3)]
15	Foam system	○	○	○[3)]
16	Sprinkler system	○	○	○[3)]
17	Ballast system	○	○	○[1)]
18	Cooling water system	○	○	○[1)]
19	Tank cleaning services	○	○	○
20	Non-essential systems	○	○	○
Fresh water				
21	Cooling water system	○	○	○[1)]
22	Condensate return	○	○	○[1)]
23	Non-essential system	○	○	○
Sanitary/Drains/Scuppers				
24	Deck drains (internal)	○	○	○[4)]
25	Sanitary drains	○	○	○
26	Scuppers and discharge (overboard)	○	○	-

Table 5.6.10 Application of Mechanical Joints

Systems		Kind of connections		
		Pipe Unions	Compression Couplings[6)]	Slip-on joints
Sounding/Vent				
27	Water tanks/Dry spaces	○	○	○
28	Oil tanks (f.p. 〉 60℃)	○	○	○[2),3)]
Miscellaneous				
29	Starting/Control air[1)]	○	○	-
30	Service air (non-essential)	○	○	○
31	Brine	○	○	○
32	CO_2 system[1)]	○	○	-
33	Steam	○	○	-

Abbreviations ○ : Application is allowed - : Application is not allowed

NOTES :
1) Inside machinery spaces of category A - only approved fire resistant types
2) Not inside machinery spaces of category A or accommodation spaces. May be accepted in other machinery spaces provided the joints are located in easily visible and accessible positions.
3) Approved fire resistant types
4) Above free board deck only
5) In pump rooms and open decks - only approved fire resistant types
6) If compression couplings include any components which readily deteriorate in case of fire, they are to be of approved fire resistant type as required for slip-on joints.

Table 5.6.11 Application of Mechanical Joints Depending upon the Class of Piping

Type of joints	Classes of piping systems		
	Class I	Class II	Class III
Pipe Unions			
Welded and brazed type	○(OD $\leq$ 60.3mm)	○(OD $\leq$ 60.3mm)	○
Compression Couplings			
Swage type	○	○	○
Bite type	○(OD $\leq$ 60.3mm)	○(OD $\leq$ 60.3mm)	○
Flared type	○(OD $\leq$ 60.3mm)	○(OD $\leq$ 60.3mm)	○
Press type	-	-	○
Slip-on joints			
Machine grooved type	○	○	○
Grip type	-	○	○
Slip type	-	○	○

Abbreviations ○ : Application is allowed - : Application is not allowed

and to repair welding pipelines.
  (a) carbon and carbon-manganese steels having minimum tensile strength 320, 360, 410, 460 and 490N/mm^2.
  (b) low alloy carbon-molybdenum, chromium-molybdenum, chromium-molybdenum-vanadium steels having chemical composition 0,3 Mo;1Cr-0.5Mo;2.25Cr-1Mo;0.5Cr-0.5Mo-0.25V.
(2) The manufacturers are to submit to the Society for its approval the detailed construction drawings and welding procedures (quality of materials, welding method, specification of welding materials, type of edge preparation, heat treatment, test methods are to be shown) before the commencement of the work.

2. Welding workmanship

(1) Welding is to be carried out in accordance with the previously approved welding procedures using approved electrodes, approved automatic welding materials or other equivalent materials. Tack welds are to be made with an electrode suitable for the base metal; tack welds which form part of the finished weld are to be made using approved welding procedures. When welding materials requiring preheating, the same preheating is to be applied during tack welding.
(2) Welding is to be carried out at welding shops, in principle, and by the welders holding the Society's qualification specified in **Pt 2, Ch 2, Sec 5**.
(3) Base materials used in the welding work, unless otherwise specifically approved, are to conform to the requirements in **Pt 2, Ch 1**, and further the carbon content is not to exceed 0.35%.
(4) Edge preparation is to be in accordance with recognized standards and/or approved drawings. The preparation of the edges is to be preferably carried out by mechanical means. When flame cutting is used, care is to be taken to remove the oxide scales and any notch due to irregular cutting by matching grinding or chipping back to sound metal.

3. Welded connections

(1) Welded butt joints are to be of the full penetration type. For Class I pipes, special provisions are to be taken to ensure a high quality of the root side.
(2) If the parts to be joined differ in wall thickness, the thicker wall is to be gradually tapered to that of the thinner of the butt joint with a slope not steeper than 1/4.
(3) Branches may be attached to pressure pipes by means of welding provided that the pipe is reinforced at the branch by a compensating plate or collar or other approved means, or alternatively that the thicknesses of pipe and branch are increased to maintain the strength of the pipe.
(4) Alignment of joints
The tolerances on the alignment of the pipes to be welded are to be as follows.
  (a) Where the pipes welded with backing ring: 0.5 mm.
  (b) Where the pipes welded without backing ring:
    (i) In the case of the nominal diameter less than 150 mm and up to 6 mm in thickness, 1 mm or 25% of the thickness, whichever is less.
    (ii) In the case of the nominal diameter less than 300 mm and up to 9.5 mm in thickness, 1.5 mm or 25% of the thickness, whichever is less.
    (iii) In the case of the nominal diameter 300 mm and over, or over 9.5 mm in thickness, 2 mm or 25% of the thickness, whichever is less.

4. Preheating of welds

When pipes are welded, pipes are to be preheated adequately depending on the kinds and thickness of materials as specified in **Table 5.6.12**.

5. Post weld heat treatment

(1) The heat treatments are not to impair the specified properties of the materials; verifications may be required to this effect as necessary. The heat treatments are preferably to be carried out in suitable furnaces provided with temperature recording equipment. However, localized heat treatments on a sufficient portion of the length way of the welded joint, carried out with approved procedures, also can be accepted.
(2) After the welding(excluding the oxy-acetylene welding process), the pipes specified in **Table 5.6.13** are to be subject to post weld heat treatment according to the kinds of materials for relieving the residual stress. The post weld heat treatment is to consist in heating the piping slowly and uniformly to a temperature within the range indicated in the **Table 5.6.13,** and soaking at this temperature for a suitable period(in general, one hour per 25mm of thickness with minimum of half an hour), cooling slowly and uniformly in the furnace to a temperature not exceeding 400°C and subsequently cooling in a still atmospheric temperature. In any case, the heat treatment temperature is not to be higher than t_T – 20°C, where t_T is the temperature of the final tempering treatment of the material.
(3) After the oxy-acetylene welding, the pipes specified in **Table 5.6.14** are to be subject to post weld heat treatment according to the kinds of materials.
(4) Post weld heat treatment of pipes and pipe fittings made of materials other than those specified in (1), (2) and (3) above is to be made as deemed appropriate by the Society according to the kinds of base metals, welding materials, welding procedure and so on.

Table 5.6.12 Preheating of Welds

Kind of material		Thickness of welds t (mm)	Minimum preheating temperature (°C)
Grade 1 Grade 2 Grade 3	$C+\frac{Mn}{6}\le 0.4$	$t \geqq 20^{(1)}$	50
	$C+\frac{Mn}{6}>0.4$	$t \geqq 20^{(1)}$	100
Grade 4	RST 412	$t > 13^{(1)}$	100
	RST 422	$t < 13$	100
	RST 423	$t \geqq 13$	150
	RST 424(2)	$t < 13$	150
		$t \geqq 13$	200

NOTES:
1. Kind of materials are to be in accordance with the requirements in **Pt 2, Ch 1, 402**.
2. (1) and (2) marked in this Table are as follows :
   (1) For welding in ambient temperature below 0 °C, the minimum preheating temperature is required independent of the thickness unless specifically approved by the Society.
   (2) For these materials, preheating may be omitted for thicknesses up to 6 mm if the results of hardness test carried out on welding procedure qualification are considered acceptable by the Society.

Table 5.6.13 Pipes Requiring Post Weld Heat Treatment

Kind of material		Thickness of welds t (mm)	Minimum preheating temperature(°C)
Grade 1 Grade 2 Grade 3		$t \geqq 15^{(2)(3)}$	550~620
Grade 4	RST 412	$t \geqq 15^{(2)}$	580~640
	RST 422 RST 423	$t > 8$	620~680
	RST 424	any(1)	650~720

NOTES:
1. Kind of materials is to be in accordance with the requirements in **Pt 2, Ch 1, 402**.
2. (1) ~ (3) in this Table are as following.
   (1) Post weld heat treatment may be omitted for pipes having thickness $\le$ 8mm, diameter $\le$ 100mm and design temperature $\le$ 450°C
   (2) When steels with specified Charpy V notch impact properties at low temperature are used, the above thickness which post welded heat treatment is to be applied may be increased by special consideration of the Society.
   (3) For C and C-Mn steels, stress relieving heat treatment may be omitted up to 30mm thickness by special consideration of the Society.

106. Forming of pipes and heat treatment after forming

1. Hot forming of pipes of Class I and Class II is to be generally carried out in the temperature range of 1000°C ~ 850°C. However, the temperature may decrease to 750°C during the forming process. For steel pipes of Grade 4, the stress relieving heat treatment is to be carried out according to the requirements specified in **Table 5.6.13**.

(1) When the hot forming is carried out within this temperature range, a subsequent new heat treatment in accordance with is required for RST422, RST423 and RST424. No subsequent heat treatment is required for Grade 1 through 3 and RST412.

(2) When the hot forming is carried outside the above temperature range, a subsequent new heat treatment in accordance with **Table 5.6.14** is generally required for all grades.

2. When pipes of Class I and Class II are subjected to cold-forming, a stress relieving heat treatment in accordance with **Table 5.6.13** is required for all grades other than carbon and carbon-manganese steels with minimum tensile strength 320, 360 and 410N/mm^2. After cold forming, when $r \le 4D$ (where r is the mean bending radius and D is the outside diameter of pipe), consideration is to be given to a complete heat treatment in accordance with **Table 5.6.14.**

Table 5.6.14 Heat Treatment after Forming and Welding of Pipes

Kind of Material		Heat treatment and temperature (℃)
Grade 1 Grade 2 Grade 3		Normalizing 880 to 940
Grade 4	RST412	Normalizing 900 to 940
	RST422, RST423	Normalizing 900 to 960 Tempering 640 to 720
	RST424 (2.25Cr-1Mo)	Normalizing 900 to 960 Tempering 650 to 780
	RST424 (0.5Cr-0.5Mo-0.25V)	Normalizing 930 to 980 Tempering 670 to 720

107. General requirements for piping arrangement

1. Installation

(1) Pipes are to be arranged in good and systematic order to facilitate the removal of pipes and fittings as well as the maintenance of machinery.

(2) Ample provision is to be made to take care of expansion or contraction stresses in pipes due to temperature changes or deflection of the hull.

(3) Piping arrangements are to be so made as not

to give effects on the performance of machinery due to the stay of drain and air or the pressure loss in pipes.

(4) The support of the pipe system is to be such that detrimental vibrations do not arise in the system.

(5) Heavy pipes, valves and fittings are to be supported in such a way that their weight does not cause large additional stresses in adjacent piping and connected machinery.

(6) So far as practicable, pipes are not to be led in the vicinity of electrical equipment such as generators, motors, switchboards, control gears, etc. Where it is not practicable, all detachable pipe joints are to be at a safe distance from the electrical equipment, unless provision is made to prevent any leakage from pouring on the equipment.

(7) Oil pipes (fuel oil, lubricating oil, cargo oil and other oil) are not to be led upright the boiler, steam pipes, exhaust gas pipes, silencer and the other areas which are in a high temperature, and so far as practicable, to be isolated from the above systems.

(8) Hydraulic unit having working pressure above 1.5 MPa and having potential of oil leakage coming contact with hot surfaces, electrical installations or other sources of ignition, is to preferably be placed in separate spaces. If it is impracticable to locate such units in a separate space, adequate shielding is to be provided.

2. Protection of pipes and fittings

(1) All pipes, valves, cocks, pipe fittings, valve operating rods and handles are to be effectively secured and adequately protected for those liable to be damaged, and for those installed in cargo holds and chain lockers. Where a casing is provided for protection, it is to be so constructed as to be easily removed for inspection.

(2) All pipes including bilge, air and sounding pipes in refrigerating spaces are to be well insulated so that water in pipes may not freeze.

(3) For pipes arranged in the positions inaccessible for maintenance and inspection, due consideration such as corrosion protection is to be given to prevent corrosion.

3. Relief valves

All pipe lines which may be exposed to pressures greater than the design pressure are to be safeguarded by suitable relief valves or equivalent safety devices.

4. Pressure gauges and thermometers

(1) Pressure gauges and thermometers are to be provided on piping systems where deemed necessary.

(2) Cocks or valves are to be provided at the root of pressure measuring devices for isolating them from the pipes under a pressurized condition.

(3) Where thermometers are fitted in fuel oil, lubricating oil and other flammable oil piping or apparatuses, the thermometer is to be put in a safe protective pocket to prevent oil from spraying in case of fracture or removal of the thermometer.

5. Gaskets and packings for piping

Gaskets and packings used for flanges, pipe joints, valve covers, valves spindles, etc. in piping systems are to be selected carefully by taking account of the kinds of fluids, operating conditions and the type of flange contact surfaces.

6. Slip joints

Slip joints are not to be used in pipe lines in cargo holds, deep tanks and other spaces which are not easily accessible, unless otherwise specified.

7. Penetrations through bulkheads, decks, etc.

Where pipes are led through watertight bulkheads, decks, boundary plates of deep tanks and inner bottom plating, arrangements are to be made to ensure the integrity of the watertightness of the structure.

8. Fittings on watertight bulkheads

(1) Valves or cocks such as drain valves, which do not constitute a part of any pipe line are not to be fitted on the collision bulkhead.

(2) Pipes piercing the collision bulkhead are to be fitted with suitable valves operable from above the freeboard deck and the valve chest is to be secured at the bulkhead inside the forepeak. The valve, however, may be fitted on the after side of the collision bulkhead provide that the valves are readily accessible under all service conditions and the space in which they are located is not a cargo space.

(3) Valves and cocks, such as drain valves, which do not constitute a part of any pipe lines may be fitted to watertight bulkheads other than the collision bulkhead, provided that they are readily accessible at any time for the inspection. Such valves and cocks are to be operable from above the bulkhead deck and to be provide with an indicator to show whether they are open or closed, except where the valves or cocks are secured at the fore or after bulkhead inside the engine room. In addition, the operation rod is to be so constructed that the weight of it is not supported by the valve or cock.

9 Prohibition of carriage of oil in forepeak tanks

In ships of 400 *gross tonnage* and above, compartments forward of the collision bulkhead are not to be arranged for the carriage of oil or other liquid substances which are flammable.

10. Marking

(1) The pipes located in the space where deemed necessary for safety are to be marked with distinctive colour.
(2) The valves for piping systems which are available for fire extinguishing aboard ship are to be marked with red paint.

11. Pipe cleaning

Piping systems are to be cleaned after fabrication or installation in ships where considered necessary.

12. Sea water and fresh water pipings

Sea water pipes are to be led separately as far as possible from fresh water pipes. Where such leading is not practicable, care is to be taken to prevent the accidental contamination of fresh water with sea water.

SECTION 2
Air, Overflow and Sounding Pipes

201. Air pipes

1. General

(1) Air pipes are to be fitted to all tanks, cofferdams and tunnels.
(2) The air pipes are to be fitted at the fore and after portions of the tanks. Where the tanks are less than 7 m both in length and in width or having inclined top plates, one air pipe may be fitted at the highest part of the tanks.
(3) Where the tank top is of unusual or irregular profile, special consideration is to be given to the number and position of the air pipes.
(4) Air pipes are to be arranged to be self-draining under normal conditions of trim and to be clearly marked at the upper end.

2. Termination of air pipes

Air pipe to double bottom tank, deep tanks, cofferdams or tanks which can be run up from the sea are to be led to above the bulkhead deck. The position of open ends of air pipes are to be in accordance with the following requirements depending on the kinds of tanks.

(1) Air pipes to fuel oil and cargo oil tanks, cofferdams and all tanks which can be pumped up are to be led to the open air above weather decks.
(2) The open ends of air pipes to fuel oil and cargo oil tanks are to be situated where no danger will be incurred from issuing oil or vapour when the tank is being filled.
(3) Air pipes from lubricating oil tanks may terminate in the machinery space, provided that the open ends are so situated that issuing oil or gas cannot come into contact with electrical equipment or heated surfaces.
(4) Air pipes from fresh water tanks may terminate in the machinery space.
(5) Air pipes for fuel oil service, settling and lubrication oil tanks are to be such that in the event of a broken air pipe this is not directly to lead to the risk of ingress of seawater splashes or rain water.

3. Air pipe closing devices

(1) All openings of air pipes extending above weather decks are to be provided with permanently attached effective means of closing. In ships intended to carry timber deck cargoes on the weather decks, the closing means are to be of an automatic type. And All automatic type closing devices are to be approved by the Society.
(2) Provision is to be made for relieving vacuum when the tanks are being pumped out.
(4) Air pipe closing devices are to be designed so that they can withstand both ambient and working conditions up to an inclination of $\pm 40°$ without failure or damage.
(5) Air pipe closing devices are to be constructed to allow inspection of the closure and the inside of the casing as well as for changing the seals.
(6) In the case of air pipe closing devices of the float type, suitable guides are to be provided to ensure unobstructed operation under all working conditions of heel and trim.
(7) Efficient seating arrangements are to be provided for the closures.
(8) Air pipe closing devices are to be self draining.
(9) The clear area through an air pipe closing device is to be at least equal to the area of the inlet.
(10) The maximum allowable tolerances for wall thickness of ball floats are not to exceed 10% of the nominal thickness.
(11) Casings of air pipe closing devices are to be of approved metallic materials adequately protected against corrosion.
(12) Closures and seats made of non-metallic materials are to be compatible with the media intended to be carried in the tank and to sea water at ambient temperatures between -25°C and 85°C.

4. Size of air pipes

(1) The aggregated sectional area of air pipes to tanks which can be pumped up is not to be less than 1.25 times the aggregated sectional area of filling pipes. Where the tank is provided with an overflow pipe, the above-mentioned sectional area of air pipes may be adequately reduced.
(2) The internal diameters of air pipes to cofferdams or tanks which form part of ship's structure are not to be less than 50 mm.

5. Height of air pipes

Where air pipes extend above the freeboard and superstructure decks, the exposed parts of the pipes are to be of substantial construction; the height from the upper surface of the deck to the point where water may have access below is to be at least as given in the following table: Where these height may interfere with the working of the ship, a lower height may be accepted, provided that the Society is satisfied that the closing arrangement and other circumstances justify the lower height.

Location	Height of coaming
On the freeboard deck	760 mm
On the superstructure deck	450 mm

202. Overflow pipes

1. General

(1) Where tanks which can be pumped up come under either one of the following categories, overflow pipes of steel are to be fitted:
(a) Where the cross-sectional area of the air pipes does not comply with the requirements in **201. 4** (1).
(b) Where there is any opening below the open ends of air pipes fitted to tanks.
(c) Fuel oil settling tank and fuel oil service tank.

(2) Overflow pipes are to be arranged to be readily visible and self-draining under normal conditions of trim and to be clearly marked at the upper end.

2. Termination of overflow pipes

(1) In case of fuel oil and lubricating oil tanks, the overflow pipe is to be led to an overflow tank of adequate capacity or to a storage tank having a space reserved for overflow purposes.

(2) A sight glass is to be provided in the overflow pipe at a readily visible position or, alternatively, an alarm device is to be provided to give warning either when the tanks are overflowing or when the oil reaches a predetermined level in the tanks.

(3) Overflow pipes from tanks, other than fuel oil, cargo oil and lubricating oil tanks, are to be led to the open air or to suitable tanks where the overflows can be disposed of.

3. Size of overflow pipes

The total cross-sectional area of the overflow pipes is not to be less than 1.25 times the effective area of the filling pipes. In any case, the minimum internal diameter for overflow pipes is not to be less than 50mm.

4. Prevention of counter-flow of overflow lines

(1) The overflow system is to be so arranged that water from the sea cannot enter through the overflow main line into tanks located in other watertight compartments in the event of any tank being damaged.

(2) Where overflows from tanks which are used for the alternative carriage of oil, ballast water, general cargo, etc., are connected to an overflow system, arrangements are to be made to prevent the entering of liquid or vapour from other tanks into the tank carrying general cargo, or to prevent the entering of oil different quality or ballast water from other tanks into the tank carrying oil.

(3) Overflow pipes discharging through the ship's sides are to extend above the load line and are to be provided with non-return valves fitted on the ship's sides. Where the overflow pipes do not extend above the freeboard deck, additional effective means are to be provided to prevent the sea water from passing inboard.

203. Sounding pipes

1. General

(1) All tanks, cofferdams and other compartments which are not at all times readily accessible are to be provided with sounding pipes.

(2) In cargo holds, sounding pipes are to be fitted to the bilges on each side and as near the suction pipe rose boxes as practicable.

(3) All sounding pipes are to be clearly marked at the upper end.

2. Termination of sounding pipes

(1) Sounding pipes are to be led to positions above the bulkhead deck which are at all times readily accessible and are to be provided with effective closing means at the upper end.

(2) The termination of sounding pipes to fuel oil tanks, lubricating oil tanks and other flammable oil tanks are not to terminate in passenger or crew spaces and adjacent to the electrical equipment, boilers and other heated surfaces.

(3) In machinery spaces and shaft tunnels where it is not always practicable to extend the sounding pipes above the bulkhead deck, short sounding pipes extending to readily accessible positions above the platform may be fitted. In this case, the following closing means are to be fitted to the upper end of the pipes according to the kinds of tanks:
(a) Sounding pipes to double bottom oil tank are to be fitted with self-closing blanking devices and with a small-diameter self-closing control cock located below the blanking device for the purpose of ascertaining before the blanking

device is opened that oil fuel is not present. Provisions are to be made so as to ensure that any spillage of oil fuel through the control cock involves no ignition hazard.
(b) Sounding pipes to fuel oil tanks above double bottom are to be fitted with an approved oil level gauge, in addition to the requirements of (a) above.
(c) sounding pipes to lubricating oil tanks and other flammable oil tanks are to be fitted with sluice valves or cocks with self-closing means.
(d) Sounding pipes to other tanks mentioned in (a) to (c) and cofferdams are to be fitted with sluice valves, cocks or screw caps attached to the pipes by chains.

3. Construction of sounding pipes

(1) Sounding pipes are to be arranged as straight as practicable, and if curved, the curvature must be sufficiently easy to permit the ready passage of the sounding rod or chain.
(2) Striking plates of adequate thickness and size are to be fitted under open ended sounding pipes. Where sounding pipes having closed ends are employed, the closing plugs are to be of substantial construction.
(3) The inside diameter of sounding pipes is not to be less than 32 mm. But the inside diameter of sounding pipes passing through a refrigerated chamber cooled down 0 °C or below is not to be less than 65 mm.

4. Sounding devices other than sounding pipes

(1) Sounding devices of approved type may be used in lieu of sounding pipes for sounding tanks.
(2) These devices are to be tested at the working condition on completion of the installation.
(3) Glass gauges used for tanks carrying fuel oils, lubricating oils and other flammable oils are to comply with the following requirements (a) and (b).
(a) The glasses used for oil level indicators are to be of flat shape and of heat resisting quality, and adequately protected from mechanical damage. Round glass gauges may, however, be used subject to the approval by the Society, for small tanks provided that special consideration is paid to the construction, strength and protection from mechanical damages of the glasses.
(b) The valves or cocks at the lower ends of glass gauges are to be provided with self-closing means. However, the valves and cocks may be omitted according to the discretion of the Society.

SECTION 3
Ship-side Valves and Overboard Discharge

301. Ship-side valves and fittings

1. Installation

(1) All sea inlet and overboard discharge pipes are to be fitted with valves or cocks secured direct to the shell plating or to the plating of fabricated steel water boxes attached to the shell plating.
(2) These valves or cocks are to be fitted up to the doublings which are welded to shell plating or sea chest by using stud bolts not piercing the shell plating, or to the distance pieces attached to shell plating by using bolts.

2. Construction of distance pieces

Distance pieces attached to the shell plating are to be of rigid construction and as short as practicable.

3. Construction of sea chests

(1) Sea chests forming part of the ship's structure are to be as compact as possible and of rigid construction with no air to stay inside.
(2) Gratings are to be fitted at all openings in the ship's side for sea inlet valves or sea chest. The net area through the gratings is to be not less than twice that of the valves connected to the sea inlets, and provision is to be made for clearing the gratings by use of low pressure steam or compressed air.

4. Sea inlet and overboard discharge valves

(1) Sea inlet and overboard discharge valves or cocks are in all cases to be fitted in easily accessible position. Indicators are to be provided local to the valves or cocks showing whether they are open or shut.
(2) Sea inlet valves are to be so located as to minimize the possibility of blanking off the suction and the valve spindles are to be extended above the lower platform. Power operated sea inlet valves are to be arranged for manual operation in the event of failure of the power supply.
(3) Discharge valves or cocks are to have spigots extending through the shell plating unless they are provided with distance pieces or doublings having spigots.

5. Blow-off valves of boilers and evaporators

(1) Blow-off valves or cocks on the ship's side are to be fitted in accessible positions above the level of the working platform, and are to be provided with indicators showing whether they are open or shut. Cock handles are not to be capable of being removed unless the cocks are shut and if valves are fitted, the hand wheels are to be suitably retained on the spindle.
(2) These blow-off valves or cocks are to have spig-

ots extending through the shell plating and protecting rings.

6. Location of overboard discharges

The location of overboard discharges is not to be such that water can be discharged into life boats when launched. Where such location is unavoidable, special consideration is to be given to prevent the discharge water from entering into the life boats.

302. Scuppers and sanitary discharge

1. General

Scuppers, sanitary discharges or similar openings led through the ship's side are to have, as far as possible, one common discharge; if this is impracticable, it is recommended to minimize the number of discharge openings by other means. In general, however, different systems of overboard discharges are not to be connected to each other unless specially approved by the Society.

2. Scupper

(1) Scuppers sufficient in number and size to provide effective drainage are to be fitted in all decks.

(2) Where scuppers penetrate shell plating or superstructure side plating, suitable reinforcement is to be made at the penetrating parts.

3. Scuppers of exposed decks

Scuppers draining weather decks and spaces within superstructures or deck houses not fitted with efficient weathertight doors are to be led overboard.

4. Non-return valves of scuppers and sanitary pipes

Scuppers and sanitary pipes from spaces below the freeboard deck or from spaces within enclosed superstructures or enclosed deckhouses on the freeboard deck are to be led to the bilges or to suitable sanitary tanks. Alternatively, they may be led to overboard where they are provided with valves in accordance with the following requirements.

(1) Each separate discharge is to have one automatic non-return valve with a positive means of closing it from a position above the freeboard deck or, alternatively, one automatic non-return valve having no positive closing means and one stop valve controlled from above the freeboard deck. However, where the scuppers lead overboard through the shell plating in way of manned engine room, the fitting to the shell plating of a locally operated positive closing valve, together with a non-return valve inboard, will also be accepted. The means for operating the positive action valve from above the freeboard deck are to be readily accessible and provided with an indicator showing whether the valve is open or closed.

(2) Where, however, the vertical distance from the load line to the inboard end of the scupper pipe exceeds $0.01 L_f$(L_f : length for freeboard specified in **Pt 3, Ch 1** of the Rules), the scupper pipe may have two automatic non-return valves without positive means of closing in lieu of valves prescribed in (1). In this case, the inboard valve is to be located above the level of the tropical load line and always accessible for inspection under service condition. If this is not practicable to fit inboard valve above the specified waterline then it can be accepted below provided locally controlled stop valve is fitted between two automatic non-return valves.

(3) Where the vertical distance from the summer load water line to the inboard end of the discharge pipe exceeds $0.02 L_f$, a single automatic non-return valve without positive means of closing may be fitted.

5. Overboard scuppers

Scuppers and discharge pipes originating at any level and penetrating the shell plating either more than 450 mm below the freeboard deck or less than 600 mm above the summer load waterline, are to be provided with an automatic non-return valve at the shell plating. This valve, unless required by **Par 4**, may be omitted provided that the pipe thickness is in accordance with the **Table 5.6.2**.

6. Deck wash and sanitary pipes

Sea water pipes for deck wash and sanitary pipes are not to be led through cargo holds except where specially approved for unavoidable cases.

SECTION 4
Bilge and Ballast System

401. General

1. Application

(1) The requirements of this Section apply to the bilge and ballast system on the ship not less than 50 m in length

(2) Bilge and ballast system of passenger ship, special ship and the ship less than 50 m in length are to be in accordance with the discretion of the Society.

2. Piping arrangement

(1) An efficient bilge pumping system is to be provided, capable of pumping from and draining any watertight compartment other than a space permanently appropriate for the carriage of liquid and for which other efficient means of pumping are provided, under all practical conditions and these suctions are, except where otherwise

stated, to be branch bilge suctions connected to a main bilge line.

(2) An efficient ballast piping system is to be provided, capable of pumping ballast water into and from any tanks for carriage of ballast water under all practical conditions.

(3) Where the fixed pressure water-spraying fire-extinguishing system or other fixed fire-extinguishing systems which will supply copious quantities of water are fitted for ro-ro spaces as defined in **Pt 8, Ch 1, 104** (10) or cargo spaces containing motor vehicles with fuel in their tanks for their own propulsion or where means of cooling the under deck cargo space for dangerous goods specified in **Pt 8, Ch 1, 312.** by an arrangement of spraying nozzles or flooding the cargo space with water are provided, an arrangement is to be fitted to ensure that such water is discharged directly overboard.

402. Drainage of compartment other than machinery spaces

1. Cargo holds

(1) In ships having only one hold, and this over 33 m in length, bilge suctions are to be fitted in suitable positions in the fore and after suctions of the hold.

(2) Where the inner bottom plating extends to the ship's side, the bilge suctions are to be led to wells placed at the wings and also at the center line if the top plating has inverse camber. But in the case of fishing vessels, a single well may be accepted.

(3) Where close ceiling or continuous gusset plates are fitted over the bilges, arrangements are to be made whereby water in a hold compartment may find its way to the suction pipes.

(4) Bilge pipe arrangement in refrigerating chambers of ships except those to be registered according to **Pt 1, Ch 1, Sec 13,** is to be in accordance with the requirements in **Pt 9, Ch 1, Sec 5**.

2. Tanks

All tanks including double bottom tanks are to be provided with suction pipes, led to suitable power pumps, from the after end of each tank. Where fore and after peak tanks are used as fresh water tanks and small capacity, a hand pump may be substituted.

3. Dry compartment other than cargo holds

(1) Bilge of chain lockers, fore and after peaks not used as tanks or deck forming the top of these tanks may be drained by eductors or hand pumps. These eductors or hand pumps are to be capable of being operated at any time from accessible position above the summer load water line.

(2) If steering gear compartments or other small enclosed spaces situated above the after peak tank are adequately isolated from the adjacent tween decks, they may be drained by scuppers of not more than 65 mm in nominal diameter, discharging to the shaft tunnel or an accessible compartment, and fitted with self-closing cocks situated in an accessible position.

4. Maintenance of integrity of bulkheads

(1) The intactness of the machinery space bulkhead, and of tunnel plating required to be of watertight construction, is not to be impaired by the fitting of scuppers discharging to machinery space or tunnels from adjacent compartments which are situated below the bulkhead deck. These scuppers may, however, be led into a strongly constructed scupper drain tank situated in the machinery space or tunnel, but closed to these spaces and drained by means of a suction of appropriate size led from the main bilge line through a screw-down non-return valve.

(2) The scupper tank air pipe is to be led to above the bulkhead deck, and provision is to be made for ascertaining the level of water in the tank.

(3) Where one tank is used for the drainage of several watertight compartments, the scupper pipes are to be provided with screw-down non-return valves.

403. Drainage of machinery spaces

1. Machinery space with double bottom

(1) Where the double bottom extends the full length of the machinery space and forms bilges at the wings, it will be necessary to provide one branch and one direct bilge suction at each side.

(2) Where the double bottom plating extends the full length and breadth of the compartment, one branch bilge suction and one direct bilge suction are to be led to each of two bilge wells, situated one at each side.

2. Machinery space without double bottom

(1) Where there is no double bottom and the rise of floor is not less than 5°, one branch and one direct bilge suction are to be led to accessible positions as near the centerline as practicable.

(2) In ships where the rise of floor is less than 5°, additional bilge suctions are to be provided at the wings.

3. Additional bilge suctions

Additional bilge suctions are to be provided where considered necessary in connection with the arrangement of machinery room, ship's bottom structure or machinery layout.

4. Separate machinery spaces

Where the machinery space if divided by a watertight bulkhead to separate the boiler room or the auxiliary engine room from the main engine room, the bilge pipe arrangements in the boiler room and the auxiliary engine room are to be in accordance with the requirements of **Par 1** or **2**. However, only one direct bilge suction is enough though there is a double bottom.

5. Direct bilge suction

(1) The direct bilge suctions provided in machinery rooms are to be connected directly to the pumps driven by independent power specified in **405. 1** and their arrangements are to be such that they can be used independently of all other piping lines.

(2) The inside diameter of direct bilge suction pipes is not to be less than the inside diameter of main bilge pipes required. Where direct bilge suction is provided on each side of the machinery room with double bottom and also the emergency bilge suction is provided, the inside diameter of the direct bilge suction pipe at the side where the emergency bilge suction is provided, may be reduced to the required inside diameter of bilge suction branch pipe.

(3) Where the separate machinery spaces are of small dimensions, the sizes of the direct bilge suctions to these spaces will be specially considered.

6. Emergency bilge suction

(1) In addition to the bilge branch suctions and direct bilge suctions, an emergency bilge suction is to be provided in each main machinery space.

(2) This suction with a screw-down non-return valve having a hand wheel which is easily operable from above the platform in the machinery space, is to be led to the main cooling water pump.

(3) Where two or more cooling water pumps are provided, each capable of supplying cooling water for normal power, only one pump need be fitted with an emergency bilge suction.

(4) In ships with steam propelling machinery, the suction is to be have a diameter of at least two-thirds that of the pump suction. In other ships, the suction is to be the same size as the suction branch of the pump.

(5) Where main cooling water pumps are not suitable for bilge pumping duties, the emergency bilge suction is to be led to the largest available power pump, which is not a bilge pump as specified in **405. 1**. This pump is to have a capacity not less than that required for a bilge pump specified in **405. 2**, and the bilge suction is to be the same size as that of the pump suction branch.

(6) Where the pump to which the emergency bilge suction is connected is of self-priming type, the direct bilge suction arranged on the same side of the ship as the emergency bilge suction may be omitted.

404. Size of bilge suction pipes.

1. Main bilge line

The internal diameter d_m of the main bilge line is to be not less than that required by the following formula, to the nearest National Standard Pipes, but in no case is the diameter to be less than that required for any branch bilge suction:

$$d_m = 1.68\sqrt{L(B+D)} + 25 \quad (mm)$$

where:

$L,\ B,\ D$ = Length, breadth and depth of ship, respectively (m), defined in **Pt 3, Ch 1**.

2. Branch bilge suction

The internal diameter d_b of the branch bilge suction pipes is not to be less than that required by the following formula, to the nearest National Standard Pipes, but in no case is the diameter to be less than 50 mm except that for drainage of a small compartment, it may be reduced to 40 mm, where considered acceptable by the Society.

$$d_b = 2.15\sqrt{l(B+D)} + 25 \quad (mm)$$

where:

l = Length of the compartment which shall be drained by branch pipe (m).

$B,\ D$ = Breadth and depth of ship, respectively (m), defined in **Pt 3, Ch 1**.

3. Main bilge line of tanker and similar ships

In oil tankers, where bilge pumps in the machinery space are exclusively used for the bilge drainage of the machinery space, the internal diameter of main bilge suction pipes may be reduced to the value obtained from the following formula.

$$d_{m0} = \sqrt{2}\ (2.15\sqrt{l_m(B+D)} + 25) \quad (mm)$$

where:

l_m = Length of engine room (m).

$B,\ D$ = Breadth and Depth of ship, respectively (m), defined in **Pt 3, Ch 1**.

4. Distribution chest branch pipes

(1) The internal sectional area of bilge suction pipes connecting two or more branch bilge suction pipes to the main bilge line is not to be less than the sum of internal sectional areas of the largest two branch bilge suction pipes, but need not be greater than that required for the main bilge line.

(2) Where permitted, common-main type bilge system is to have the fore-and-after piping installed inboard of 20 % of the molded beam of the vessel. The control valves required in the branches from the bilge main are to be accessible at all times and are to be of the stopcheck type with an approved type of remote operator. Remote operators may be located in a manned machinery space, or from an accessible position above the freeboard deck, or from underdeck walkways. Remote operators may be of the hydraulic, pneumatic or reach-rod type.

5. Peak tanks and shaft tunnels

The internal diameter of bilge pipes in peak tanks and shaft tunnels is not to be less than 65 mm. However, in ships of 60 m or less in length, the internal diameter may be reduced to 50 mm.

6. Where bilge suctions are provided at the fore and after part of cargo hold in accordance with the requirements in **402. 1** (1), the internal diameter of the branch bilge suction pipe at the fore part may be reduced to 0.7 times that obtained from the formula in **Par 2**.

405. Bilge pumps

1. Number of pumps

(1) All ships are to be provided in their machinery rooms with at least two independent power bilge pumps connected to the bilge main. In ships of 90 m in length and under, one of these pumps may be driven by the main engines.

(2) Ballast, sanitary and general service pumps driven by independent power may be accepted as independent power bilge pumps, provided that they are connected properly to the main bilge line.

(3) One of the independent power bilge pumps prescribed in (1) may be substituted by an eductor in connection with a sea water pump other than bilge pump where considered acceptable by the Society. In this case, the capacity of the eductor is to comply with the requirement in **Par 2**.

2. Capacity of pumps

(1) The capacity, Q, of each bilge pumping unit or bilge pump is not to be less than that required by the following formula.

$$Q = 5.66\, d_m^2 \times 10^{-3} \quad (m^3/hr)$$

where:

d_m = Required internal diameter of main bilge line (mm).

(2) Where one bilge pump or pumping unit is of slightly less than the required capacity, the deficiency may be made good by an excess capacity of the other unit. But in any cases the capacity of this pump is to be more than 70 % of the required capacity.

3. Self-priming type

All power pumps required in **Par 1** are to be of the self-priming or the equivalent type and are to be so arranged that they are immediately operable when in use.

4. Connection of bilge pumps and suction pipes

All of the power pumps prescribed in **Par 1** are to be arranged for discharging bilge from all holds, engine room and shaft tunnel. Where, however, an eductor is used exclusively for bilge drainage in a hold, the bilge suction pipe of this hold need not be connected to the bilge pumps prescribed in **Par 1**. In this case, the eductor is to be so arranged as to be driven by two or more pumps. Capacity of the sea water pump for sending driving water to the eductor, capacity of the eductor, internal diameter of the suction pipe are to be considered appropriate by the Society.

5. Pump connections

(1) The bilge pumps may be used for ballast, fire or general service duties of an intermittent nature.

(2) The connections at the bilge pumps are to be such that one unit may continue in operation when the other pump is being opened up for overhaul.

(3) Pumps required for essential services are not to be connected to a common suction or discharge chest or pipe unless the arrangements are such that the working of any of the pumps so connected is unaffected by the other pumps being in operation at the same time.

406. Pipe systems and their fittings

1. Isolation of bilge system

Bilge suction pipes used for draining cargo holds, machinery room and shaft tunnels are to be entirely separate from other pipes than the bilge suction pipes.

2. Prevention of communication between compartments

The arrangement of valves, cocks and their connections for bilge system is to be such as to prevent the possibility of one watertight compartment being placed in communication with another or of dry cargo spaces, machinery spaces or other dry compartments being placed in communication with the sea or with tanks. For this purpose, screw-down non-return valves are to be provided as follow.

(1) Screw-down non-return valves or cocks which bilge and water or oil are not to be communicated at same time, are to be provided at the bilge pipes connected to the pump drawing water or oil.
(2) Screw-down non-return valves are to be provided between each branch bilge suction and distribution chests.

3. Bilge pipes in way of double bottom tanks

Bilge pipes passing through double bottom tanks are to be led through oiltight or watertight pipe tunnel or alternatively, are to be of sufficient thickness complying with the requirements in **Table 5.6.2**.

4. Bilge pipes or ballast pipes in way of deep tanks

Bilge pipes in way of deep tanks or ballast pipes in way of deep tanks except ballast tanks, are to be led through an oiltight or watertight pipe tunnel or alternatively, extra heavy steel pipes in **Table 5.6.2** are to be used for this purpose and all joints of them are to be welded, and they are to be properly installed taking sufficient care of leakage, expansion and contraction.

5. Valves and valve boxes

(1) All valves, valve boxes or cocks which are fitted to the bilge piping are to be provided at easily accessible locations in any condition of the ship.
(2) Bilge pipes passing through double bottoms, side tanks, bilge hopper tanks or void spaces, where there is a possibility of damage of these pipes due to grounding or collision, are to be provided with non-return valves near the bilge suctions or stop valves capable of being closed from readily accessible positions.

6. Pipes in various purpose deep tanks

(1) Where a hold is intended for carrying ballast water and cargo alternately, adequate provisions such as blank flange or spool piece are to be made in the ballast piping system to prevent inadvertent ingress of sea water through ballast pipes when carrying cargo and in the bilge piping system to prevent inadvertent discharge of ballast water through bilge pipes when carrying ballast water.
(2) Where a tank is intended to be used both for fuel oil and ballast water, adequate provisions such as blank flange or spool piece are to be made to prevent mixing of fuel oil and ballast water in the ballast pipe when carrying fuel oil and in the fuel oil pipe when carrying ballast water.

7. Ballast piping system is to be provided with a suitable provision such as a non-return valve or a stop valve which can be kept closed any time excluding the time of ballasting and deballasting and which is provided with an indicator to show whether it is open or closed, in order to prevent the possibility of water inadvertently passing from the sea to the ballast tanks or of ballast passing from one ballast tank to another.

8. Mud boxes

All bilge suction pipes in the machinery room are to be provided with mud boxes, having straight tail pipes to bilges and fitted with covers which can be readily opened or closed and placed at easily accessible positions above the floor level of the machinery room. For emergency bilge suction pipes these requirements may not be complied with.

9. Rose boxes

All bilge suction branch pipes of such cargo holds and spaces other than machinery compartment are to be fitted at their open ends with rose boxes which can be cleaned without disconnecting the flanges of the suction pipes. The diameter of suction holes on the rose boxes is not to be greater than 10mm and the total open area of perforation is not to be less than three times that of the suction pipe.

10. Bilge wells

(1) Bilge wells are to be constructed of steel and not less in capacity than 0.17 m^3. However, where the spaces to be drained are of small dimensions, steel bilge hats of reasonable capacity may be fitted.
(2) The depth of bilge wells constructed in double bottom and the vertical distance between the bottom shell plating and the bottom plate of bilge wells are to comply with the requirements in **Pt 3, Ch 7, 103**.

11. Manhole

Where accessible manholes to the bilge well are necessary, they are to be fitted as near bilge suctions as practicable. It is to be avoided, as far as practicable, to provide the above manholes in the fore and after bulkheads and tank top plating of the machinery space. Where, however, this arrangement is necessary, a manhole cover of the hinged type is to be fitted and notice plate indicating "To be kept shut except when access is required", is to be posted up in well observable position near the manholes.

SECTION 5
Feed Water and Condensate System for Boiler

501. Feed water pumps

1. Ships equipped with main boiler for steam propulsion and essential auxiliary boiler for driving of essential auxiliaries are to be provided with at least two independent power driven feed water pumps. One feed pump may, however, be accepted in case of auxiliary boiler other than the essential auxiliary boiler.

2. Each pump is to be of the capacity sufficient to supply water to the boilers under designed full load conditions.

3. The feed pumps are to be driven by independent prime movers.

4. The feed pumps are to be used exclusively for feed purposes.

502. Feed water piping

1. Two separate means of feed are to be provided for all main and auxiliary boilers which are required for essential services. One feed water system may, however, be accepted in case of auxiliary boiler other than the essential auxiliary boiler.

2. A feed water regulator capable of automatically controlling the feed rate is to be provided on the feed water system of main boiler or essential auxiliary boiler.

3. A feed water regulator capable of automatically controlling the feed rate is to be provided on the feed water system of auxiliary boiler with automatic controller other than essential auxiliary boiler.

503. Condensate pumps

1. At least two independent condensate pumps are to be provided for dealing with condensate from the main condenser.

2. Each of these condensate pumps is to have a capacity to deal with the maximum designed rate of condensate from the condenser.

504. Piping

1. Where two feed pumps or two condensate pumps are required, these pumps are to be installed such that one pump may continue in operation when the other pump is being opened up for overhaul.

2. The pipe lines connected to boiler feed water or drinking fresh water tanks are to be entirely separate from oil pipe lines or pipe lines for oily water.

3. Boiler feed water pipes are not to be led through tanks which contain oil, nor are oil pipes to be led through boiler feed water tanks.

505. Distilling plant and feed water tank

1. In ships with main boilers, at least one distilling plant with a sufficient capacity is to be provided.

2. All ships with boilers are to be provided with feed water tanks of sufficient capacity.

SECTION 6
Steam and Exhaust Gas Piping

601. Steam piping

1. Piping

(1) In all steam piping systems, provision is to be made for expansion and contraction to take place without unduly straining the pipes.
(2) Water pockets in the steam flow lines are to be avoided as far as practicable in order to prevent water hammer in the system. If this cannot be avoided, drain cocks or valves are to be fitted in such places that the pipes may be efficiently drained while in operation.
(3) Steam pipes are not to be led through cargo spaces without special approval.
(4) If a steam pipe or fitting may receive steam from any source at a higher pressure than that for which it is designed a suitable reducting valve, relief valve and pressure gauge are to be fitted.

2. Steam supply to auxiliary machinery

In ships with two or more boilers, the arrangement of steam piping for auxiliaries is to be such that it is possible to supply steam from at least two boilers to the essential auxiliaries, prime movers thereof and steam whistle.

3. Oil heating pipes

Where steam is used for heating of fuel oil or lubricating oil, the steam drain pipes are to be led to observation tanks in a well-lighted and accessible position in machinery spaces.

602. Exhaust gas piping

1. Exhaust gas pipes for internal combustion engines

(1) Exhaust gas pipes and silencers are to be water cooled or effectively insulated against heat. Silencers are to be so arranged that they may be easily cleaned.
(2) In principle, exhaust gas pipes of two or more engines are not to be connected together. But if the pipes have to be led to a common silencer, effective means are to be arranged to prevent the return of exhaust gases to the cylinders of non-operating engines.
(3) Boiler uptakes and engine exhaust lines are not to be connected, except when specially approved as in the case where the boilers are arranged

to utilize the waste heat from the engines.

(4) Exhaust gas lines led overboard near the water line are to be provided with suitable device to prevent water from being siphoned back to the cylinders.

2. Exhaust gas pipes for boilers

Exhaust gas pipes for boilers are to be complied with **Ch 5, 134. 4**.

SECTION 7
Cooling Water System

701. Main cooling water pumps

1. Cooling water system for the main engines, essential auxiliary engines and various attached coolers are to be provided with main cooling water pump to have sufficient capacity for supplying the cooling water under working condition at the maximum continuous output.

2. In steam turbine ships, adequately installed scoop arrangement may be accepted in place of main cooling water pumps.

3. Main cooling water pumps may be driven either directly by main or auxiliary engines or by independent prime movers.

702. Stand-by cooling water pumps

1. Cooling water system for the main engines, essential auxiliary engines and various attached coolers are to be provided with stand-by cooling water pump in addition to the main cooling water pump to have sufficient capacity for supplying the cooling water under normal service condition.

2. Stand-by cooling water pumps are to be driven by independent prime movers.

3. In ships having steam turbines as their main engines and provided with the scoop arrangement in place of main cooling water pumps, their main condensers are to be so arranged as to be sufficiently cooled with other cooling systems while ships run at low speed, in addition to the cooling system by stand-by cooling water pumps.

4. Where duplicate essential auxiliary engines are provided with exclusive cooling water pump respectively, stand-by cooling water pump need not be provided.

5. Where any suitable independent power driven pump for other purposes is available as a stand-by cooling water pump, this pump may be regarded as a stand-by cooling water pump.

6. Where fresh water is employed for the cooling, the stand-by fresh water cooling pump need not be fitted if there is suitable connections with sea water cooling system.

7. Where two or more main engines are provided, each of them having a built-in main cooling pump, and where it is possible to give a navigable speed even if one of the pumps is out of use, the stand-by cooling pumps may be dispensed with on condition that one complete spare pump is carried on board.

8. In small ship with engines provided with main cooling water pump driven by main engine, stand-by cooling water pump may be omitted.

703. Sea inlets

Sea water cooling systems for the main engine and prime mover driving the essential auxiliaries needed to propel the ship, are to be connected to at least two sea inlets, on opposite sides and close to the ship's bottom.

704. Strainer

Where sea water is used for the direct cooling of the main engine and essential auxiliary engines, the cooling water suction pipes are to be provided with strainers which can be cleaned without interruption to the cooling water supply. In small ship, however, these strainers may be omitted with approval of Society.

705. Using lubricating oil or fuel oil

Where lubricating oil or fuel oil is used for cooling the machinery, the lubricating oil system or fuel oil systems are to be complied with **Sec 8** or **9** respectively.

SECTION 8
Lubricating Oil System

801. Lubricating oil pumps

1. Main engines, propulsion shaftings and their power transmission systems, and auxiliary machinery essential for the propulsion and their prime movers are to be provided with main lubricating oil pumps of sufficient capacity to maintain the supply of oil at the maximum continuous output and stand-by lubricating oil pumps of sufficient capacity to supply oil under normal service condition.

2. The main lubricating oil pumps may be driven either directly by main engines or by independent prime movers. Stand-by lubricating oil pump, however, are to be driven by independent prime movers.

3. A ship having two or more main engines and two or more propeller shaftings with exclusive lubricating oil pumps respectively, is to be provided with stand-by lubricating oil pumps at least one unit in common for each main engine, one unit in common for each propeller shafting and one unit in common for each transmission system.

4. Where duplicate essential auxiliary engines are provided with exclusive lubricating oil pump respectively stand-by pump may be omitted.

5. Where any suitable independent power driven pump for other purposes is available as a stand-by lubricating oil pump, this pump may be regarded as a stand-by lubricating oil pump.

6. For engines having maximum continuous output not exceeding 257 kW [350 PS] with a built-in main lubricating oil pump, a stand-by lubricating oil pump may be omitted with the approval of the Society.

7. Main lubricating oil pumps and their corresponding stand-by lubricating oil pumps are to be easily changed over each other.

802. Piping

1. Lubricating oil pipings are to be entirely separate from other piping system.

2. For ships of 100 m and above in length where a double bottom is used as a lubricating oil sump tank, a stop valve is to be provided between the engine and the lubricating oil sump tank and is to be so arranged as to facilitate its operation from the engine room floor.

803. Lubricating oil filters and purifiers

1. Where forced lubrication system (including gravity supply from head tank) is adopted for lubrication of engines, lubrication oil filters are to be provided.

2. The filters used for the lubricating oil systems of main engine, power transmission of propeller shafting and controllable pitch propeller system are to be capable of being cleaned without stopping the supply of filtered lubricating oil.

3. Lubricating oil purifiers or equally effective filters are to be provided in ships which have internal combustion engines or steam turbines as their main engines.

804. Lubricating oil drain

Metallic drip trays with sufficiently deep coaming are to be provided under lubricating oil pumps, lubricating oil filters, lubricating oil tanks and other lubricating oil appliances which are often opened up for cleaning or adjustment, and leaked oil and/or discharged drain are to be led to lubricating oil drain tanks. If it is impossible to lead them from each drip tray to a lubricating oil drain tank, coaming of each drip tray is to be made deep and every possible means is to be taken to ensure that no drain is left behind at any time.

SECTION 9
Fuel Oil System

901. General

1. Limits of flash point of fuel oil

(1) No fuel oil having a flash point of less than 60 °C is normally to be used for internal combustion engines and boilers. However, fuel oil having a lower flash point of not less than 43 °C may be used for engines driving emergency generators.

(2) Ships certified for restricted service within areas having a climate ensuring that ambient temperatures of spaces where such fuel oil is stored will not rise to within 10°C below its flash point, may use oil fuel with flash point below 60°C but not less than 43°C for internal combustion engines and boilers.

(3) In cargo ships the use of fuel having a flashpoint of less than 43 °C (for example crude oil) may be permitted provided that such fuel oil is not stored in any machinery space and subject to the approval by the Society of the complete installation.

2. Arrangement of fuel oil systems

(1) The compartments in which fuel oil burning systems, fuel oil settling and service tanks, fuel oil purifiers, etc. are located, are to be readily accessible and well ventilated.

(2) The spaces in which pretreatment machinery installations for flammable liquid, such as purifiers, oil heaters are installed are to comply with the following requirements. However, in case where the main components in such system are impracticable to install in a separate room, special consideration is to be paid for the arrangement of the above machinery installations, storage of the leaked oil and the insulation, etc.

(a) The main components in such system are to be placed in a separate room, enclosed by steel bulkheads extending from deck to deck and provided with self-closing steel doors.

(b) Independent mechanical ventilation or a ventilation arrangement which can be isolated from the machinery space ventilation is to be provided.

(c) A fire detection system is to be provided.

(d) A fixed fire extinguishing system is to be provided.

(3) Fuel oil tanks, fuel oil pumps, fuel oil filters,

etc. are not to be located right above or near units of high temperature including boilers, steam pipe lines, exhaust pipe lines, silencers, etc.

(4) The distance of separation between fuel oil tanks and boilers is to be complied with the requirements **Ch 5, 134. 2**.

(5) Fuel oil pipes are to be led, wherever practicable, remote from heated surfaces and electrical appliances, but where this is impracticable, the pipes are to have a minimum number of joints and are to be led in well lighted and readily visible positions.

(6) Valves, cocks and other fittings fitted on fuel oil tanks are to be located in safe positions so as to protect them from the external damage.

(7) All valves or cocks connected to fuel oil system in machinery spaces or boiler spaces are to be capable of being operated from the floor.

3. Fuel oil pipes and their fittings

(1) Fuel oil pipes are to be of steel. Fuel oil pipes intended for the design temperature above 60 °C and the design pressure above 1 MPa are to be seamless steel pipes or pipes fabricated with the approved procedure.

(2) The valves and fittings used for the fuel oil system with a design temperature above 60°C and a design pressure above 1 MPa are to be of not to be less than 1.6 MPa in nominal pressure of Korean Industry Standard or national industry standard. The valves and fittings used for fuel oil transfer piping lines, fuel oil suction piping lines and other low pressure fuel oil piping lines are not to be less than 0.5 MPa in nominal pressure.

(3) Packings for pipe joints are to be both heat and oil resisting and to be as thin as practicable.

(4) Where union joints are used for short pipes connecting fuel oil injection pipes for internal combustion engines or boiler burners, they are to be of specially robust construction and to have metal contact of conical or spherical shape.

(5) Oil fuel lines are to be screened or otherwise suitably protected to avoid as far as parcticable oil spray or oil leakages onto hot surfaces, into machinery air intakes, or other sources of ignition. The number of joints in such piping systems are to be kept to a minimum.

4. Drainage system

(1) Metallic drip trays with sufficiently deep coaming are to be provided under burners, fuel oil pumps, fuel oil filters, fuel oil tanks such as fuel oil settling and service tanks, and other fuel oil appliances which are opened up for cleaning or maintenance.

(2) Fuel oil settling tanks and service tanks are to be provided with drain valves or cocks on their bottoms.

(3) Where drain valves or cocks are fitted to fuel oil tanks, the valves or cocks are to be of self-closing type.

(4) Oil in the drip trays and from drain valves is to be led to suitable oil drain tanks not forming part of an overflow system.

(5) Suitable appliances are to be provided for disposing fuel oil drains stored in the drain tanks.

5. Construction of fuel tanks

Fuel oil tanks which do not form part of ship's structure are to be so constructed that they can be readily inspected and cleaned, and the thickness of plating of the tank is not to be less than 6 mm, but in case of small tanks may be reduced to 3 mm.

6. Tank filling pipes

(1) Filling pipes of fuel oil tanks from outboard are to be of exclusive use and to be led above decks as far as possible, and to be provided with strong covers at their open ends.

(2) Filling pipes of fuel oil tanks except double bottom tanks are to be fitted at or near the top of fuel oil tanks, but, if this is impracticable, non-return valves are to be fitted at the tanks, or alternatively, valves or cocks having remote control devices specified in **Par 7**.

7. Valves for tank suction pipe

(1) All suction pipes from double bottom fuel oil tanks are to be provided with stop valves or cocks which are capable of controlling in engine room.

(2) The suction pipes from all fuel oil tanks, except double bottom fuel oil tanks, are to be provided with stop valves or cocks secured to the tank wall.

(3) Where the valves or cocks prescribed in (2) are provided in the main engine room or boiler room, they are to be capable of being closed directly as well as from a readily accessible position outside the room. Indicators are to be provided at the position of the valves or cocks and at the remote control positions to show whether they are opened or closed. In case of very small tanks, consideration will be given to the omission of remote shutdown devices.

(4) Where valves or cocks of deep oil tanks are provided inside a shaft or pipe tunnel or a similar space, valves on tanks are to be fitted, but control in the event of fire may be effected by means of an additional valve on the pipe or pipes outside the tunnel or similar space. If such additional valve is fitted in machinery space, it is to be fitted as close to the bulkhead as possible and operated from a position outside of this space. However, in case of very small tanks, considerations will be given to the omission of remote control.

(5) Pneumatic remote shut-down devices (of the type that requires compressed air only at the time of closing) of main suction valves of fuel oil tanks are to comply with the following requirements:
(a) an exclusive air bottle for remote shut-down is to be provided in an easily accessible position outside the compartment in which fuel oil tanks are situated.
(b) The capacity of air bottle is to be sufficient for closing all the main suction valves of fuel oil tanks at least three times.
(c) The air bottle is to be provided with a pressure measuring device at a position which can be easily seen from the position where the remote shut-down device is operated.
(d) Air pipes from the air bottle to the main suction valve's actuators are not to be provided with valves except for valves for remote control and blow-off valves for these pipes.
(e) Air pipes from the air bottle to the main suction valve's actuators are to be steel or copper pipes.
(f) Air charging pipes to the air bottle are to be provided with non-return valves.

8. Fuel oil pumps

(1) Stop valves or cocks are to be fitted on both the suction and delivery sides of fuel oil pumps.
(2) All pumps which are capable of developing a pressure exceeding the design pressure of the system are to be provided with relief valves arranged discharge back to the suction side of the pump. However, pressure relief valves may not be fitted when the system is served only by centrifugal pumps, so designed that the pressure delivered can not exceed that for which the piping is designed.
(3) The power supply to the fuel oil transfer pump, fuel oil burning pump, fuel valve cooling oil pump, other similar fuel oil pumps and fuel oil purifiers is to be capable of being stopped from a remote position which will always be accessible in the event of fire taking place in the compartment in which they are situated or its neighbourhood, as well as from the compartment itself.

9. Fuel oil transfer pumps

(1) In ships where a power pump is used for pumping up to the settling and service tanks, at least, two independent power fuel oil pumps are to be provided, and these pumps are to be connected ready for use. In case of small ships, however, a manual pump of proper capacity may be used in lieu of power pump.
(2) Where any suitable fuel oil pump being driven by an independent prime mover for other purposes is available as one of the transfer pumps, this pump may be regarded as a fuel oil transfer pump.

10. Fuel oil piping

(1) Fuel oil piping systems are to be entirely separated from other piping systems as far as practicable. Should it be unavoidable to interconnect to other systems, effective means are to be provided to prevent the accidental contamination with other liquids.
(2) Where it is intended to carry fuel oil and ballast water in the same compartment alternately, the pipes are to be so arranged that the fuel oil can be pumped from any one compartment at the same time as the ballast water is being discharged from any other compartment. Where settling or service tanks are provided, each having a capacity sufficient to permit 12 *hours* normal service without replenishment, the above requirement may be modified.
(3) Pipelines intended for serving the oil fuel tanks are not to pass through the cargo and slop tanks and are to have no connection with pipelines serving the cargo and sloptanks.

11. Fuel oil heaters

(1) Tanks in which fuel oil is heated are to be provided with suitable means for ascertaining the temperature of the oil. Where steam heaters or heaters using other heating media are provided in fuel oil systems, they are to be fitted with at least a high temperature alarm or low flow alarm in addition to a temperature controller, except where the temperature dangerous for the ignition of the medium cannot be reached.
(2) Double bottom tanks and deep tanks are not to be provided with electric heaters, unless approved by the Society.
(3) Electric heaters for heating fuel oil are to comply with the following requirements:
(a) Electric heaters are to be provided with automatic temperature controlling devices.
(b) In order to avoid in any case a surface temperature of heating element of 220°C and above, a safety temperature switch, independent from the automatic control sensor, is to be provided. The safety switches are to cut off the electrical power supply in the event of excessive temperature and are to be provided with manual reset.
(c) Electric heaters are to be adequately protected to avoid any mechanical damage at the time of tank cleaning.
(4) Fuel oil heaters are to be provided with a relief valve on the oil side, the dischage from the relief valves is to be led to a safe position.

12. Oil tanks for galleys

Oil tanks provided for galleys are not to be installed in the galley space and are to be fitted with filling and air pipes of approved construction. Stop valve is to be fitted on the fuel oil supply line at an easily accessible location so that the valve can be readily shut in case of fire in the galley.

13. Fuel oil service tanks

Two fuel oil service tanks for each type of fuel used on board necessary for propulsion and vital systems or equivalent arrangements are to be provided with a capacity of at least 8 hours at maximum continuous rating of the propulsion plant and normal operating load at sea of the generating plant.

902. Burning systems for boiler

1. Burning system

(1) Where the main boiler is provided with the combustion system of pressurized fuel injection type, at least two oil burning units, each unit comprising a burning pump, a suction filter, a discharge filter and a heater, are to be provided, and each unit is to be capable of supplying oil for generating steam of required quantity.

(2) As for essential auxiliary boiler and other boilers to supply steam for fuel oil heating necessary for the operation of the main engine or cargo heating that is required continuously, the burning systems are to be provided in accordance with the requirements in (1) above. However, where the alternative means, such as exhaust gas economizer, heating equipments, etc., are available to ensure the normal navigation and cargo heating with the burning system being out of operation only one unit of burning system will be accepted.

2. Oil feeding by gravity

Where in main boiler or essential auxiliary boiler oil is fed to the burners by gravity, the fuel oil filters are to be capable of being cleaned without stopping the supply of fuel oil.

3. Cold starting

In main or essential auxiliary boiler, a suitable cold starting device which does not require power from the shore is to be provided.

4. Burners

(1) Boiler burners are to be so arranged that they cannot be removed unless the fuel supply is cut off and also that the fuel oil cannot be supplied unless the burners are set correctly.

(2) Boilers designed to use both exhaust gas and fuel oil, are to be provided with devices which will not allow the supply of fuel oil unless the gas in the exhaust gas pipe is cut off.

5. Piping arrangement for fuel oil burning pumps

Fuel oil pipings of burning pumps are not to be connected with other piping lines than those for fuel oil.

6. Automatic combustion systems

Where the automatic control and/or remote control are used with boilers, the burning systems are to be in accordance with the requirements in **Pt 6, Ch 2** in addition to the requirements in this Chapter.

903. Fuel oil supply system of internal combustion engines

1. Fuel oil supply pumps

(1) Where fuel oil supply pumps are required to be provided for internal combustion engines for propulsion and driving auxiliary machinery essential for the propulsion, one stand-by fuel oil supply pump driven by independent power having a sufficient capacity to maintain the supply of fuel under normal service condition is to be provided in addition to the main fuel oil supply pump which has a sufficient capacity for supplying the fuel oil under working condition at the maximum continuous output of the internal combustion engine.

(2) Where any fuel oil pump driven by independent power source intended for other purposes is available as a stand-by fuel oil supply pump, this pump may be regarded as a stand-by fuel oil supply pump.

(3) As for the internal combustion engines driving the auxiliary machinery for important use requiring main and stand-by and where each engine is provided with a fuel oil supply pump, the stand-by fuel oil supply pump may be omitted.

(4) For engines having maximum continuous output not exceeding 370 $kW[500PS]$ with a built-in main fuel oil supply pump, a stand-by fuel oil supply pump may be omitted subject to the approval by the Society.

(5) Main fuel oil supply pumps may be driven by engines or independent power, but stand-by fuel oil supply pumps are to be driven by independent power sources.

(6) Where two or more main propulsion machinery is provided, and where each of them has a built-in main fuel oil supply pump and when it is possible to give a navigable speed even if one of them is out of use, stand-by fuel oil supply pump may be dispensed with on condition that one complete spare pump is carried on board.

2. Fuel oil filters

(1) Fuel oil filters are to be provided on fuel oil supply piping lines for internal combustion engines. These fuel oil filters under pressure for

diesel engines are to be located such that, in the event of oil leakage, they can not be sprayed onto the exhaust manifold.

(2) The filters for internal combustion engines for propulsion are to be capable of being cleaned without stopping the supply of filtered fuel oil.

3. Fuel oil heating devices and fuel oil purifying devices

Where low grade oil is used as fuel oil, suitable fuel oil heating devices and fuel oil purifying devices are to be provided.

SECTION 10
Pneumatic Piping System

1001. Pneumatic starting devices

1. Number and total capacity of main air reservoirs

(1) Where the main engines are arranged for starting by compressed air, at least two starting air reservoirs of about equal capacity are to be fitted. These reservoirs are to be connected ready for use.

(2) The total capacity of compressed air reservoirs for main engine starting is to be sufficient to provide, without being replenished, not less than 12 consecutive starts altering between Ahead and Astern of each main engine of the reversible type, and not less than 6 consecutive starts for installations in which the propeller is reversible without compressed air and for controllable pitch propeller. The number of starts refers to engine in cold and ready to start conditions.

(3) Where the auxiliary engines are designed for starting by compressed air, two separate auxiliary air reservoirs which are to be sufficient for at least three starts for each auxiliary engine when in cold and ready to start conditions are to be fitted, or starting air for auxiliary engines is to be supplied by separate piping from main air reservoirs. In case where only one auxiliary reservoir is fitted, starting air pipes are to be connected with main air reservoir.

(4) Where the auxiliary engines are designed for starting by the main air reservoirs, the capacity of the main air reservoirs is to be more than sum of the capacity required in (2) and (3) above, and the amount consumed for engine control systems, whistle, etc.

(5) For multi-engine installations, the number of starts required for each engine is to be determined as deemed appropriate by the Society.

2. Number and total capacity of air compressors

(1) Where the main engines are designed for starting by compressed air, at least two starting air compressors are to be provided and arranged so as to be able to charge each reservoir.

(2) At least one of them is to be driven by a prime mover other than main engines. Where cylinders are provided with air charging valves by the small engine, the charging valves may be considered as equivalent to an air compressor driven by the main engine.

(3) The total capacity of air compressors is to be sufficient to supply air in the reservoirs from atmospheric pressure to the pressure required for the consecutive starts prescribed in **Par 1** within one *hour*.

3. Emergency air compressors

(1) Where prime movers driving air compressors specified in **Par 2** are arranged for air starting, an independent power driven emergency air compressor is to be provided.

(2) The prime movers driving the emergency air compressor are to be capable of starting without compressed air.

(3) The capacity of the emergency air compressor is to be sufficient to start the prime movers of the air compressor prescribed in **Par 2**. For this purpose, a small air reservoir for emergency air compressor may be provided.

(4) In case of a small installation, a manual air compressor of adequate capacity may be accepted as an emergency air compressor.

4. Arrangement of starting air piping

(1) All discharge pipes from starting air compressors are to be led directly to starting air reservoirs.

(2) All starting pipes from the air reservoirs to main or auxiliary engines are to be entirely separate from the said compressor discharge system.

1002. Construction and safety device

1. Construction and safety device of air compressors

(1) Provision is to be made to the arrangement of air compressor to reduce the entry of oil into compressed air to a minimum.

(2) Air coolers of air compressors are to be so constructed and arranged that they can be easily overhauled for inspection.

(3) Each air compressor is to be provided with a relief valve to prevent that the pressure of cylinder exceeds the design pressure.

2. Construction and safety device of air reservoirs.

(1) Relief devices and other fittings for air reservoirs are to comply with the requirements in **Ch 5, 317**.

(2) Air reservoirs are to be so constructed and arranged that they can be readily opened up for cleaning and inspection, and to be provided with drainage arrangement at a suitable position per-

mitting drain to be effectively blown out under extreme condition of trim.

(3) All air reservoirs are to be provided with pressure gauges at the position where it can be easily seen.

SECTION 11
Refrigerating Machinery

1101. General

1. Application

The requirements in this Section apply to the refrigerating machinery and their piping system used for refrigeration, except for the refrigerating machinery of 7.5 kW [10 PS] or less having R12, R22, $R404a$ or R502 as the primary refrigerants.

2. Related requirements

The design and construction of the pressure vessels and piping systems used for the refrigerating machinery are to comply with the requirements in **Pt 9, Ch 1, 403. 3** and **4**.

3. Location

(1) The refrigerating machinery space is to be effectively ventilated and drained, and separated by gastight bulkheads from the adjacent refrigerated chambers.

(2) The installation of refrigerating machinery using R717(NH_3) as refrigerant is to be in accordance with the requirements of **Pt 9, Ch 1, 402**. However, it may be installed in the machinery compartment for fishing vessels, and in this case, the following requirements are to be complied with.

(a) The compartment is to be provided with an independent mechanical ventilating system which can be operated outside the machinery compartment. In no case should the ventilation system have a capacity of less than 30 changes of air per $hour$ based upon the total volume of the compartment.

(b) At least two sets of breathing apparatus are to be provided and one of them is to be located at a position easily accessible in case of gas leakage.

(c) Where the escape way from the monitoring room or control room is so arranged as to pass the machinery compartment, at least one set of breathing apparatus is to be provided in the monitoring room or control room.

(d) An alarm system for the leakage of refrigerant is to be provided.

1102. Pressure relief valve

1. Compressor

A pressure relief valve or rupture disc is to be provided between compressor cylinder and gas delivery stop valve, the discharge being led to suction side of the compressor. However, chlorofluormethane compressor may be provided with a pressure control switch in lieu of the above safety device.

2. Pressure vessel

Pressure vessels which can become filled with liquid refrigerants and can be isolated are to be provided with relief valves, the discharge being led to a safe place above deck. Relief valves on high pressure parts of primary refrigerants may be arranged to discharge the gas to low pressure parts before relieving to the atmosphere. In this case, the operation of the relief valve is not to be interrupted by back pressure accumulation. Where the discharged gas is led to the atmosphere, the rupture disc or other suitable protections may be provided in series with the relief valve.

3. Condenser

Relief valves are to be provided to the cooling liquid side of condenser and brine side of evaporator except where the pump is so constructed that the pressure does not exceed the maximum working pressure.

SECTION 12
Tests and Inspections

1201. Tests of auxiliary machinery

1. The pressure receiving portions of the essential auxiliary are to be tested to a hydrostatic pressure of 1.5 times the design pressure after having been machine-finished, except where otherwise specified. The test pressure, however, is not to be less than 0.2 MPa.

2. The compressor cylinders and crankcases of the refrigerating machinery subject to the requirements in **Sec 11** are to be tested to hydrostatic pressure of 1.5 times the pressure specified in **Pt 9, Ch 1, 403. 3**, respectively and additionally be subjected to tightness tests for the pressure respectively stipulated in the same Article.

1202. Hydrostatic tests of valves and pipe fittings

1. Valves and pipe fittings belonging to Class I and Class II piping are to be subjected to a hydrostatic test at the pressure of 1.5 times the design pressure. However, the hydrostatic test may be omitted according to the discretion of the Society.

2. Valves, cocks and distance pieces fitted to the ship side below the load waterline are to be subjected to a hydrostatic test at the pressure of 0.5 MPa.

1203. Hydrostatic tests of fuel tanks

Fuel oil tanks with their fittings which do not form part of ship's structure are, after having been constructed, to be tested to a hydrostatic pressure corresponding to a head of water not less than 2.5 m above the top plates. Hydrostatic tests may be replaced by gastight tests at the discretion of the Society.

1204. Tests on workmanship of pipes

1. Welding procedure qualification tests

The manufacturers are to submit the detailed data in connection with the welding work for examination by the Society and also to conduct the welding procedure qualification test specified by the Society where they plan to joint pipes to pipes, pipes to valves or pipes to fittings belonging to Class I and Class II piping system by welding for the first time, or where they adopt a new welding method, and where they change quality of base metals, grade of welding materials or type of joint. But, for minor changes in the welding process, the test may be omitted where approved by the Society.

2. Non-destructive tests

(1) For butt welded joints of Class I pipes with an outer diameter exceeding 65 mm, full radiographic examination is to be carried out.
(2) For butt welded joints of Class I pipes with an outer diameter not exceeding 65mm and of Class II pipes with an outer diameter exceeding 90mm, at least 10% random radiography examination is to be carried out.
(3) More stringent requirements may be applied at the Society's discretion depending on the kinds of materials, welding procedure and controls during the fabrication. An approved ultrasonic testing procedure may be accepted, at the Society's discretion, in lieu of radiography testing when the conditions are such that a comparable level of weld quality is assured.
(4) Fillet welds of flange pipe connections are to be examined by the magnetic particle method or by other appropriate non-destructive methods, in case of Class I pipes. In other cases, magnetic particle examination or equivalent non-destructive testing may be required at the discretion of the Surveyor.
(5) The Society may require other particular testing considering welding procedures or properties of welding consumables.
(6) Radiographic examination methods are to comply with the requirements in **Ch 5, 404. 3** to **5**.
(7) Radiographic and ultrasonic examination are to be performed with an appropriate technique by trained operators. At the request of the Society, complete details of the radiographic and ultrasonic technique are to be submitted for approval.
(8) Magnetic particle examination is to be performed with suitable equipment and procedures, and with a magnetic flux output sufficient for defect detection. The equipment is to be required to be checked using standard samples.

3. Hydrostatic tests

(1) All Class I and II pipes and their associated fittings are to be subjected to a hydrostatic test at the pressure of 1.5 times the design pressure. Further, all steam pipes, feed water pipes, compressed air pipes and fuel oil pipes, together with their fittings, are to be similarly tested where the design pressure is greater than 0.35 MPa. The test is to be carried out after completion of manufacture and before insulating or coating. However, where joints between pipes and valves are welded on board, the hydrostatic test may be omitted provided non-destructive tests deemed appropriate by the Society are carried out.
(2) For steel pipes and intergral fittings having a design temperatures above 300 °C, the test pressure is to be determined by the following formula but need not exceed 2 times the design pressure.

$$P_h = 1.5 \frac{\sigma_{100}}{\sigma} P \quad (MPa)$$

where:

σ_{100} = Allowable stress at 100°C (N/mm^2).
σ = Allowable stress at the design temperature (N/mm^2).
P = Design pressure (MPa).

The value of the test pressure may be reduced to 1.5 times the design pressure, in order to avoid excessive stress in way of bends, T-pieces, etc. In any case the membrane stress is not to exceed 90 % of the specified yield stress at the testing temperature.
(3) When, for technical reasons, it is not possible to carry out complete hydro-testing before assembly on board, for all sections of piping, proposals are to be submitted for approval to the Society for testing the closing lengths of piping, particularly in respect to the closing seams.
(4) When the hydrostatic test of piping is carried out on board, these tests may be carried out in conjunction with the test required **Ch 6, 1205.**
(5) Pressure testing of small bore pipes (less than 15mm) may be waived at the discretion of the

Society depending on the application.

1205. Tests of piping systems on board.

Piping systems are, after installation on board, to be tested in accordance with the following requirements.

(1) All piping systems specified in this Chapter are to be subjected to a leak test at the working conditions.
(2) Fuel oil piping systems and heating coils in tanks are to be subjected to a leak test at the pressure not less than 1.5 times the design pressure but in no case less than 0.4 MPa.
(3) All piping systems are to be tried out together with machinery.
(4) Primary refrigerant piping systems for refrigerating machinery which is subject to the requirements in **Sec 11** are to be subjected to a leak test at 90 % of the design pressure specified in **Pt 9, Ch 1, 403. 3**. ⚓

CHAPTER 7
STEERING GEARS

Section

SECTION 1
General

101. Application

1. The requirements in this Chapter apply to power-driven steering gears. For small ships, however, the requirements in **102., 103., 105., 301. 3** and **410.** may be modified.

2. Manual steering gears are to be of the construction approved by the Society, and to be tested and examined to the satisfaction of the Society.

102. Terminology

The terms used in this Chapter are defined as follows:

(1) **Main steering gear** is the machinery, rudder actuators, steering gear power units, if any, and ancillary equipment and the means of applying torque to the rudder stock (e.g. tiller or quadrant) necessary for effecting movement of the rudder for the purpose of steering the ship under normal service conditions.

(2) **Auxiliary steering gear** is the equipment other than any part of the main steering gear necessary to steer the ship in the event of failure of the main steering gear but not including the tiller, quadrant or components serving the same purpose (hereinafter referred to as "tiller, quadrant, etc.").

(3) **Steering gear power unit** (hereinafter referred to as "**power unit**") is:
(a) in the case of electric gear, an electric motor and its associated electrical equipment;
(b) in the case of electro-hydraulic steering gear, a hydraulic pump, electric motor and its associated electrical equipment; and
(c) in the case of hydraulic steering gear other than those in (b), a hydraulic pump and its driving engine.

(4) **Power actuating system** is the hydraulic equipment provided for supplying power to turn the rudder stock, comprising a power unit or units, together with the associated hydraulic pipes and fittings, and a rudder actuator. The power actuating system may share common mechanical components, i.e., tiller, quadrant, etc.

(5) **Rudder actuator** is the component which converts directly hydraulic pressure into mechanical action to move the rudder.

(6) **Control system** is the equipment by which orders are transmitted from the navigating bridge to the power units. Steering gear control systems comprise transmitters, receivers, hydraulic control pumps and their associated motors, motor controllers, piping and cables.

103. Plans and documents

Plans and documents to be submitted are as follows:

(1) Plans
(a) General arrangements of steering gear
(b) Details of tiller, quadrant, etc.
(c) Assembly and details of power units
(d) Assembly and details of rudder actuators
(e) Piping diagram of hydraulic pipes; Arrangements of control systems
(f) Diagram of hydraulic and electrical systems (including alarm devices and automatic steering gear)
(g) Arrangements and diagram of an alternative source of power
(h) Diagram of a rudder angle indicator

(2) Documents
(a) Particulars
(b) Calculation sheet of the strength of essential parts.
(c) Operating instructions (including plans show-

ing the change-over procedure for power units and control systems, plans showing the sequence of automatic supply of power from an alternative source of power; and the type, particulars and an assembly of the power source in the case that the alternative source of power is an independent source of power)
(d) Manuals for countermeasures to be taken at the time of a single failure of the power actuating system;

104. Display of operating instructions

Simple operating instructions with a block diagram showing the change-over procedures for power units and control systems are to be permanently displayed on the navigating bridge and in the steering gear compartment of a ship equipped with power-operated steering gears.

105. Related requirements

1. The strength of the pressure vessels such as accumulators, etc. used in power actuating systems is to comply with the relevant requirements in **Ch 5** in addition to this Chapter.

2. Hydraulic piping systems used in the power actuating systems are to comply with the relevant requirements in **Ch 6** in addition to this Chapter.

3. Electrical equipment for steering gear are to comply with the relevant requirements in **Pt 6, Ch 1** in addition to this Chapter.

SECTION 2
Performance and Arrangement

201. Number of steering gears

1. Unless expressly provided otherwise, every ship is to be provided with a main steering gear and an auxiliary steering gear. The main steering gear and the auxiliary steering gear are to be so arranged that the failure of one of them will not render the other one inoperative.

2. Where the main steering gear comprises two or more identical power units, the auxiliary steering gear need not be fitted provided that:

(1) The main steering gear is capable of operating the rudder as required **202.** (1) while operating with all power units. In a passenger ship, the main steering gear is capable of operating the rudder as required by **202.** (1) while any one of the power units is out of operation;

(2) The main steering gear is so arranged that after a single failure in its piping system or in one of the power units the defect can be isolated so that steering capability can be maintained or speedily regained. Steering gears other than of the hydraulic type will be considered by the Society in each case.

202. Performance of main steering gear

The main steering gear is to be:

(1) capable of putting the rudder over from 35 *degrees* on one side to 35 *degrees* on the other side with the ship at its load draught and running ahead at the speed specified in **Pt 3, Ch 1, 120**. and, under the same conditions, from 35 *degrees* on either side to 30 *degrees* on the other side in not more than 28 *seconds*;

(2) operated by power where necessary to meet the requirements in (1) and in any case when the diameter of upper rudder stock is required in **Pt 4, Ch 1** to be over 120 *mm* (excluding the additional for strengthening for navigation in ice, the same being referred hereinafter);and

(3) so designed that they will not be damaged at maximum astern speed; however, this design requirement need not be provided by trials at maximum astern speed and maximum rudder angle.

203. Performance of auxiliary steering gear

The auxiliary steering gear is to be:

(1) capable of putting the rudder over from 15 *degrees* on one side to 15 *degrees* on the other side in not more than 60 *seconds* with the ship at its load draught and running ahead at one half of the speed specified in **Pt 3, Ch 1, 120.** or 7 *knots*, whichever is the greater, and capable of being brought speedily into action in an emergency; and

(2) operated by power where necessary to meet the requirement in (1) and in any case when the diameter of upper rudder stock is required in **Pt 4, Ch 1** to be over 230 *mm*.

204. Piping

1. The hydraulic piping system is to be arranged so that transfer between power units can be readily effected.

2. Suitable arrangements to maintain the cleanliness of the hydraulic fluid are to be provided taking into consideration the type and design of the power actuating system.

3. Arrangements for bleeding air from the power actuating system are to be provided where necessary.

4. Relief valves are to be fitted to any part of the hydraulic system which can be isolated and in which pressure can be generated from the power source or from external forces. The setting pressure of the relief valves is not to be less than 1.25 times the maximum working pressure expected in the protected part. The minimum discharge capacity of the relief valves are not to be less than total capacity of pumps which provide power for the actuator, increased by 10%. Under such conditions the rise in pressure is not to exceed 10% of the setting pressure. In this regard, due consideration is to be given to the extreme foreseen ambient conditions in respect of oil viscosity.

5. A low level alarm is to be provided for each hydraulic fluid reservoir to give the earliest practicable indication of hydraulic fluid leakage. This alarm is to be audible and visual and to be given on the navigating bridge and at a position from which the main engine is manually controlled.

6. A fixed storage tank having sufficient capacity to recharge at least one power actuating system including the reservoir, where the main steering gear is operated by hydraulic power. The storage tank is to be permanently connected by piping in such a manner that the hydraulic system, can be readily recharged from a position within the steering gear compartment and is to be provided with a contents gauge.

205. Re-start and power-failure alarm of power units

Main and auxiliary steering gear power units are to be:

(1) arranged to re-start automatically when power is restored after a power failure:and

(2) capable of being brought into operation on the navigation bridge. In the event of a power failure to any one of the power units, an audible and visual alarm is to be given on the navigating bridge.

206. Alternative source of power

Where the diameter of upper rudder stock is required in **Pt 4, Ch. 1** to be over 230*mm*, an alternative source of power supply to steering gears is to be provided in accordance with the following:

(1) The alternative source of power is to be either:
(a) emergency source of electric power; or
(b) independent source of power located in the steering gear compartment and used only for this purpose.

(2) The alternative source of power is to be capable of automatically supplying, within 45 *seconds*, alternative power to the power unit and its associated control system and the rudder angle indicator. In every ship of 10,000 *gross tonnage* and upwards, the alternative source of power is to have a capacity for at least 30 *minutes* of continuous operation of the steering gear and in any other ship for at least 10 *minutes*.

(3) Steering gears operated by the alternative power supply are to be capable of operating the rudder as required by **203.**

(4) The automatic starting arrangement for the generator or the prime mover of the pump used as the independent source of power specified in (1) (b) is to comply with the requirements for starting device and performance in **Pt 6, Ch 1, 1406.**

207. Electrical installations for electric and electro-hydraulic steering gear

1. Cables used in power circuits required to be installed in duplicate by this Chapter are to be separated as far as practicable throughout the length.

2. Means for indicating that the power units are running are to be installed on the navigating bridge and at the position from which the main engine is normally controlled.

3. Each electric or electro-hydraulic steering gear comprising one or more power units is to be served by at least two exclusive circuit fed directly from the main switchboard. However, one of the circuits may be supplied through the emergency switchboard.

4. An auxiliary electric or electro-hydraulic steering gear associated with a main electric or electro-hydraulic steering gear may be connected to one of the circuits supplying this main steering gear. The circuits are to have adequate rating for supplying all motors which can be simultaneously connected to them and may be required to operate simultaneously.

5. Short circuit protection and overload alarm are to be provided for such circuits and motors. The overload alarm is to be both audible and visual and to be situated in a conspicuous position in the place from which the main engine is normally controlled.

6. Protection against excess current including starting current, if provided, is to be for not less than twice the load current of the motor or circuit so protected, and to be arranged to permit the passage of the appropriate starting currents.

7. Where a three-phase supply is used an alarm is to be provided that will indicate failure of any one of the supply phases. The alarm is to be both audible and visual and to be situated in a conspicuous position in the place from which the main engine is normally controlled.

8. When in a ship of less than 1,600 *gross tonnage* an auxiliary steering gear which is required by **203**. to be operated by power is not electrically powered or is powered by an electric motor primarily intended for other services, the main steering gear may be fed by one circuit from the main switchboard. Where such an electric motor primarily intended for other services is arranged to power such an auxiliary steering gear, the requirements in **Pars 5** to **7** may be waived by the Society if satisfied with the protection arrangement together with the requirements in **205.** and **301. 1** (3) applicable to auxiliary steering gear.

208. Position of steering gears

1. The steering gear is to be installed in an enclosed compartment readily accessible and, as far as possible, separated from machinery spaces.

2. The steering gear compartment is to be provided with suitable arrangements to ensure working access to steering gear machinery and controls. These arrangements are to include handrails and gratings or other non-slip surfaces to ensure suitable working conditions in the event of hydraulic fluid leakage.

209. Means of communication

A means of communication is to be provided between the navigating bridge and the steering gear compartment.

210. Rudder angle indicator

The angular position of rudder is to be:

(1) indicated in the navigating bridge. The rudder angle indicator is to be independent of the control system;

(2) recognizable in the steering gear compartment.

SECTION 3
Controls

301. General

1. Steering gear control is to be provided:

(1) for the main steering gear, both on the navigating bridge and in the steering gear compartment;

(2) where the main steering gear is arranged in accordance with the requirements in **201. 2**. by two independent control systems, both operable from the navigating bridge. This does not require duplication of the steering wheel or steering lever. Where the control system consists of a hydraulic telemotor, a second independent system need not be fitted.

(3) for the auxiliary steering gear, in the steering gear compartment and, if power operated, it is also to be operable from the navigating bridge and to be independent of the control system for main steering gear.

2. Any main and auxiliary steering gear control system operable from the navigating bridge is to comply with the following:

(1) If electric, it is to be served by its own separate circuit supplied from a steering gear power circuit from a point within the steering gear compartment, or directly from switchboard busbars supplying that steering gear power circuit at a point on the switchboard adjacent to the supply to the steering gear power circuit.

(2) Means are to be provided in the steering gear compartment for disconnecting any control system operable from the navigating bridge from the steering gear it serves.

(3) The system is to be capable of being brought into operation from a position on the navigating bridge.

(4) In the event of a failure of electrical power supply to the control system, an audible and visual alarm is to be given on the navigating bridge.

(5) Short circuit protection only is to be provided for steering gear control supply circuits.

3. Cables and pipes of control systems required to be in duplicate by this Chapter are to be separated as far as practicable throughout their length.

302. Change-over from automatic to manual steering

The steering gears of a ship provided with an automatic pilot are to be capable of immediate change-over from automatic to manual steering.

SECTION 4
Materials, Constructions and Strength

401. Materials

1. Materials used in the steering gears are to be sound, flawless and adequate for their service conditions.

2. Materials used for cylinders and housings of rudder actuators, pipings subjected to a hydraulic pressure and the components transmitting mechanical forces to the rudder stock are not to have a minimum elongation of less than 12% nor a specified minimum tensile strength in excess of 650 N/mm^2 [66 kgf/mm^2]. This does not apply to the materials for valves and bolts where approved by the Society.

3. Materials used for tillers and quadrants are to be forged steels or cast steels tested in accordance with the requirements in **Pt 2, Ch 1**.

4. Materials used for housings, bosses and vanes of rotary vane type rudder actuators, and cylinders of rudder actuators are to be forged steels, cast steels or nodular graphite cast irons tested in accordance with the requirements in **Pt 2, Ch 1**.

5. Materials used for bolts for assembling split type tillers or quadrants and bolts for securing the vanes to the bosses of rotary vane type rudder actuators are to be forged steels or rolled steels tested in accordance with the requirements in **Pt 2, Ch 1**.

6. Materials used for major parts other than those mentioned in **Pars 3** to **5** are to comply with the requirements in recognized standards.

7. Materials other than those mentioned in **Pars 2** to **6** may be used where approved by the Society.

402. Welds

1. All welded joints of the parts of power actuating systems are to be such that there are no incomplete penetration and other injurious defects.

2. Welded joints in parts subjected to the internal pressure of the power actuating system are to have sufficient strength.

403. General construction of steering gear

1. The steering gears are to be of sufficient strength and reliability.

2. Configurations of major parts of the steering gear are to be determined to avoid local concentration of stress.

3. The design pressure for calculations to determine the scantlings of piping and other steering gear components subjected to internal hydraulic pressure is to be at least 1.25 times the maximum working pressure to be expected under the operational conditions specified in **202. 1** taking into account any pressure which may exist in the low pressure side of the system. The design pressure is not to be less than the relief valve setting pressure.

4. Special consideration is to be given to the suitability of any essential component which is not duplicated. Any such essential component is, where appropriate, to utilize anti-friction bearings such as ball bearings, roller bearings or sleeve bearings which are to be permanently lubricated or provided with lubrication fittings.

5. Where considered necessary, fatigue analysis is to be carried out to the piping and components, taking into account pulsating pressure due to dynamic loads. Both the cases of high cycle and cumulative fatigue are to be considered.

404. Strength of rudder actuators

1. Strength of all components of rudder actuators subjected to an internal pressure, except for the allowable stress specified in this Chapter, is to comply with relevant requirements in **Ch 5**.

2. In the strength calculations specified in **Par 1**, the allowable stress for the equivalent primary general membrane stress is not to be greater than the following values (1) or (2), whichever is the smaller:

(1) $\dfrac{\sigma_B}{A}$

(2) $\dfrac{\sigma_Y}{B}$

where:

σ_B = Specified minimum tensile strength of the material (N/mm^2 [kgf/mm^2]).

σ_Y = Specified minimum yield stress or 0.2% proof stress of the material (N/mm^2 [kgf/mm^2]).

A, B = As given in the following **Table 5.7.1**.

Table 5.7.1 Constants of A and B

	Steel	Cast steel	Nodular cast iron
A	3.5	4	5
B	1.7	2	3

405. Oil seals in rudder actuators

1. Oil seals between non-moving parts, forming part of the external pressure boundary, are to be of the metal upon metal type or of an equivalent type.

2. Oil seals between moving parts, forming part of the external pressure boundary, are to be duplicated, so that the failure of one seal does not render the actuator inoperative. Alternative arrangements providing equivalent protection against leakage will be accepted where approved by the Society.

406. Flexible hoses

Hose assemblies of type approved by the Society and complying with the following requirements may be installed in pipings where flexibility is required.

(1) Hoses are not to be subjected to torsional deflection (twisting) under normal operating conditions.
(2) In general, the hose is to be limited to the length necessary to provide for flexibility and for proper operation of machinery.
(3) Hoses are to be high pressure hydraulic hoses and suitable for the working conditions, i.e. the internal fluids, pressures, temperatures, etc.
(4) Burst pressure of hoses is not to be less than four times the design pressure.

407. Tillers and quadrants

The scantlings of tillers and quadrants of forged steels are to comply with the requirements in the following. The scantlings of those of cast steels will be considered by the Society in each case.

(1) The scantlings of tillers are to comply with the requirements in the following:

(a) The sectional area of each side of the tiller boss about the vertical section at centre of rudder stock is not to be less than that obtained from the following formula:

$$A = 0.4\, d_u^2 \quad (cm^2)$$

where:
d_u = The diameter of upper stock required in **Pt 4, Ch 1** taken as having been calculated for upper rudder stock of mild steel with a yield strength of 235N/mm^2 (i.e. with a material factor K_S = 1)

(b) The section modulus, Z, of arm about the vertical axis is not to be less than that obtained from the following formula:

$$Z = 0.163\left(1 - \frac{r_0}{R}\right) d_u^{\,3} \quad (cm^3)$$

where:
d_u = The diameter of upper stock required in **Pt 4, Ch 1** taken as having been calculated for upper rudder stock of mild steel with a yield strength of 235N/mm^2 (i.e. with a material factor K_S = 1)
r_0 = Distance from the centre of rudder stock to the section (cm).
R = Length of tiller arm measured from the centre of rudder stock to the point of application of the driving force (cm). In case where the length varies in accordance with rudder angle, R is the maximum length within 35 *degrees* of rudder angle.

(c) The standard sectional area of arm at its outer end is obtained from the following formula:

$$A = 0.22\, d_u^2 \quad (cm^2)$$

where
d_u = The diameter of upper stock required in **Pt 4, Ch 1** taken as having been calculated for upper rudder stock of mild steel with a yield strength of 235N/mm^2 (i.e. with a material factor K_S = 1)

(d) In case of tiller having two arms, where power units are connected to each arm and these two power units are driven simultaneously, the scantlings of arms may be suitably modified.

(2) The scantlings of quadrants are to be as required by the following:
(a) Where 3 arms are provided, the scantlings of quadrants are given as follows:
(i) Scantlings of boss
Depth = d_u (cm)
Outside dia. = 1.8d_u (cm)
(ii) Scantlings of arm at its root
Breadth = 0.77d_u (cm)
Thickness = 0.39d_u (cm)
(iii) Scantlings of arm at its outer end
Breadth = 0.52d_u (cm)
Thickness = 0.25d_u (cm)

where:
d_u = The diameter of upper stock required in **Pt 4, Ch 1** (cm).

(b) Where two arms are provided, the breadth and thickness of arms are not to be less than 1.1 times those specified in (a). Where four arms are provided, the breadth and thickness of arms may be reduced to 0.9 times those specified in (a).
(c) Where loose quadrants are used in addition to the tiller fixed to the rudder stocks, arms of loose quadrants may be of the dimensions given in (a) (iii) throughout their length.

(3) Tillers and quadrants are to be of shrinkage fit or bolted to the stock in addition to being secured by a key in any case.

(4) Where tillers or quadrants are bolted on both sides of rudder stock, there are to be at least two bolts on each side of the head. Diameter of the bolts at the bottom of threads is not to be less than that obtained from the following formula. In such a case, the thickness of coupling flange is not to be less than three-fourths of the diameter of the bolts.

$$d = 0.5\sqrt{\frac{d_u^{\,3}}{nb}} \quad (cm)$$

where:
d_u = The diameter of upper stock required in **Pt 4, Ch 1** taken as having been calculated for upper rudder stock of mild steel with a yield strength of 235N/mm^2 (i.e. with a material factor K_S = 1)
n = Number of bolts on each side of the head.
b = Distance from the centre of rudder stock to the centre of bolts (cm).

(5) The scantlings of tillers and quadrants of exclusive auxiliary steering gear system are to have the strength 0.5 times those specified in (1) and (2).

408. Steering chains, rods, blocks, etc.

1. The diameter of unstudded short link chains, d, for steering is not to be less than 9.5mm or that obtained from the following formula, whichever is the greater.

$$d = 0.38\sqrt{\frac{d_u^{\,3}}{R}} \quad (mm)$$

where:
d_u = The diameter of upper stock required in **Pt 4, Ch 1** (mm).
R = The length of tillers or the radius of quadrants measured from the centre of rudder

stock to the centre line of steering chain (*mm*).

2. The diameter of steering rods is to be at least 1.25 times the diameter of steering chains required by the preceding Paragraph.
3. The leading blocks of steering chains are to be as direct as possible and sharp bends are to be avoided.
4. The diameter of leading block sheaves, measured at the centre of chain is not to be less than 16 times the diameter of steering chains. The pins of sheaves are not to be of less diameter than twice that of chains.
5. Where the steering chain is led at an angle less than 120 *degrees*, the sheave and pin are not to be of less diameter than 1.25 times that given by the preceding Paragraph.
6. The frames, base plates, pins and other parts of blocks subjected to shock are not to be of cast iron. The bolts connecting the sheave to the hull are not to have total sectional area less than that obtained from the following formula:

$$A = 2.4\ d_s^2 \qquad (cm^2)$$

where:

d_s = The diameter of steering chains (*mm*).

7. For sheaves intended to be used with ropes, the radius of grooves is to be equal to that of the rope plus 0.8 *mm*, and the diameter of sheave is not to be less than 14 times that of the rope.

409. Stoppers

1. Tillers and quadrants are to be provided with rudder stoppers.
2. Steering gears are to be provided with positive arrangements, such as limit switches, for stopping the gear before the rudder stops are reached. These arrangements are to be synchronized with the gear itself and not with the steering gear control. These arrangements, however, may be operated through a mechanical links such as a floating levers.

410. Buffers

Steering gears other than of hydraulic type are to be provided with spring buffers or other suitable butter arrangements to relieve the gear from shocks given by the rudder.

SECTION 5
Testing

501. Shop tests

1. Pressure vessels and piping systems are to be subjected to tests in accordance with the requirements in **Chs 5** and **6**, in addition to the tests specified in this Section.
2. All pressure parts are to be subjected to pressure tests with a pressure equal to 1.5 times the design pressure.
3. Each type of pumps used as a power unit is to be subjected to a running test for a duration of not less than 100 *hours*. The test arrangements are to be such that the pump may run in idle condition, and at maximum delivery capacity at maximum working pressure. The passage from one condition to another is to occur at least as quickly as on board. During the test, idling periods are to be alternated with periods at maximum delivery capacity at maximum working pressure. During the whole test no abnormal heating, excessive vibration or other irregularities are permitted. After the test, the pump is to be disassembled to ascertain that there is no abnormality. The test may be waived for a power unit which has been proved to be reliable in marine service.

502. Testing after installation

1. Hydraulic piping systems are after installed on board to be subjected to a leak test at a pressure at least equal to the maximum working pressure.
2. The steering gear is after installed on board to be subjected to the running test.

503. Sea trials

The steering gears are to be subjected to the following tests during sea trials. However, the tests required in (4), (7) and (8) may be carried out at the time when a vessel is being anchored or at dockside.

(1) Tests on the steering capabilities specified in **202**. and **203**. For controllable pitch propellers, the propeller pitch is to be at the maximum design pitch approved for number of maximum continuous ahead revolution at the main steering gear trial. If the ship cannot be tested at the load draught, alternative trial draught conditions will be specially considered. In this case for the main steering gear trial, the speed of ship corresponding to the number of maximum continuous revolution of main engine is to apply.

(2) Running tests of the power units, including transfer between power units.

(3) Tests on the isolation of one power actuating system, checking the time for regaining steering capability.
(4) Tests on the hydraulic fluid recharging system.
(5) Tests on the emergency power supply required by **206**.
(6) the steering gear controls, including transfer of control and local control
(7) Tests on the means of communication between the navigating bridge and the steering gear compartment.
(8) Tests on the functioning of indicators for the alarms, rudder angle indicator and power units.

SECTION 6
Additional Requirements Concerning Tankers of 10,000 Gross Tonnage and Upwards and Other Ships of 70,000 Gross Tonnage and Upwards

601. Main steering gears

1. In every oil tanker, ships carrying liquefied gases or dangerous chemicals in bulk (hereinafter referred to as "**tankers**" in this Section) of 10,000 *gross tonnage* and upwards and in every other ship of 70,000 *gross tonnage* and upwards, the main steering gear is to comprise two or more equivalent power units complying with the requirements in **201. 2**.

2. The steering gear in every tanker of 10,000 *gross tonnage* and upwards is to comply with the following:

(1) The main steering gear is to be so arranged that in the event of loss of steering capability due to a single failure in any part of one of the power actuating system of the main steering gear, excluding failure in the tiller or quadrant and seizure in the rudder actuator, steering capability is to be regained in not more than 45 *seconds* after the loss of one power actuating system.
(2) The main steering gear is to comprise either:
(a) Two independent and separate power actuating systems, each capable of meeting the requirements in **202. 1**; or
(b) at least two equivalent power actuating systems which, acting simultaneously in normal operation, are to be capable of meeting the requirements in **202. 1**. In this case, the following requirements of (i) and (ii) are also to be met:
(i) Loss of hydraulic fluid from one system is to be capable of being detected and the defective system automatically isolated so that the other actuating system or systems are to remain fully operational.
(ii) Where necessary to obtain steering capability, interconnection of hydraulic power actuating systems is to be provided.
(3) Steering gears other than of the hydraulic type will be considered by the Society in each case.

602. Controls

In the case of tankers of 10,000 *gross tonnage* or upwards, the modification for the hydraulic telemotor permitted in **301. 1** (2) is not to be applied.

603. Number and strength of rudder actuators

1. For tankers of 10,000 *gross tonnage* and upwards, but of less than 100,000 *tons deadweight*, a single rudder actuator may be permitted provided that:

(1) Following loss of steering capability due to a single failure of any part of the piping system or in one of the power units, steering capability is to be regained within 45 *seconds*;
(2) Special consideration is to be given to stress analysis for the design including fatigue analysis and fracture mechanics analysis, as appropriate, to the material used, to the installation of sealing arrangements and to testing and inspection and to the provision of effective maintenance. In this case, the high cycle fatigue and cumulative fatigue are to be considered.
(3) Isolating valves are to be directly mounted on the rudder actuator so as to isolate the rudder actuator from the hydraulic oil in the piping systems; and
(4) Relief valves for protecting the rudder actuator against overpressure as required in **204. 4** are to be provided.

2. For tankers of 10,000 *gross tonnage* and upwards, but less than 100,000 *tons deadweight* and equipped with a single rudder actuator, the strength of the rudder actuator is to comply with the following requirements in addition to those of **404**.

(1) A detailed calculation of the major parts of the rudder actuator is to be carried out to confirm their strength.
(2) A detailed stress analysis of the parts of rudder actuators subject to hydraulic pressure is to be carried out to confirm the strength sufficient to withstand the design pressure.
(3) Where considered necessary because of the design complexity or manufacturing procedures, a fatigue analysis and fracture mechanics analysis are to be carried out. In this case, the high cycle fatigue and cumulative fatigue are to be considered. In connection with these analyses, all foreseen dynamic loads are to be taken into account. Where considered necessary by the Society, experimental stress analysis may be required in addition to, or in lieu of, theoretical calculations.
(4) For the purpose of determining the general scantlings of parts of rudder actuators subject to internal hydraulic pressure, the allowable stresses are to comply with:

(a) $\sigma_m \leqq f$
(b) $\sigma_l \leqq 1.5f$
(c) $\sigma_b \leqq 1.5f$
(d) $\sigma_l + \sigma_b \leqq 1.5f$
(e) $\sigma_m + \sigma_b \leqq 1.5f$

where:
σ_m = Equivalent primary general membrane stress (N/mm^2 [kgf/mm^2]).
σ_l = Equivalent primary local membrane stress (N/mm^2 [kgf/mm^2]).
σ_b = Equivalent primary bending stress (N/mm^2 [kgf/mm^2]).
f = Lesser of σ_B / A or σ_Y / B
σ_B = Specified minimum tensile strength of material (N/mm^2 [kgf/mm^2]).
σ_Y = Specified minimum yield stress or 0.2% proof stress of material (N/mm^2 [kgf/mm^2]).
A, B = As given in the following Table.

	Rolled or forged steel	Cast steel	Nodular cast iron
A	4	4.6	5.8
B	2	2.3	3.5

(5) Where the parts of rudder actuators subject to hydraulic pressure are subjected to a burst test at the minimum bursting pressure specified below and they are confirmed to withstand this test, the detailed stress analysis required by (2) may be omitted. Where, however, considered necessary because of the design complexity or manufacturing procedures, the detailed stress analysis required by (2) is to be carried out notwithstanding the above.

$$P_b = P \cdot A \frac{\sigma_{Ba}}{\sigma_B} \quad (MPa)$$

where:
P_b = Minimum bursting pressure (MPa).
P = Design pressure (MPa).
A = As given in (4)
σ_{Ba} = Actual tensile strength of the material (N/mm^2).
σ_B = Specified minimum tensile strength of the material (N/mm^2).

604. Non-destructive tests

For tankers of 10,000 *gross tonnage* and upwards, but less than 100,000 *tons deadweight* and equipped with a single rudder actuator, the rudder actuator is to be subjected to suitable and complete non-destructive testing to detect both surface flaw and volumetric flaws. The procedure and acceptance criteria for the non-destructive testing will be considered by the Society in each case. Where considered necessary, fracture mechanics analysis is to be used for determining maximum allowable flaw size. ⚓

CHAPTER 8
WINDLASSES AND MOORING WINCHES

SECTION 1
General

101. Appliction

1. The requirements in this Chapter apply to electric driven, steam reciprocating engine driven or hydraulic driven windlasses and mooring winches. The requirements of windlasses and mooring winches manually operated as the main driving power are to be to the satisfaction of the Society.

2. In addition to complying with the requirements in this Chapter, those are to be applied with appropriate modifications respectively such as follows: For power transmission gears, **Ch 3**; For pressure vessels and hydraulic pumps, **Ch 5**; For piping arrangements, **Ch 6**.

102. Plans and documents

Plans and documents to be submitted are as follows:

(1) Plans
   (a) Geneal arrangement
   (b) Sectional drawings
   (c) Diagram of steam and hydraulic systems
   (d) Diagram of electric systems and arrangement of control systems
   (e) Detail drawings of gears and driving shafts of power transmission gears
(2) Documents
   (a) Particulars for major parts
   (b) Particulars for material of power transmission parts
   (c) Calculation sheet for the strength of major parts

103. Materials

Materials used in the major parts are to be of steel forgings, steel castings or equivalent thereto.

SECTION 2
Windlasses

201. Definitions

1. The working load, derived from the nominal diameter and the grade of anchor chain cables, is the tensile force exerted upon the cable lifter in the tangential direction when the anchor and anchor chain cable are being hoisted.

2. The overload pull is the necessary temporary overload capacity of the windlass.

3. The holding load is the maximum static load on the anchor chain cables which the cable lifter brake should withstand.

4. Nominal speed is the average speed of recovery of 55m(two lengths) of anchor chain cables when 82.5m(three lengths) of the cables are submerged and freely suspended at commencement of lifting.

5. The breaking test load of the anchor chain cables is the minimum breaking test load specified in **Pt 4**, **Table 4.8.6**.

202. Design, construction and equipment

1. Type of drive

The drive of windlasses with two cable lifters is to be of the type capable of hauling up both anchors simultaneously.

2. Strength

(1) The parts for the windlass proper such as the bedplate, cable lifter, cable lifter shaft, bearing frame, brake gear, holding down bolt, etc. are to have such strength that the stress on these parts is below the yield points of the materials when sustaining the holding load on the cable lifter specified in **Table 5.8.1**.
(2) The driving section of windlass is to have such strength that the stress on each part is below 40% of the yield points of the materials used when the working load specified **203. 1.** is applied.

Table 5.8.1

Division of chian cable stopper	Holding load
with chain cable stopper	B.T.L × 0.45
without chain cable stopper	B.T.L × 0.8
Note : B.T.L. ; Breaking test load of anchor chain cable	

3. Construction and equipment

(1) Construction

(A) The windlasses are to be so designed as to ensure smooth operation of the components in consideration of impact such as waves. The closed portions of the windlass installed on exposed decks are to have suitable watertight construction.

(B) The cable lifters are to be provided with 5 teeth at minimum, and the revolution speed of the anchor chain cable lifter is to be controllable.

(2) Equipment

(A) Protective devices and safety devices

Prime movers and gearing are to be provided with protective devices and safety devices against excessive torque and shock as follows;

(a) Overpressure preventive devices for hydrulic equipment

(b) Slipping clutches between electric motor and reduction gear

(c) Protective devices for the electric motor against overload

(d) Covers for open gear

(B) Clutches

Windlasses are to be fitted with clutches between the cable lifter and the driving shaft. Power operated cluches are to be declutchable by hand.

(C) Brake systems

(i) Electric windlasses are to be provided with an automatic control brake system which operates when the control handle is in the "Off" position or when the power supply is cut off. The automatic breaking system is to be capable of sustaining 130% of the working load.

(ii) Each cable lifters are to be fitted with a hand-brake. Where the hand-brake is capable of controlling remotely, a quick acting local emergency stop mechanism is to be provided.

(D) Emergency stop mechanism

Each remotely controlled windlass is to be fitted with a quick acting local emergency stop mechanism.

203. Performance

1. Depending on the grade of the chain cable, windlasses are to be capable of exerting the working load specified in **Table 5.8.2** at a rated speed at least 0.15 m/s.

Table 5.8.2 Working Load

Kind of chain cable	Working load (N)
Grade 1 chain	$37.5\,d^2$
Grade 2 chain	$42.5\,d^2$
Grade 3 chain	$47.5\,d^2$
NOTES: 1. d is the diameter of chain cable (mm). 2. Studless chain cables are to be to the satisfaction of the Society.	

2. The windlasses are to be capable of continuous operation for a period of 30 minutes under the working load specified in **1.** and be capable of operating under the overload for a period of 2 minutes at a correspondingly reduced lifting speed.

204. Tests and Inspections

Windlasses are to be carried out following tests after construction, which are in accordance with the procedures as deemed appropriate by the Society.

(1) No load test
(2) Load test
(3) Brake test

SECTION 3
Mooring Winches

301. Definitions

1. Drum load is the maximum rope tention, measured at the drum exit, when the winch is hoisting or hauling at nominal speed with the rope wound on the drum in a single layer.

2. Holding load is the maximum rope tension that can be maintained by a braking system in the first layer.

3. Stalling load is the maximum rope tension, measured at the drum exit when the drum ceases to rotate in the direction of haul, the prime mover being set for maximum torque and rope being wound on the drum in a single layer.

4. Recovery load is the maximum rope tension, measured at the drum exit when the drum commences to rotate in the direction of haul, the prime mover being set for maximum torque under automatic control and the rope being wound on the drum in a single layer.

5. Rendering load is the maximum rope tension, measured at the drum exit when the drum just commences to rotate in the opposite direction to the applied driving torque, the prime mover being set for maximum torque in automatic control, with the rope wound on the drum in a single layer.

6. Nominal speed is the maximum speed that can be maintained by the winch when it is applying the drum load.

7. Light line speed is the maximum rope speed that the winch can be maintained with the rope wound on the drum in a single layer, and negligible tension on the rope.

8. Creep speed is the maximum uniform speed, measured on the first layer, that the winch can maintain under drum load.

302. Design, construction and equipment

1. Prime mover

(1) The prime mover is to be capable of controlling its rotation and speed for both hauling direction and veering direction of the rope.
(2) The prime mover is to be capable of being operated at the nominal speed, light line speed and creep speed.
(3) The prime mover is to be capable of being used continuously for 30 minutes under the drum load.
(4) The prime mover is to provided with protective devices neccesary for preventing its damage due to an overload exeeding the drum load.

2. Strength

(1) The stress created in each part of the winch is not to exceed 0.4 times the yield point or 0.2% proof stress of the material.
(2) The stress created in associated components of the winch under maximum output torque of the prime mover is not to exceed 0.9 times the yield point or 0.2% proof stress of the material.
(3) The stress created in the brake system, bearing frame, bed plate, drum shaft, anchor bolts and other components forming the main member of the main drum and winch under holding load is not to exceed 0.9 times the yield point or 0.2% proof stress of the material.

3. Construction and equipment

(1) Construction
(a) The winch is to be designed as to ensure impacts of wind and waves and to ensure smooth operation of the components in consideration of impact such as waves.
(b) The drum is to be provided with a brake and is to be declutchable from the prime mover by clutch. The closed portion of the winch installed on exposed decks is to be have suitable watertight construction.
(2) Safety devices and protections
The winch is to be provided with the following safety devices and protections.
(a) Pressure relieving device of the hydraulic system (only applicable to the case of hydraulic drive)
(b) Overload protections for electric motor in operation (only applicable to the case of electric motor drive)
(c) Automatic brake (only applicable to the case of electric motor drive)
(d) Protection covers of gears
(e) Automatic neutralizing mechanism of manual control handle or lever for controlling prime mover

303. Performance

1. The drum load is not to be greater than 0.33 times the breaking load of the rope when operating at the corresponding nominal speeds.

2. The holding load is to be not less than 0.8 times the breaking load of the rope.

3. The recovery load is to be not less than 0.5 times the drum load.

4. The rendering load is to be not more than 0.5 times the breaking load of the rope.

5. The light line speed, measured on the first layer on the drum, is to be not less than 2.0 times the nominal speed.

6. The creep speed is to be not more than 0.5 times the nominal speed.

304. Tests and Inspections

Mooring winches are to be carried out following tests after construction, which are in accordance with the procedures as deemed appropriate by the Society.

(1) No load test
(2) Load test
(3) Holding load test
(4) Automatic control brake test
(5) Automatic tension control test ⚓

PART J

ELECTRICAL

CHAPTER 1
ELECTRICAL EQUIPMENT

SECTION 1
General

101. General

1. Application

(1) The requirements of this Chapter apply to the electrical equipment and electric propulsion machinery intended for ships without special limitations for their service or purpose. For electrical equipment and electric propulsion machinery intended for ships with special limitations for their service or purpose and intended for small ships of less than 500 *ton gross tonnage*, the requirements in this Chapter may be modified within an extent considered appropriate by this Society.
(2) Except where a specific statement is made to the contrary, all requirements specified in this chapter are equally applicable to A.C. and D.C. installations.
(3) When the Society considers necessary, requirements specified in international electrical standards may apply.

2. Special electrical equipment

Electrical equipment and electric propulsion machinery not specified in this Chapter are to be as deemed appropriate by the Society.

3. Passenger ships

The electrical equipment of passenger ships engaged on international voyages is to comply with the requirements in this Part and in addition, attention is to be paid to compliance with the requirements of passenger ships specified in the International Convention for the Safety of Life at Sea (hereinafter referred to as the "SOLAS Convention").

4. Terminology

Terms used in this Chapter are as follows:

(1) **Dangerous spaces** are the tanks or pump rooms which contain flammable liquid or flammable high pressure gases and other places where flammable liquid or flammable high pressure gases are likely to be leaked or accumulated.
(2) **Selective tripping** is such an arrangement that only the protective device nearest to a fault point is opened automatically in order to maintain the power supply to the rests of sound circuits, in the event of a fault in the circuit having protective devices connected in series.
(3) **Preference tripping** is such an arrangement that the protective devices for unimportant circuits are opened automatically in order to ensure the power supply for vital services, when any one generator becomes overloaded or likely.
(4) **Normal operational and habitable condition** is a condition under which the ship as a whole, the machinery, services, means and aids ensuring propulsion, ability to steer, safe navigation, fire and flooding safety, internal and external communication and signals, means of escape, and emergency boat winches, as well as the designed comfortable conditions of habitability are in working order and functioning normally.
(5) **Emergency condition** is a condition under which any services needed for normal opera-

tional and habitable conditions are not in working order due to failure of the main source of electrical power.

(6) **Main source of electrical power** is a source intended to supply electrical power to the main switchboard for distribution to all services necessary for maintaining the ship in normal operational and habitable conditions.

(7) **Main generating station** is the space in which the main source of electrical power is situated.

(8) **Main switchboard** is a switchboard which is directly supplied by the main source of electrical power and is intended to distribute electrical energy to the ship's services.

(9) **Emergency source of electrical power** is a source of electrical power, intended to supply the emergency switchboard in the event of failure of the supply from the main source of electrical power.

(10) **Emergency switchboard** is a switchboard which in the event of failure of the main electrical power supply system is dierctly supplied by the emergency source of electrical power or the transitional source of emergency power and is intended to distribute electrical energy to the emergency services.

102. Drawings and data

The drawings and data to be submitted for approval before the commencement of work are generally as follows:

1. Drawings and data to be submitted by the shipyard

(1) Investigation table of electrical load analysis (including main and emergency sources)
(2) Wiring diagram for power systems (including emergency source)
(3) Wiring diagram for lighting systems (imcluding emergency lightings)
(4) Wiring diagram for control systems
(5) Wiring diagram for navigation and communication systems
(6) Wiring diagram for radio systems
(7) Wiring diagram for fire detection and alam systems
(8) General arrangement for electrical systems (bridge, radio room, accommodation space, engine room, all decks, etc.)
(9) Arrangemect for navigation and signal lights
(10) Drawings indicating dangerous spaces (if necessary)
(11) Drawings of measuring equipmect for cargo tanks (if necessary)
(12) List of particulars of high voltage electrical equipment (if necessary)
(13) Calculation sheets of short-circuit current in the circuits (if necessary)
(14) Drawings and data as deemed necessary by the Society (in case of special construction ships)

2. Drawings and data to be submitted by the manufacturers of electrical equipment

(1) Manufacturing drawings for generators of 100 kVA and above and motors of 100 kW and above
(2) Drawings of main and emergency switchboard (including battery charging and discharging board)
(3) Drawings of control panel in bridge
(4) Drawings of control panel in engine room
(5) Drawings of remote control system (for main engine, generator and boiler)
(6) Manufacturing drawings for alarm and control system (including list of alarm points)
(7) Drawings of explosion-proof electrical equipment
(8) Drawings and data as deemed necessary by the Society (in case of special equipment)

103. Construction and installation

1. Construction

Electrical equipment is to be so constructed as to provide easy accessibility to all parts requiring inspection, overhaul and repair.

2. Protection against corrosion

(1) Bolts, nuts, pins, screws, terminals, studs, springs and such other small parts are to be made of corrosion resistant materials or those suitably protected against corrosion.
(2) If electrical fittings, not of aluminium, are attached to aluminium, suitable means are to be taken to prevent corrosion.

3. Protection against electrical shock

(1) Where the operators are liable to inadvertently touch the live part of electrical apparatus due to ship's inclination and vibration, such parts are to be protected with suitable means to prevent electrical shock.
(2) The moving parts, reciprocating parts, high temperature parts or charged parts of electrical equipment are to be provided with suitable protections for one who watches, operates or approaches the equipment to avoid injury.
(3) To minimize shock from high-frequency voltage induced by the radio transmitter, handles, handrails, etc. of metal on the bridge or upper decks are to be in good electrical connection with the hull or superstructure.

4. Installation of propulsion machines

Means are to be provided to prevent the accumulation of bilge under propulsion machines (generators, motor-generators, motors, electro-magnetic slip couplings).

5. Installation and protective enclosure

Electrical equipment is to be accessibly placed in well ventilated and adequately lighted spaces in which inflammable gases cannot accumulate and where it is not exposed to the risk of mechanical injuries or damage from water, steam or oil, and is to be so installed that space is available for maintenance. Where, however, electrical equipment are unavoidably installed in spaces not fulfilled the above conditions, they are to be of the following construction.

(1) Drip-proof construction where water drip and oil are liable to drop.
(2) Water-proof construction where installed on exposed decks liable to get wet by sea water, rain or bilge water.
(3) Submersible construction where employed in water.
(4) Explosion-proof construction where explosive or inflammable materials are stored or liable to accumulate.

6. Insulating materials and insulated windings

Insulating materials and insulated windings are to be of resisting quality against moisture, sea air and oil vapour.

7. Power source control switches

Electrical equipment is not to remain alive through the control circuits or pilot lamps when switched off by the control switch.

8. Mechanical lock

All nuts and screws used in connection with current carrying parts and working parts are to be effectively locked.

9. Consideration of magnetic compass

Electrical equipment and cables are to be placed at such a distance from the magnetic compasses that the interfering external magnetic field is negligible, even when circuits are switched on and off.

104. Earthing of electrical equipment

1. Fixed electrical equipment

All accessible non-current-carrying metal parts of fixed electrical equipment are to be effectively earthed. Where earthing connections are necessary, the sectional area of the earthing conductor is not to be less than a half of the cross sectional area of the current-carrying conductor with a minimum of 1.5 mm^2, but need not exceed 70 mm^2.

2. Exposed metal parts of electrical machines or equipment which are not intended to be live but which are liable under fault conditions to become live are to be earthed unless the machines or equipment are:

(1) supplied at a voltage not exceeding 50 V $D.C.$ or 50 V $A.C.$, root mean square between conductors; auto-transformers are not to be used for the purpose of achieving this voltage; or
(2) supplied at a voltage not exceeding 250 V by safety isolating transformers supplying only one consuming device; or
(3) constructed in accordance with the principle of double insulation.

3. Additional safety means are to be provided for portable electrical apparatus for use in confined or exceptionally damp spaces where particular risks due to conductivity exist.

105. System of supply

The following systems of supply are considered as standard:

(1) Two-wire for direct current.
(2) Three-wire for direct current (three-wire insulated system or three-wire mid-wire earthed system).
(3) Single phase two-wire for alternating current.
(4) Three phase three-wire for alternating current.
(5) Three phase four-wire for alternating current.

106. Voltage and frequency

1. Supply voltage

Supply voltage is not to exceed:

(1) 500 V for cooking and heating equipment permanently connected to fixed wiring.
(2) 11,000 V $A.C.$ for electric propulsion equipment.
1,500 V $D.C.$ for electric propulsion equipment.
(3) 11,000 V $A.C.$ for generators and power equipment.
500 V $D.C.$ for generators and power equipment.
(4) 250 V for lighting, heaters in cabins and public rooms and other applications not mentioned (1), (2) and (3) above.

2. Standard frequency

Frequency of 60 Hz is recognized as a standard.

3. Voltage and frequency variations

All electrical appliances supplied from the main or emergency systems are to be so designed and manufactured that they are capable of operating satisfactorily under the normally occurring variations in voltage and frequency. Unless otherwise specified electrical equipment is to operate satisfactorily with the variations from its rated value shown in **Table 6.1.1.** Any special systems, e.g. electronic circuits, whose function cannot operate satisfactorily within the limits shown in **Table 6.1.1** is not to be supplied directly from the system but by alternative

Table 6.1.1 Voltage and Frequency Variations

Type of variations	Variations	
	Permanent	Transient
Frequency	± 5 %	± 10 % (5 sec)
Voltage	+ 6 %, − 10 %	± 20 % (1.5 sec)
NOTE: This Table do not apply to battery systems.		

means, e.g. through stabilized supply.

107. Ambient conditions

1. The ambient conditions given in **Table 5.1.2** and **Table 5.1.3** in **Pt 5, Ch 1** are to be applied unless otherwise specified, to the design, selection and arrangement of electrical installations as to ensure proper operation.

2. The operation of all electrical equipment is to be sufficient under such conditions of vibration as to arise in normal practice.

108. Clearance and creepage

1. The clearances and creepages between live parts and between live part and earthed metal (hereinafter to be called the “clearance and creepage”) are to be adequate for the working voltage having regard to the nature and service condition of the insulating material.

2. The clearance and creepage for the inside terminal box of rotating machinery, the switchboard busbar and the controlling equipment, etc. are to conform to the values as required in each relevant Section in this Chapter.

109. Testing and inspection

1. General

(1) The following electrical equipment for essential service is to be tested, in principle, in accordance with relevant requirements of this Chapter at the manufacturer’s works.
(A) Propulsion machines and their control gears.
(B) Generators, motors, and their spare armatures, stators and rotors.
(C) Control gears for motors.
(D) Switchboards.
(E) Transformers for power and lighting.
(F) Power semi-conductor rectifiers and their accessories.

(2) The following electrical appliances and cables are to be tested according to the test methods approved by the Society before being taken into use.
(A) Fuses
(B) Circuit-breakers
(C) Electro-magnetic contactors
(D) Explosion-proof electrical equipment
(E) Cables

2. Inspections based on Quality Assurance Scheme

Where the electrical equipment is manufactured by Quality Assurance Scheme specified in Guidance for Approval of Manufacturing Process and Type Approval, a part or all of the tests may be omitted.

3. Trials

Electrical equipment and cables, after installation on board the ship, are to be tested and inspected in accordance with the requirements in **Sec 18.**

4. Additional tests and inspections

The Society may require, when it deems necessary, other tests and inspections than those specified in this Chapter.

5. Exemption from tests and inspections

Electrical equipment having the certificate considered acceptable by the Society may be exempted partially or wholly from the tests and inspections.

6. Type approval

For the electrical appliances and cables listed in **1** (2), the Society may excute the type tests upon request from the manufacturers. When the test results are satisfactory to the Society, type approval will be given to them by the Society.

7. Tests and inspections on type approved products

(1) The electrical appliances and cables having been type approved by the Society may be exempted partially or wholly from the tests and inspections.

(2) The manufacturers producing the type approved products are to, by itself, carry out the tests and inspections on them according to the approved methods. The Society may require for the manufacturers to submit the results of the tests and inspections done by itself, when it is considered necessary.

SECTION 2
Rotating Machinery

201. General

1. Requirements of electrical installation

(1) All electrical auxiliary services necessary for maintaining the ship in normal operational and habitable conditions will be ensured without recourse to the emergency source of electrical power.

(2) Electrical services essential for safety will be ensured under various emergency conditions.

(3) The safety of crew and ship from electrical hazards will be ensured.

2. Main source of electrical power

(1) A main source of electrical power of sufficient capacity to supply all those services mentioned in **1** (1) is to provided. This main source of electrical power is to consist of at least two generating sets.

(2) The capacity of these generating sets is to be such that in the event of any one generating set being stopped it will still be possible to supply those services necessary to provide nor-

mal operational conditions of propulsion and safety. Minimum comfortable conditions of habitability is also to be ensured which include at least adequate services for cooking, heating, domestic refrigeration, mechanical ventilation, sanitary and fresh water.

(3) The arrangements of the ship's main source of electrical power are to be such that the services referred to in **1** (1) can be maintained regardless of the speed and direction of the propulsion machinery or shafting.

(4) In addition, the generating sets are to be such as to ensure that with any one generator or its primary source of power out of operation, the remaining generating sets are to be capable of providing the electrical services necessary to start the main propulsion plant from a dead ship condition. The emergency source of electrical power may be used for the purpose of starting from a dead ship condition if its capability either alone or combined with that of any other source of electrial power is sufficient to provide at the same time those services required to be supplied by **1402. 2** (1) to (5).

(5) Where the main source of electrical power is necessary for propulsion and steering of the ship, the system is to be so arranged that the electrical supply to equipment necessary for propulsion and steering and to ensure safety of the ship will be maintained or immediately restored in the case of loss of any one of the generators in service. and load shedding or other equivalent arrangements is to be provided to protect the generators required by this regulation against sustained overload.

3. Fault current

Ship's service generators are to be capable of withstanding the mechanical and thermal effects of fault current for the duration of any time delay which may be fitted in a tripping device for discrimination purposes.

4. Clearance and creepage inside terminal box

The clearance and creepage for the inside terminal box of rotating machine are not to be less than as required **Table 6.1.2.** However, the requirements in the above are not applied to small motors such as controlling motors, self synchronous motors, etc. and also not applied when an insulating barrier is used.

Table 6.1.2 Minimum Clearance and Creepage inside the Terminal Box of Rotating Machine

Rated voltage (V)	Clearance (mm)	Creepage (mm)
61 ~ 250	5	8
251 ~ 380	6	10
381 ~ 500	8	12

5. Air coolers and means of prevention of moisture condensation

(1) Where air coolers are provided for rotating machines they are so arranged as to prevent the possibility of water into the machines by leakage or condensation in the air coolers.

(2) Where there is fear of deterioration of insulations by moisture condensation within rotating machines, it is to be provided with means to prevent it.

202. Prime movers for generators

1. Application

Prime movers are to be constructed in accordance with the following requirements in addition to the requirements of the applicable Chapters of the Rules.

2. Governors

Governors on prime movers driving main or emergency electric generators are to be capable of automatically maintaining the speed within the following limits:

(1) Momentary variations are to be 10% or less of the maximum rated speed when the rated load of the generator is suddenly thrown off.

(2) Momentary variations are to be 10% or less of the maximum rated speed when 50% of the rated load of the generator is suddenly thrown on, followed by the remaining 50% load suddenly thrown on after an interval sufficient to restore the speed to steady state. The speed is to return to within 1% of the final steady state speed in no more than 5 *seconds*. When dificulty arises to meet the above requirements or when an installation requires different characteristics, this would be considered.

(3) At all loads between no load and the rated load the permanent speed variation is not to be more than 5% of the maximum rated speed.

3. Governors on prime movers operating in parallel

For *A.C.* generating sets operating in parallel, the governors or prime movers are to have such characteristics that load sharing stipulated in **206. 4** is ensured, and are to be of those easily conducting the load adjustment, at normal frequency, within 5% of the rated load.

4. Turbine-driven *D.C.* generators operating in parallel

Turbine-driven *D.C.* generators arranged to run in parallel are to be fitted with switching device to open the generator circuit-breakers when the emergency governor comes into function.

203. Rotating machinery shaft

1. Rotating machinery shaft

The diameter of rotating machinery shaft in the length from the section where rotor is fixed to the shaft end of prime mover side or load side is not to be less than value obtained from the formula specified in **Pt 5, Ch 3, 203.** of the Rules. P, n and F in the formula mean as follows:

P = Output of rotaing machinery (kW).
n = Number of revolutions of rotaing machinery (rpm).
F = Values given in **Table 6.1.3.**
In case where the stress concentration remains on the part of minimum shaft diameter or where it is apprehended that the transient torque is remarkably greater than the normal torque in operation, F is to be increased by the value recognized by the Society.

Table 6.1.3 Values of Constant F

Bearing arrangement of a rotating machinery shaft	In case of generator driven by steam or gas turbine, generator driven by diesel engine through slip type coupling[(1)], or ecectrical motor	In case of generator driven by diesel engine other than those mentioned in the left-hand column
Where bearings are arranged at both sides of a rotating machinery shaft	110	115
Where no bearing is arranged at prime mover side or load side of a rotating machinery shaft	120	125
NOTE: (1) Slip type coupling signifies hydraulic coupling, electro-magnetic coupling or the equivalent		

2. Shaft coupling

Where bearings are fitted at both ends of rotating machinery shaft, the diameter of the shaft near the coupling part of the driving side and the shaft of bearing contacting parts may be taken as 93% of the values obtained from the formula in **Par 1** provided that there is no sudden change in the shape of the shaft.

3. Torsional vibration

Generator shafting is to be so designed to prevent any excessive vibration within the operating range. The torsional vibration of generator shafting driven by diesel engine is to conform to the requirements equivalent to those given in **Pt 5, Ch 4, 203.**

204. Temperature rise

1. The temperature rise of rotating machines is not to exceed the values in **Table 6.1.4** when continuously operated at the rated load or intermittently operated according to their duties. Where, however, the ambient temperature does not exceed 45 °C, the temperature rise may be increased by the difference from the values in the Table.
2. The temperature rise of static exciters is to comply with the requirements in **307. 2.**

205. Ship's service $D.C.$ generator

1. $D.C.$ generators

$D.C.$ generators other than those referred to in **Par 2** are to be either of the following types:

(1) Compound-wound generator
(2) Shunt-wound generator with an automatic voltage regulator

2. $D.C.$ generators used for charging batteries

$D.C.$ generators used for charging batteries without series of regulating resistor are to be either of the following types:

(1) Shunt-wound generator
(2) Compound-wound generator with switches arranged so that the series winding can be made inoperative at the time of charging

3. Field regulator for $D.C.$ generators

Field regulator for $D.C.$ generator is to be capable of adjusting the voltage of the generator to within 0.5% of the rated voltage for machines above 100 kW and 1% of the rated voltage for smaller machines respectively at all loads between no load and full load at the operating temperature.

4. Overall voltage regulation of $D.C.$ generators

The overall voltage regulation of $D.C.$ generators is to conform to the following requirements. The rotating speed is to be adjusted with the rated speed at full load.

(1) Shunt-wound generator : After the temperature test, when the voltage sets at full load, the steady voltage at no load is not to exceed 115% of the full load value, and the voltage obtained at any value of load is not to exceed the no load value.
(2) Compound-wound generator : After the temperature test, when the voltage at 20 % load is adjusted within ±1% of rated voltage, the voltage at full load is to be within ±1.5 % of the rated voltage and the average of the ascending and descending load / voltage curves

Table 6.1.4 Temperature Rise of Rotating Machines (°C) (Based on 50°C ambient temperature)

Item	Part of machine	Class A insulation			Class E insulation			Class B insulation			Class F insulation			Class H insulation		
		T	R	E.T.D.	T	R	E.T.D.	T	R	E.T.D.	T	R	E.T.D.	T	R	E.T.D.
1	Stator windings of *A.C.* mach.	*40	50	50	*55	65	65	*60	70	70	*75	90	90	*95	115	115
2	Insulated rotor windings	*40	50	–	*55	65	–	*60	70	–	*75	90	–	*95	115	–
3A	Field windings of multilayer	*40	50	–	*55	65	–	*60	70	–	*75	90	–	*95	115	–
3B	Low-resistance field windings and compensating windings	50	50	–	65	65	–	70	70	–	90	90	–	115	115	–
3C	Field windings of singlelayer with exposed bare surface	55	55	–	70	70	–	80	80	–	100	100	–	125	125	–
3D	Field windings of synchronous machine having cylindrical type rotor	–	–	–	–	–	–	–	80	–	–	100	–	–	115	–
4	Iron core and other parts in contact with windings	50	–	–	65	–	–	70	–	–	90	–	–	115	–	–
5	Permanently short-circuited windings uninsulated. Iron core and other parts not in contact with windings. Brushes and brush holders.	The temperature rise is in no case to reach such a value that there is a risk of injury to any insulating material on adjacent parts.														
6	Commutators and slip-rings	50	–	–	60	–	–	70	–	–	80	–	–	90	–	–

T = Thermometer method
R = Resistance method
E.T.D. = Embedded temperature detector

NOTES :
1. Temperature rise of totally enclosed machines with the mark * may be increased by 5°C from the values given in the Table.
2. Where the windings and commutators or slip-rings to which they are connected are insulated with different classes of insulating material, the temperature rise associated with the lower class is to be applied to the commutator or slip-rings.
3. There is no need to simultaneously measure the temperature of any part by means of two methods (e.g. thermometer method and resistance method).
4. For stator windings of *A.C.* machines of 5000 *kVA* and above, or of having an axial core length (including the ventilating duct) of one *meter* and above, resistance method or embedded temperature detector is to be used. In this case, the temperature rise in class E insulation is not to exceed 60°C.
5. The temperature rise of rotating machines equipped with air cooler may be increased by 20°C from the values in the Table, provided that the temperature of cooling water at the inlet of air cooler does not exceed 30°C.

between 20% load and full load is not to vary by more than 3% from the rated voltage. However, for the compound-wound generators operating in parallel, the drop in voltage may be acceptable up to 4% of the rated voltage when the load is gradually increased from 20% load to 100% load.

(3) Three-wire generator : In addition to conforming to (1) and (2) above, when the generator is operating at the rated current on either positive or negative leads and a current of 25% of the rated current in the neutral wire, the resulting difference in voltage between the positive and neutral leads or the negative and neutral leads is not to exceed 2% of the rated voltage between the positive and negative leads.

5. Load sharing of *D.C.* generators

When *D.C.* generators are run in parallel, the load on any generator is not to differ by more than ±10% of the rated output of the largest generator from its proportionate share, based on the generator ratings, of the combined load, for any steady-state condition in the combined load between 20% and 100% of the sum of the rated outputs of all the generators. The starting point for the test is to be at 75% load with each generator carrying its proportionate share.

6. Series winding of compound-wound generator

The series winding of each two-wire compound-wound generator is to be connected to the negative terminal.

7. Equalizer connection

Equalizer connections fo *D.C.* generator are to have a cross-sectional area not less than 50% of that of the negative connection from the generator to the switchboard.

206. Ship's service *A.C.* generator

1. Automatic voltage regulators

Each *A.C.* generator, unless of the self-excited type, is to be provided with an automatic voltage regulator.

2. Overall voltage regulation of *A.C.* generators

The overall voltage regulation of *A.C.* generators is to be such that at all loads from zero to full load at the rated power factor, the rated voltage is to be maintained under steady conditions within ±2.5%, except that for emergency generators the limits may be increased to ±3.5%.

3. Exciters of *A.C.* generators

Exciters of *A.C.* generators are to be capable of maintaining the current of at least three times its rated current for a duration up to 2 *seconds*, unless protection selectivity requirements which allow different characteristics exist.

4. Load sharing of *A.C.* generators

When *A.C.* generators are run in parallel, each generator is to be stable in running and the load on any generator is not to differ by more than 15 % of the rated output of the largest generator from its proportionate share, based on the generator ratings, of the combined load for any steady-state condition in the combined load between 20 % and 100 % of the sum of the rated loads of all the generators. The starting point for the test is to be at 75 % load with each generator carrying its proportionate share.

207. Shaft currents

Suitable measures are to be taken to prevent the ill effects of flow of currents circulating between the shaft and bearings.

208. Welding

When welding is applied to the shaft and other torque members of rotating machines, this is subject to the approval of the Society.

209. Testing and inspection

1. General

Rotating machines of essential use are to meet the requirements of this Section in their construction and are to be tested in accordance with the requirements of the following articles. However, the tests required by **Pars 3, 4** and **11** may be omitted subject to the Society's permission for each rotating machine which is produced in series having identical type with the first unit tested in the presence of the surveyor. In case of motors of cage rotor type, the test required by **Par 5** may be omitted in addition to the above tests.

2. Material test of shaft

(1) The shaft materials for rotating machines of 100 *kW* and above are to be tested in accordance with the requirements in **Pt 2, Ch 1.**

(2) The shaft materials for rotating machines less than 100 *kW* are to comply with the relevant Korean Industrial Standards (KS) or the equivalents.

3. Temperature test

After the rotating machine has run continuously under full rated load until a final steady temperature, the temperature rises in the machine are not to exceed the values in **204.**

4. Overcurrent or excess torque test

After the temperature test, rotating machines, except special type, are to withstand the following overcurrent or excess torque test while maintaining the voltage, revolving speed and frequency as near their rated values as possible. In the above, special types involve deck machinery motors (winch, windlass, capstan, etc.) and single phase *A.C.* motors.

Kinds	Overcurrent or excess torque	*Seconds*
D.C. generators	50% overcurrent	15
A.C. 9enerators	50% overcurrent	120
D.C. motors	50% excess torque	15
Synchronous motors	50% excess torque	15
Induction motors	60% excess torque	15

5. Overspeed test

Rotating machines are to withstand the overspeed test specified in the following for 2 *minutes*.

Kinds		Testing speed
Generators	Turbine driven	115 % of rated speed
	Internal combustion engine driven	120 % of rated speed
	All others	125 % of rated speed
Motors	Shunt-wound motors	125% of rated speed
	Series-wound motors	200 % of rated speed
	Compound-wound motors	125 % of no load speed
	Synchronous motors	125 % of synchronous speed
	Induction motors	125 % of synchronous speed

6. Insulation resistance test

(1) Immediately after the temperature tests, the insulation resistance are to be measure using

Table 6.1.5 Testing Voltage

Item	Machine or part		Testing voltage (r.m.s.) (V)
1	Armature windings	0.4 kW (or kVA) or less	$2E + 500$
		Exceeding 0.4 kW (or kVA)	$2E + 1000$ (Minimum 1500 V)
2	Separately excited field windings of $D.C.$ machines		$2E_f + 1000$ (Minimum 1500 V)
3	Synchronous machines	Field winding not starting as a motor	$10E_x$ (Minimum 1500 V)
		Field winding starting as a motor i) When intended to be started with the field windings short-circuited ii) When intended to be started with the field windings on open circuit	 $10E_x$ (Minimum 1500 V) $2E_i + 1000$
		Insulated rotor windings for starting use	$2E_i + 1000$
4	Secondary windings of the wound rotor type induction motor i) For non-reversing motors or motors reversible from standstill only ii) For motors to be reversed or braked by reversing the primary supply while the motors are running		 $2E_s + 1000$ $4E_s + 1000$
5	Exciter		$2E_i + 1000$ (Minimum 1500 V)

NOTES:
1. E = Rated voltage
   E_f = Maximum rated voltage in field circuit
   E_X = Rated exciting voltage
   E_s = Induced voltage between the terminals of secondary windings when the machine is at a standstill.
   E_i = Induced terminal voltage between the terminals of field windings and starting rotor windings when applied the starting voltage to armature winding during the rotor's standstill and terminal voltage in such condition that the field windings or starting windings are started by connecting with the resistance.
2. Such windings connected with armature windings as series, shunt, interpole and compensating windings of $D.C.$ machines are to be tested in accordance with armature windings of Item 1 in the above table.
3. As for the semi-conductor rectifier of exciters, the requirements for semi-conductor rectifiers for power in **Sec 12** are to be applied.

a direct current insulation tester between:
(A) All current carrying parts connected together and earth.
(B) All current carrying parts of different polarity or phase, where both ends of each polarity or phase are individually accessible.

(2) The minimum values of test voltages and insulation resistances are given in the following.

Rated voltage Un(V)	Minimum test voltage(V)	Minimum insulation resistance($M\Omega$)
$Un \le 1000$	500	1
$1000 < Un \le 7200$	1000	$1+\frac{U_n}{1000}$
$7200 < Un \le 15000$	5000	$1+\frac{U_n}{1000}$

7. High voltage test

Rotating machines are to withstand for 1 *minute* the high voltage test between live parts and between live parts and earth with $A.C.$ voltage in commercial frequency as given in **Table 6.1.5.**

8. Voltage regulation test

Generators are to be subjected to voltage regulation test specified in the following and are to pass the requirements.

(1) Test for the requirements specified in **205. 4** or **206. 2** of the Rules
(2) When the generator is driven at rated speed, giving its rated voltage, and is subjected to a sudden change of symmetrical load within the limits of specified current and power factor, the voltage is not to fall below 85% nor exceed 120% of the rated voltage. The voltage of the generator is then to be restored to within plus or minus 3% of the rated voltage for the main generator sets in not more than 1.5 *seconds*. For emergency sets, these vlues may be increased to plus or minus 4% in not more than 5 *seconds*, respectively.

9. Winding resistance measurement

The resistances of the machine windings are to be measured using an appropriate bridge method, or voltage and current method.

10. Commutation test

Rotating machines with commutators are to work with fixed brushes setting from no load to 50% overload without injurious sparking.

11. Verification of steady short-circuit condition

It is to be verified that under steady-state short-circuit conditions, the generator with its voltage regulating system is capable of maintaining, without sustaining any damage, a current of at least three times the rated current for a duration of 2 *seconds* or, where precise data is available, for a duration of any time delay which may be fitted in a tripping device for discrimination purposes.

12. No load test

Machines are to be operated at no load and rated speed whilst being supplied at rated voltage and frequency as a motor or if a generator it is to be driven by a suitable means and excited to give rated terminal voltage. During the running test, the vibration of the machine and operation of the bearing lubrication system, if appropriate, are to be checked.

13. Parallel operation test

Generators to run in parailel operation are to be subjected to parallel operation test and are to pass the requirements in **205. 5** or **206. 4.**

14. Verification of bearings

Upon completion of the above tests, machines which have plane bearings are to be opened upon request for examination by the Surveyor, to establish that the shaft is correctly seated in the bearing shells.

SECTION 3
Switchboards, Section Boards, Distribution Boards and Protective Equipment

301. General

1. Installation

Switchboards are to be installed in dry places away from the vicinity of steam, water and oil pipes.

2. Space for operation and maintenance

Sufficient space for operation is to be provided in front of switchboards. Where necessary, space at the rear of switchboards is to be ample to permit operation and maintenance of disconnecting switches, switches, fuses and other parts. The space is not to be less than 0.5 *m* in width.

3. Safety precautions to operators

Where the live parts of switchboards face a passageway, the following means are to be provided.

(1) Insulated handrails are to be provided.
(2) Insulated mats are to be provided on the floor of passageway.

302. Construction

1. Construction

(1) Busbars, circuit-breakers and other electrical appliances of the main switchboards are to be so arranged that the electrical equipment of essential use installed in duplicate will not become out of action simultaneously by a single fault.
(2) The generator switchboard is to be provided for each generator, and the switchboards adjoining each other are to be partitioned by the walls of steel or flame-retardant material. The main busbars are to be subdivided into at least two parts which are to be normally connected by the circuit breaker or other approved means. So far as is practicable, the connection of generating sets and other duplicated equipment are to be equally divided between the parts.
(3) Cable entries of switchboard are to be so constructed that no ingress of water be permitted into the switchboard along the cables.

2. Dead-front type switchboards

For voltage between poles, or to earth, exceeding 55 V $D.C.$ or 55 V $A.C.$, switchboards are to be of dead-front type.

3. Materials of insulation and wiring for switchboards

(1) Insulating materials used in the construction of switchboards are to be mechanically strong, flame-retardant and moisture-resistant.
(2) Insulated wires for switchboard are to be those of flame-retardant and moisture-resistant, having the maximum permissible conductor temperature not less than 75°C.
(3) Ducts and straps for wiring are to be of flame-retardant materials.
(4) Insulated wires for control and instrument circuits are not to be bunched together with wires for main circuits, unless the rated voltage and maximum permissible conductor temperature of both wires are the same.

303. Busbars and equalizer connections

1. Busbars

(1) Busbars are to be of copper having the conductivity of 97% or more.
(2) Busbar connections are to be so made as to inhibit corrosion and oxidization.
(3) Busbars and their connections are to be so supported as to withstand the electromagnetic force resulted from short-circuiting.
(4) Temperature rises of busbars, connecting conductors and their connections are not to exceed 45°C at the limit ambient temperature of 45°C when carrying full load current.
(5) The clearances and creepages of busbars are not to be less than the values in **Table 6.1.6.**

2. Equalizer for $D.C.$ generator

(1) The current rating of equalizer connections and equalizer switches is not to be less than 50 %

Table 6.1.6 Clearances and Creepages of Busbars

Rated voltage(V)	Clearance (mm)	Creepage (mm)
250 or less	15	20
251 ~ 660	20	30
Exceeding 660	25	35

the rated full-load current of the generator.

(2) The current rating of equalizer busbars is not to be less than 50% the rated full-load current of the largest generator in the group of parallel operation.

304. Measuring instruments for switchboards

1. *D.C.* ship's service generator panels

D.C. ship's sercice generator panels are at least to be provided with the instruments given in **Table 6.1.7.**

2. *A.C.* ship's service generator panels

A.C. ship's service generator panels are at least to be provided with the instruments given in **Table 6.1.8.**

3. Instrument scales

(1) The upper limit of the scale of every ammeter is to be approximately 130% of the normal rating of the circuit.

(2) The upper limit of the scale of every voltmeter is to be approximately 120% of the normal voltage of the circuit.

(3) Ammeters for *D.C.* generators or wattmeters for *A.C.* generators which may operate in parallel

Table 6.1.7 Instruments for *D.C.* Generator Panel

Operation	Type of instrument	Quantity	
		2-wire system	3-wire system
Not parallel	Ammeter	1 for each generator (positive pole)	* 2 for each generator (positive and negative poles)
	Voltmeter	1 for each generator	1 for each generator (voltage measurement between positive and negative poles or between positive or negative pole and neutral pole)
Parallel	Ammeter	1 for each generator (positive pole)	* 2 for each generator (in case of compound winding, between equalizer and armature, and in case of shunt winding, for positive and negative poles)
	Voltmeter	2 (busbar and each generator)	2 (voltage measurement between busbar and positive and negative poles of each generator, or between positive or negative pole and neutral pole)

NOTES:
1. For * in the Table, a zero center ammeter is to be added to earth line when employed neutral line earthed system.
2. One voltmeter is to be capable of measuring shore supply voltage.
3. Where a control panel is provided for automatic control of generators, the instruments in the above table may be installed on the control panel, except that, if the control panel is installed outside engine rooms, the minimum number of instruments required to carry out single or parallel operation of generators are to be mounted on switchboards.

Table 6.1.8 Instruments for *A.C.* Generator Panel

Operation	Type of instrument	Quantity
Not parallel	Ammeter Voltmeter Wattmeter Frequency meter * Ammeter	1 for each generator (current measurement of each phase) 1 for each generator (voltage measurement between each phase) 1 for each generator (It may be omitted for 50KVA or less) 1 (frequency measurement of each generator) 1 for exciting circuit of each generator
Parallel	Ammeter Voltmeter Wattmeter Frequency meter Synchroscope * Ammeter	1 for each generator (current measurement of each phase) 2 (voltage measurement between each phase of generators and busbar) 1 for each generator 2 (frequency measurement of each generator and busbar) 1 set 1 for exciting citcuit of each generator

NOTES:
1. For * in the Table, the ammeters are to be provided only if necessary.
2. One of the voltmeters is to be capable of measuring shore supply voltage.
3. Where a control panel is provided for automatic control of generators, the instruments in the above table may be installed on the control panel, except that, if the control panel is installed outside engine rooms, the minimum number of instruments required to carry out single or parallel operation of generators are to be mounted on switchboards.

are to be capable of indicating reverse current or reverse power up to 15% respectively.

305. Protective devices

1. General

Electrical installations of ships are to be protected against accidental over-currents including short-circuit. The protective devices are to be capable of breaking the fault circuit and continuously serve other circuits as far as possible and at the same time eliminate the danger of damage to the system and fire hazard.

2. Protection of circuits

(1) Short-circuit protection is to be provided in each pole and phase of all insulated circuits except neutral and equalizer circuits.

(2) Overload protections are to be provided for all circuits liable to be overloaded as follows, except as permitted where the Society may exceptionally permit, and the rating or appropriate setting of the overload protective device for each circuit is to be permanently indicated at the location of the protective device.

(A) Two-wire $D.C.$ or single-phase $A.C.$ system: at least one line or phase.

(B) Three-wire $D.C.$ system: both outer lines.

(C) Three-phase, three-wire $A.C.$ system: at least two phases.

(D) Three-phase, four-wire $A.C.$ system: at each phase.

(3) Fuse, non-linked circuit breaker or non-linked switch is not to be inserted in an earthed conductor and a neutral line.

3. Circuit breakers and fuses

(1) Circuit breakers and fuses are to comply with the requirements in **Sec 8.**

(2) Circuit breakers are to be such that repairs and replacement can be done without disconnecting from the busbar connections and switching off the power source. Where isolation switch is provided additionally, the requirement may be exempted.

(3) Overcurrent relays of circuit breakers for generators and overload protection except moulded-case circuit breakers are to be capable of adjusting their current setting or time-delay characteristics.

4. Protection against overload

(1) The overcurrent tripping characteristics of circuit breakers and the fusing characteristics of fuses are to be chosen suitably taking into consideration of the thermal capacity of electrical equipment and cables to be protected thereby.

(2) Fuses of the rated current exceeding 200 A are not to be used for overload protection.

5. Protection against short-circuit

(1) The rated breaking capacity of every protective device is not to be less than the maximum value of the short-circuit current which can flow at the point of installation at the instant of contact separation.

(2) Where the rated breaking capacity of the short-circuit protection is not in compliance with the requirement in (1) above, fuses or circuit breakers having the rated breaking capacity not less than the prospective short-circuit current are to be provided at the power source side of the foregoing short-circuit protection. The generator breaker is not to be used for this purpose. The circuit breakers connected to the load side, are to be capable of being continuously in service without excessive damage in the following cases:

(a) When the short-circuit current is broken by the back-up circuit breaker or fuse.

(b) When the circuit breaker at the load side is closed on the short-circuit current, while the backup circuit breaker or fuse is broken.

(3) The making capacity of every circuit-breaker or switch intended to be capable of being closed, if necessary, on short-circuit, is not to be less than the maximum value of the short-circuit current at the point of installation.

(4) In the absence of precise data of rotating machines, the following short-circuit currents are to be assumed. Where the motor is considered as load, the short-circuit current of the motor is to be added to that of generator.

(A) $D.C.$ system

10 times the rated current for generators normally connected (including spare).

6 times the rated current for motors simultaneously in service.

(B) $A.C.$ system

10 times the rated current for generators normally connected (including spare).

3 times the rated current for motors simultaneously in service.

6. Protection of generators

(1) Generators are to be protected against short-circuit and overcurrent by a multipole circuit-breaker arranged to open simultaneously all insulated poles. For generators with capacity of less than 65kVA, however, a multipole-linked switch with a fuse or circuit-breaker in each insulated pole may be used for protection. The overload protection is to be adequate to the thermal capacity of generators.

(2) For $D.C.$ generators arranged to operate in parallel, in addition to the requirement of (1), an instantaneous reverse-current protection, operating at a fixed value of reverse-current within the limits of 2% to 15% of the rated current of generators, is to be provided. This requirement, however, does not apply to the reverse-current generated from load side, e.g.

cargo winch motors, etc.

(3) For $A.C.$ generators arranged to operate in parallel, in addition to the requirement in (1), a reverse-power protection, with time delay, selected and set within the limits of 2% to 15% of full load to a value fixed in accordance with the characteristics of the prime mover, is to be provided.

7. Protection of power and lighting transformers

(1) The primary circuits of power and lighting trans formers are to be protected against short-circuit and overload by circuit-breakers or fuses.

(2) When transformers are arranged to operate in parallel, means of isolation are to be provided on the secondary circuits. Switches and circuit-breakers are to be capable of withstanding surge currents.

8. Protection of motors

(1) Motors of rating exceeding 0.5kW and all motors for essential services are to be protected individually against overload, except steering gear motors complying with the requirements in **Pt 5, Ch 7, 207.**

(2) The protective device is to have a delay characteristics to enable the motor to start.

(3) For motors of intermittent service, the protective device is to be chosen in relation to the service condition.

9. Protection of feeder circuits

(1) Feeder circuits to section boards, distribution boards, group starters and the similar are to be protected against overload and short-circuit by multi-pole circuit breakers or fuses. Where fuses are used for this purpose, the switches complying with the requirements in **1004. 3** are to be provided at the power source side of the fuses as a rule.

(2) Circuits which supply motors fitted with overload protection may be provided with short-circuit protection only.

(3) When fuses are used to protect three-phase $A.C.$ motor circuits, consideration is to be given for protection against single phasing.

(4) In case where condensers for phase advance are used, overvoltage protective devices, if necessary, are to be installed.

10. Protection of essential service

Where two or more generators are operated in parallel and essential machinery is driven electrically, arrangements are to be made to disconnect automatically the excess nonessential loads when the generators are overloaded. If required, this preference tripping may be carried out in two or more stages.

11. Protection of batteries

Storage batteries other than engine starting batteries, are to be protected against overload and short-circuit with devices placed as near as practicable to the batteries. Emergency batteries supplying essential services may have short-circuit protection only.

12. Protection of meters, pilot lamps and control circuits

(1) Protection is to be provided for voltmeters, voltage coils of measuring instruments, earth indicating devices and pilot lamps with their connecting leads by means of fuses fitted to each insulating pole. A pilot lamp installed as an integral part of another item of equipment need not be individually protected, provided that any damage of pilot lamp circuit does not cause failures on the supply to essential equipment. Consideration is to be given to the omission of fuses in circuits such as those of automatic voltage regulators where loss of voltage might have serious consequences.

(2) Insulated wires for control and instrument circuits directly led from busbars and generator mains are to be protected by fuses at the nearest location to the connecting points. Insulated wires from the connecting points to the fuses are not to be bunched together with the wires for other circuits.

306. Section boards and distribution boards

1. General

Insulations, busbars, wiring materials and electrical protective devices for section boards and distribution boards are to be those of being in compliance with the requirements of this Section.

2. Protective enclosures

Section boards and distribution boards are to be protected by suitable enclosures depending on their locations. The enclosures are to be made of incombustable and moisture resistant materials.

3. Arrangement of appliances

Where the same section board or distribution boards is used for the supply circuits having different voltages, all appliances are to be so arranged that the wires of different rated voltages can be laid without contacting each other within the boards. The section boards and distribution boards for emergency distribution circuits are in principle to be provided independently.

307. Testing and inspection

1. General

Switchboards are to meet the requirements of this Section in their construction and are to be tested in accordance with the requirements of the following articles. However, the test required by **Par 2** may be omitted subject to the Society's per-

Table 6.1.9 Limits of Temperature Rise of Electrical Appliances for Switchboard

(Based on ambient temperature 45 °C)

Item and part			Limit of temperature rise (°C)	
			Thermometer method	Resistance method
Coils	Class A insulation		45	65
	Class E insulation		60	80
	Class B insulation		75	95
	Bare windings of single layer		75	–
Contact pieces	Mass form	Copper or copper alloy	40	–
		Silver or silver alloy	70	–
	Multilayer form	Copper or copper alloy	25	–
	Knife form	Copper or copper alloy	25	–
Terminals for external cables			45	–
Metallic resistors	Moulded-case type		245	–
	Those other than moulded-case type	For continuous service	295	–
		For intermittent service	345	–
	Exhaust (approx. 25 mm above the exhaust port)		170	–
NOTE: The temperature rise for the exciters incorporated in generators to which 50 °C is applied as a limit ambient temperature, is to take the value reduced by 5 °C as limit from the above Table.				

mission for each switchboard which is produced in series having identical type with its first unit tested in the presence of the Surveyor.

2. Temperature test

The temperature rises of switchboards are not to exceed the values given in **Table 6.1.9** under the specified current and/or rated voltage, except these provided in the relevant Sections of this Chapter.

3. Operation test

Operations of instruments, circuit-breakers, switching gears, etc. on switchboards are to be confirmed.

4. High voltage test

Switchboards with all components are to withstand the high voltage by applying the following voltage at commercial frequency for 1 *minute* between all current-carrying parts connected together and earth and between current-carrying parts of opposite polarity of phase. Instruments and auxiliary apparatus may be disconnected during the highvoltage test:

Rated voltage up to 60 V : 500 V
Rated voltage exceeding 60 V : 1000 V + twice the rated voltage (min. 1500 V)

5. Insulation resistance test

Immediately after high voltage test, the insulation resistance between all current-carrying parts connected and earth and between current-carrying parts of opposite polarity or phase is not to be less than 1 $M\Omega$ when tested with a direct current voltage of at least 500 *volts*.

SECTION 4
Cables

401. General

The application of cables used for electrical equipment in ships are to comply with the requirements of this Section. Where it is desired to use other cables than those stipulated in this Section, they are subject to the consideration of the Society.

402. Application of cables

1. Insulating materials

Insulating materials are to be as given in **Table 6.1.10.**

2. Sheath and armour

Cables are to be protected by sheath or armour in accordance with the following requirements.

(1) Cables fitted on weather decks, and in bath rooms, cargo holds, in any other location where water, oil or explosive gases may be present, are to have a metallic sheath or an impervi-

Table 6.1.10. Permissible Temperature of Insulating Materials

Insulating material	Maximum rated conductor temp.(°C)	Maximum ambient temp.(°C)
Polyvinyl chloride compound (general purpose)	60	50
Polyvinyl chloride compound (heat resisting)	75	65
Natural rubber (heat resisting)	75	65
Butyl rubber	80	70
Ethylenpropylene (EP) rubber	85	75
Silicon rubber	95 (150)	–
Mineral	95 (unlimited)	–

NOTE:
1. The values in parenthesis are permitted when installed where they are not liable to be touched by ship's personnel. In case of silicon rubber cable sheathed with lead, the value in parenthesis may be reduced to 120°C.
2. Polyvinylchloride compounds of general use are applied to PVC sheathed cords and telephone cables, and polyvinylchloride compounds of heat-resistant are applied to other PVC insulated cables.

ous sheath.

(2) In permanently wet places, metallic sheaths are to be used for cables with hygroscopic insulation.

(3) Except cables fitted in living quarters or in any other locations where they are not exposed to risk of mechanical injury, cables are to be armoured.

3. Flame retardancy

Except special types of cables such as radio frequency cables, cables are to be satisfied with the required characteristic of flame retardant or fire resisting type.

403. Current rating of cable

1. Maximum continuous load

The highest continuous load carried by a cable is not to exceed its current rating specified in **Par 5.** The diversity factor of the individual load may be allowed for in estimating the maximum continuous load.

2. Voltage drop

The voltage drop from the main or emergency switch board busbars to any electrical installation, except for navigation lights, is not to exceed 6% of the rated voltage of the installation, when the cables are carrying maximum load current under normal condition of service. For supplies from batteries of voltage not exceeding 24 *volts*, the voltage drop may be increased to 10%.

3. Estimation of lighting load

In assessing the current rating of lighting circuits every lamp holder is to be assessed at the maximum load likely to be connected to it, with a minimum of 60 *watts*, unless the fitting is so constructed as to take only a lamp rated at less than 60 *watts*.

4. Short-time load

Where the motors used for cargo winches, windlasses and capstans are short time duty the current rating of the cables may be allowed to be increased according to their duty.

5. Current rating

The current ratings of cables are not to exceed the values in **Tables 6.1.11** to **6.1.16.**

6. Correction factor for ambient temperature

Where the ambient temperature is different from that of **Par 5**, the correction factors in **Table 6.1.17** may be applied to decide the current ratings for cables.

7. Current rating of cables for short-time duty

The current rating of EP rubber insulated cables for short-time loads is not to exceed the values given in **Table 6.1.18.** The current rating of cables with insulation other than EP rubber is to be as deemed appropriate by the Society.

404. Installation of cables

1. General

Cable runs are to be, as far as possible, straight and accessible.

2. Expansion joints

The installation of cables across expanding parts in the ship's structure is, as far as possible to be avoided. Where this is not practicable a loop of cable of length proportional to the expansion of the part is to be provided. The internal radius of the loop is to be at least 12 times the external diameter of the cable

3. Precaution against fire protection

(1) Where cables are installed in bunches and the risk of fire propagation is considered high, special precautions are to be taken in cable installation to prevent fire propagation.

(2) Cables and wiring serving essential or emergency

Table 6.1.11 Current Rating of Lighting and Power Cables under Continuous Service

(Based on ambient temperature 45°C)

(1) Rubber insulated cables

Nominal sectional area (mm^2)	No. of wires / dia. of wires (mm)	Current rating in *amperes*											
		EP rubber insulation			Butyl rubber insulation			Natural rubber insulation			Silicon rubber insulation		
		Single core	2 cores	3 cores	Single core	2 cores	3 cores	Single core	2 cores	3 cores	Single core	2 cores	3 cores
1.25	7 / 0.45	18	16	13	16	14	11	15	13	11	23	20	16
2.0	7 / 0.6	25	21	17	24	20	17	23	20	16	30	26	22
3.5	7 / 0.8	35	30	25	33	28	23	31	26	22	39	33	28
5.5	7 / 1.0	46	39	32	43	37	30	41	35	29	52	44	37
8	7 / 1.2	59	50	41	55	47	39	51	43	36	66	56	46
14	7 / 1.6	83	71	58	77	65	54	72	61	50			
22	19 / 1.2	110	94	77	100	85	70	95	81	67			
30	19 / 1.4	135	115	94	120	100	84	115	98	80			
38	19 / 1.6	155	130	110	140	120	98	130	110	91			
50	19 / 1.8	185	155	130	165	140	115	150	130	105			
60	19 / 2.0	205	175	145	185	160	130	175	150	120			
80	37 / 1.6	245	210	175	225	190	160	200	170	140			
100	37 / 1.8	285	240	200	260	220	180	230	195	160			
125	37 / 2.0	325	280	230	295	250	205	265	225	185			
150	37 / 2.3	365	310	255	330	280	230	315	270	220			
200	37 / 2.6	440	375	305	390	330	275	370	315	260			
250	61 / 2.3	505			460	390	320	435	370	305			
325	61 / 2.6	595			535	455	375	505	425	350			

(2) Mineral insulated cables

Calculated sectional area (mm^2)	Current rating in *amperes*				Calculated sectional area (mm^2)	Current rating in *amperes*			
	Single core	2 cores	3 & 4 cores	7 cores		Single core	2 cores	3 & 4 cores	7 cores
1.0	20	17	14	11	25.0	135	115	95	
1.5	24	20	17	13	35.0	165			
2.5	32	27	22	18	50.0	200			
4.0	42	36	29	24	70.0	255			
6.0	55	47	39		95.0	310			
10.0	75	64	53		120.0	360			
16.0	100	85	70		150.0	410			

NOTE:
Where more than six cables belonging to the same circuit are bunched together, a correction factor of 0.85 is to be applied.

power, lighting, internal communications or signals are to be so far as practicable routed clear of galleys, laundries, machinery spaces of category A and their casings and other high fire risk areas. Cables connecting fire pumps to the emergency switchboard are to be of a fire resistant type where they pass through high fire risk areas. Where practicable all such cables are to be run in such a manner as to preclude their being rendered unserviceable by heating of the bulkheads that may be caused by a fire in an adjacent space.

4. Bunching

Cables having insulating materials with different maximum rated conductor temperature are not to be bunched together, or, where this is not practicable, the cables are to be operated so that no cable reaches a temperature higher than that permitted for the lowest temperature-rated cable in the group.

5. Protection covering

Cables having a protective covering which may damage the covering of other cables are not to be bunched with those other cables.

6. Maximum internal radius of bend

When cables are to be installed bent, the minimum internal radius of bend is to be not less than the following values:

(1) $6d$ for rubber and PVC insulated cables with metal covering .
(2) $4d$ for rubber and PVC insulated cables without metal covering.
(3) $4d$ for mineral insulated cables.

(d = overall diameter of cable)

Table 6.1.12 Current Rating of Rubber Insulated Multicore Cables for Internal Communication under Continuous Service

(Based on ambient temperature 45°C)

No. of cores	Current rating in *amperes*				
	EP rubber insulation	Butyl rubber insulation		Natural rubber insulation (heat resisting)	
	Conductor sectional area 1.25 mm^2	Conductor sectional area 2.0 mm^2	Conductor sectional area 1.25 mm^2	Conductor sectional area 2.0 mm^2	Conductor sectional area 1.25 mm^2
4		16	11	16	11
5	11	14	10	14	9
7	10	12	8	12	8
9	9	11	7	11	7
12	8	10	7	10	6
16	7	9	6	9	6
19	6	9	6	8	5
23	6	8	5	8	5
27	6	7	5	7	5
33	5	7	4	6	4
37		7	4	6	4
44		6	4	6	4

NOTE:
Where more than six cables are bunched together in which each wire carries current simultaneously, a correction factor of 0.85 is to be applied.

Table 6.1.13 Current Rating of Polyvinylchloride-Asbestos Insulated Wires for Switch boards and Polyvinylchloride Insulated Wires for Control Gears under Continuous Service

(Based on ambient temperature 45°C)

Nominal sectional area(mm^2)	Current rating in *amperes*
0.75	11
1.25	15
2.0	20
3.5	30
5.5	39
8	50
14	70
22	93
30	115
38	130
50	155
60	175
80	210
100	240

NOTE:
Where more than six cables are bunched together in which each wire carries current simultaneously, a correction factor of 0.85 is to be applied.

7. Cables in refrigerated spaces

Cables are not to be installed in refrigerated spaces, as far as possible. Where cables are unavoidably installed in the spaces, however, the following requirements are to be observed.

(1) PVC insulated cables are not to be used.
(2) Cables are to have a lead sheath or cold-resist-

Table 6.1.14 Current Rating of Polychloroprene Sheathed Portable Cords under Continuous Service

(Based on ambient temperature 45°C)

Nominal sectional area(mm^2)	Current rating in *amperes*			
	EP rubber insulation		Natural rubber insulation (heat resisting)	
	2 cores	3 and 4 cores	2 cores	3 and 4 cores
0.75	11	9	11	9
1.25	15	12	13	11
2.0	20	17	20	16
3.5	29	24	26	22
5.5	39	32	35	29
8			43	36
14			61	50

Table 6.1.15 Current Rating of 250 V Polyvinylchloride Insulated Cords under Continuous Service

(Based on ambient temperature 45°C)

Nominal sectional area (mm^2)	No. & dia. of wires (mm)	Current rating in *amperes*
		3 cores
0.75	30 / 0.18	4

Table 6.1.16 Current Rating of 150 V Polyvinylchloride Insulated Multicore Cables for Electronic Equipment under Continuous Service

(Based on ambient temperature 45°C)

Nominal sectional area (mm^2)	Current rating in *amperes*
	2 to 44 cores
0.5	2

Table 6.1.17 Correction Factor of Current Rating of Cables for Ambient Temperature

Insulation	Correction factor for ambient temperature			
	40°C	45°C	50°C	55°C
Polyvinyl chloride (general purpose)	1.15	1.00	0.82	–
Natural rubber (heat resisting) and polyvinyl chloride (heat resisting)	1.08	1.00	0.91	0.82
Butyl rubber	1.07	1.00	0.93	0.85
Ethylenepropylene (EP)	1.06	1.00	0.94	0.87
Mineral and silicon rubber	1.05	1.00	0.95	0.89

Table 6.1.18 Current Rating of EP Rubber Insulated Cables (for short-time service)

(Based on ambient temperature 45°C)

Nominal sectional area (mm^2)	Current rating in *amperes*					
	Service for half an *hour*			Service for an *hour*		
	Single core	2 cores	3 cores	Single core	2 cores	3 cores
1.25	20	17	14	20	17	14
2	26	22	19	26	22	18
3.5	37	32	26	37	32	26
5.5	49	42	35	49	42	34
8	63	54	46	62	53	44
14	91	79	67	88	76	62
22	120	110	93	115	100	84
30	150	135	115	145	125	105
38	180	160	135	165	145	120
50	215	195	170	200	175	145
60	245	225	195	220	195	165
80	300	275	240	270	240	200
100	355	330	290	315	280	240
125	415	390	340	365	325	280
150	485	455	405	415	375	325
200	600	–	–	510	–	–
250	715	–	–	560	–	–
325	880	–	–	720	–	–

ing impervious sheath.

(3) Cables are not to be, as a rule, embedded in structural heat insulation.

(4) Where cables must pass through structural heat insulation, they are to be installed at a right angle to such insulation and are to be protected by a pipe, preferably fitted with a watertight stuffing tube at each end.

(5) Cables are to be installed with ample space from ceilings, side walls or the face of air duct casings and are to be supported by plating, hangers or cleats.

(6) Supporting strips, plating or hangers used for securing the cable are to be galvanized or otherwise protected against corrosion.

405. Mechanical protection of cables

1. General

Cables exposed to risk of mechanical damage are to be protected by metal channels or casing or enclosed in steel conduit.

2. Cables in cargo holds

Cables in cargo holds and other space where there is exceptional risk of mechanical damage are to be suitably protected even if they are armoured.

3. Mechanical protection of cables

Metal casings for mechanical protection of cables are to be efficiently protected against corrosion.

4. Non-metallic ducts or conduits

Non-metallic duct or conduit is to be of flame-retardant material. PVC conduit is not to be used in refrigerated spaces or on open decks.

406. Earthing

1. Earthing of metallic coverings of cables

Metal coverings of cables are to be effectively earthed at both ends, provided that in final sub-circuits earthing may be at the supply end only.

2. Electrical continuity of metallic coverings of cables

Effective means are to be taken to ensure that all metallic coverings of cables are made electrically continuous throughout their length.

3. Lead sheath

The lead sheath of lead-sheated cables is not to be used as the sole means of earthing the non-current carrying metal parts of items of equipment.

407. Securing of cables

1. General

Cables are to be effectively secured, except cables for portable appliances and those installed in pipes, conduits or special casings.

2. Supporting and fixing distance for cables

Supporting and fixing distance for cables are not to be more than the values given in **Table 6.1.9.**

Table 6.1.19 Supporting and Fixing Distance for Cable

Cable run	Cable run space	Supporting distance(cm)	Fixing distance(cm)
Vertical run	All space	30	30
Horizontal run	Cable run in exposed space	30	30
	Cable run in space except exposed speace	30	*90

NOTE:
*In case where the cables are not laid on a hanger, etc., the distance between supports is not to be more than 30cm

3. Clips, supports and accessories

(1) Clips are to be robust and are to be those by which cables are effectively secured without any damage on coverings of the cables.
(2) Clips, supports and accessories are to be of corrosion-resistant material or to be suitably treated to prevent corrosion.
(3) Clips and supports of non-metallic materials are to be flame-retardant.
(4) When cables secured by clips of non-metallic materials are not liad on top of horizontal cable trays or supports, special considerations are to be given to prevent the release of cables during a fire.

408. Penetration of bulkheads and decks

1. Penetration through bulkheads and decks

Where cables pass through bulkheads and decks which are required to have some degree of tightness, they are to be so constructed as to ensure that the strength and tightness are not impaired.

2. Penetration through fireproof bulkheads and decks

Where cables pass through bulkheads and decks which are required to have some degree of fire integrity, they are to be so constructed as to ensure that the fire integrity is not impaired.

3. Bushing

Where cables pass through non-watertight bulkheads or steel structures, the holes are to be bushed with lead or other suitable materials in order to avoid damage to cables. If the thickness of the steel is sufficient, adequately round edges may be accepted as the equivalent of bushing.

409. Metallic pipes

1. General

Metallic pipe are to be effectively earthed and are to be mechanically and electrically continuous across joints.

2. Internal radius of bend

The internal radius of bend of pipes is to be in accordance with the requirement in **404. 6.** Where, however, pipes exceed 64mm in outside diameter, the internal radius of bend is not to be less than twice the outside diameter of the pipe.

3. Internal cross-sectional area of pipes

The internal cross-sectional area of the pipe is not to be less than 250% of the sum of the cross-sectional areas of the cables to be installed in the pipe.

4. Drainage

Horizontal pipes are to have suitable drainage.

5. Expansion joints

Where pipe arrangement is long, expansion joints are to be provided where necessary.

410. Cables for alternating current

Where it is necessary to use single-core cables for alternating current circuits rated in excess of 20A, the following requirements are to be complied with:

(1) Cables are to be either non-armoured or armoured with non-magnetic material.
(2) Where installed in pipe or conduit, cables belong to the same circuit are to be installed in the same pipe or conduit.

(3) Cable clips are to include cables of all phases of a circuit unless the clips are of non-magnetic material.
(4) Where two or three single-core cables forming respectively single-phase circuits or three-phase circuits are installed, the cables are to be in contact with one another as far as possible. In any event, the distance between adjacent cables is not to be greater than the diameter of the cable.
(5) If single-core cables of current rating greater than 250 A are to run along steel bulkheads, wherever practicable, the cables should be spaced as far away from the steel bulkheads as possible.
(6) Where single-core cables of large cross section and exceeding 30 m in length are used, the phase are to be transposed at regular intervals of approximately 15 m in order to blance the impedances of circuits.
(7) In case of circuits involving two or more single-core cables in parallel per phase, all cables are to have the same length and the same cross-section.
(8) Magnetic material is not to be placed between single-core cables of a group. Where cables pass through steel plates, all cables of the same circuit are to pass through a plate or gland of non-magnetic material and the space between the cables and the magnetic material is not to be less than 75 mm wherever practicable.

411. Joints and branch circuits

1. General

Cables are to be joined by terminals. Soldering fluxes containing corrosive substances are not to be used.

2. Terminals for cables

(1) Terminals are to have sufficient contacting surface and pressure.
(2) The length of soldered parts of copper tube terminals and other terminals is not to be less than 1.5 times the diameter of conductors.

3. Joints and branch circuits

Joint or branch circuit of cables is to be carried out in a suitable box, except where method of connection causes no possible risk of deteriorating water-proof characteristics, flame retardation, mechanical strength or electrical characteristics of cables.

412. Testing and inspection

Cables are to be in compliance with the requirements **109. 1** to **7.**

SECTION 5
Distribution

501. Methods of distribution

1. General

Every current-consuming appliance is to be supplied by either a switchboard or a section board or a distribution board.

2. Power and lighting circuits

Lighting circuits and power circuits are to be supplied from a switchboard independently.

3. Insulation monitoring system

(1) When a distribution system, whether primary or secondary, for power, heating or lighting, with no connection to earth is used, a device capable of continuously monitoring the insulation level to earth and of giving an audible or visual indication of abnormally low insulation values is to be provided.
(2) Earthing currnet flowing through the insulation monitoring system specified in (1) is not to exceed 30 mA under any circumstances.

4. Hull return distribution

(1) The hull return system of distribution is not to be used for power, heating, or lighting in a tanker or in a ship of 1,600 *tons gross tonnage* and upwards.
(A) Impressed current cathodic protection system for outer hull protection only
(B) Earth indication devices or other alternative means, however, in no case the circulation current to exceed 30mA.
(C) Limited and locally earthed systems, such as starting and ignition systems of internal combustion engines.
(D) Electrical circuits having no fear of causing hull current in the dangerous spaces, subjected to the approval of the Society.
(2) Where the hull return system is used, all final subcircuits, i.e. all circuits fitted after the last protective device, are to be two-wire and special precautions are to be taken to the satisfaction of the Society.

502. Unbalance of circuits

1. Three-wire *D.C.* systems

Unbalance of loads between an outer conductor and the middle wire at the switchboards, section boards and distribution boards is not to exceed 15% of the full load current as far as possible.

2. Three-wire *A.C.* systems

Unbalance of loads on each phase at the switchboards, section boards and distribution boards is not to exceed 15 % of the full load current as far as possible.

503. Shore connections

1. Installation of connection boxes

Where arrangements are made for the supply of electricity from a source on shore, a connection box is to be installed in a suitable position.

2. Connection boxes

The connection box is to contain terminals to facilitate a satisfactory connection and a circuit-breaker or an isolating switch with fuses. Means are to be provided for checking the phase sequence (for three-phase alternating current) or the polarity (for direct current).

3. Cables between connection box and main switchboard

Cables between the connection box and the main switchboard are to be permanently fixed and a pilot lamp for source and a switch or a circuit-breaker are to be provided on the main switchboard.

504. Power feeders

1. Essential power circuits

The circuits supplying electrical equipment which is disconnected at sea are, as a rule, not to be connected to the power circuits supplying electrical equipment required for essential services for propulsion and safety of the ship.

2. Independently supplied circuits

The feeders of the auxiliaries in main engine room and boiler room, cargo gear motors, radio equipment, searchlights, ventilating sets, etc. are to be independently supplied from switchboards or distribution boards.

3. Circuits for ventilation fans

Fans for cargohold ventilation and for accommodation ventilation are not to be supplied from the same feeder.

505. Steering gear circuits

Steering gear power unit circuits are to comply with the relevant requirements in **Pt 5, Ch 7.**

506. Navigation light circuits

1. Final sub-circuits of navigation lights

Navigation lights are to be connected separately to the navigation light indicator.

2. Control and protection

Each navigation light is to be controlled and protected in each insulated pole by a switch with fuses and a circuit-breaker fitted on the navigation light indicator.

3. Feeder circuits of navigation lights

The navigation light indicator is to be served by two circuits fed from the main switchboard. The circuits are to be separated throughout their length as widely as practicable. One of the circuits is to pass through the emergency switchboard, if provided. One of the circuits may be supplied from a lighting distribution board installed in the wheel house, if the emergency switchboard is not provided.

4. Prohibition of switches and fuses

Switch and fuse are not to be provided on the feeder circuits of navigation lights, except the switchboard and indicator.

5. Installation of navigation light indicator

The navigation light indicator is to be placed in an accessible position on the navigation bridge.

507. Lighting circuits

1. Lighting in engine room, accommodation spaces, etc.

In main engine room, boiler room, large machinery spaces, large galleys, corridors, stairways leading to boat-decks and public spaces, lighting is to be supplied from at least two circuits and to be so arranged that failure of any one circuit will not leave these spaces in darkness. One of the circuits may be emergency lighting circuit.

2. The arrangement of the main electric lighting system is to be such that a fire or other casualty in spaces containing the main source of electrical power, associated transforming equipment, if any, the main switchboard and the main lighting switchboard, will not render the emergency electric lighting system required by **1402. 2** (1) to (3) inoperative.

3. The arrangement of the emergency electric lighting system is to be such that a fire or other casualty in spaces containing the emergency source of electrical power, associated transforming equipment, if any, the emergency switchboard and the emergency lighting switchboard will not render the main electric lighting system required by **Par 1** inoperative.

4. Fixed lighting fittings of cargo holds and coal stores

Fixed lighting fittings of cargo holds and coal stores are to be controlled by multipole linked switches situated outside these areas. Provision is to be made to lock in the switches or switch boxes.

508. Feeder circuits for communication and signalling system, other lights

1. Radio installation

Feeder circuits for radio installation are to be in compliance with the requirements of the relevant regulations.

2. Internal communications

Feeder circuits for internal communications are to comply with the requirements in **Sec 11.**

3. Daylight signalling lamp

The daylight signalling lamp is not to be solely dependent upon the ship's main source of electrical power. When emergency source of electrical power is used for the lamp, it is to be in accordance with the requirements in **1402. 2.**

4. General emergency alarm systems

General emergency alarm systems specified in 7.2.1 of International Life-Saving Appliance Code (LSA Code) and public address system or other suitable means of communication specified in Regulation III / 6.4.2 of SOLAS Covention are to be supplied from both main source of electrical power and emergency source of electrical power.

5. Not under command lights and anchor lights

Not under command lights and anchor lights are to be supplied from both main source of electrical power and emergency source of electrical power.

509. Final sub-circuits

1. Motor circuits

In general, a separate final sub-circuit is to be provided for every motor of essential service and every motor of 1 kW or more in rating.

2. Lighting circuits

(1) Lighting fittings are not to be supplied from final sub-circuits for heaters and motors.

(2) The number of lighting points supplied from a final sub-circuit of 15 A or less in rating is not to exceed the followings, except the case where the number of lighting points and total load current are invariable, the number of lighting points may be increased, provided the aggregate load current does not exceed 80% of the rating of protective device in the circuit.

For circuits of 50 V and below	10 ea.
For circuits of 51 V — 130 V	14 ea.
For circuits of 131 V — 250 V	24 ea.

(3) In a final sub-circuits for panel lighting and electric signs, where lamp holders are closely grouped, the number of points supplied is unrestricted, provided the maximum operating current in the sub-circuit does not exceed 10 A.

3. Heating circuits

A separate final sub-circuit is to be provided for each heater, except the small heaters up to 10 of aggregate current rating not exceeding 15 A may be supplied from a single final sub-circuit.

4. Final sub-circuits of rating exceeding 15 A

A final sub-circuit of rating exceeding 15 A is not to supply more than one point as a rule.

5. Protection of final sub-circuits

Each insulated pole of final sub-circuits is to be protected by a fuse or a circuit breaker.

510. Indication of circuits

The current-carrying capacity of each circuit is to be permanently indicated together with the rating or appropriate setting of the overload protective device.

SECTION 6
Transformers for Power and Lighting

601. General

1. Application

Transformers rated at 1 kVA or more for single phase and at 5 kVA or more for three-phase are to comply with the requirements of this Section.

2. Number and ratings of transformer

Where essential services are supplied, the number and ratings of transformers are to be sufficient to ensure the operation of essential services even when one transformer is out of service.

602. Construction

1. Transformers in accommodation spaces

Transformers in accommodation spaces are to be of dry, naturally cooled type. In machinery spaces they may be of oil-immersed, naturally cooled type.

2. Windings of transformers

Complete insulation is to be made between primary windings and secondary windings of transformers except those for motor starting.

3. Oil-immersed transformers rated at 10 kVA or more

Oil-immersed transformers rated at 10 kVA or more are to be provided with oil gauges and means for drainage, and when rated at 75 kVA or more with thermometers in addition.

4. Precautions against short-circuit current

All transformers are to be capable of withstanding the thermal and mechanical effects without damage, when carrying with short-circuit current for 2 *seconds* while in use.

603. Temperature rise

The temperature rise of transformers is not to exceed the values given in **Table 6.1.20** during continuous operation at rated output. Where, however, the ambient temperature is not more than 40 °C, the table values may be increased by the amount of difference.

604. Voltage regulation

The voltage regulation of transformers is not to exceed the following values at full load and 100% power factor.

Single phase 5 *kVA* or more and three-phase 15 *kVA* or more : 2.5 %

Single phase less than 5 *kVA* and three-phase less than 15 *kVA* : 5%

605. Testing and inspection

1. General

Transformers are to meet the requirements of this Section in their construction and are to be tested in accordance with the requirements of the following Paragraph. However, the test required by **Par 2** may be omitted subject to the Society's permission for each transformer which is produced in series having identical type with its first unit tested in the presence of the Surveyor.

2. Temperature test

The temperature rises of transformers under the rated full load are not to exceed the values given in **603.**

3. Voltage regulation test

Transformers are to be subjected to the voltage regulation test and comply with the requirements of **604.** except that it may also be obtained by calcuation.

4. High voltage test

After the temperature test, transformers are to withstand the test voltage by applying *A.C.* 1000 *V* plus twice the maximum line voltage of commercial frequency between windings and between windings and earth for 1 *minute* . The test voltage in this test is to be at least 1500 *V*.

5. Induced high voltage test

Transformers are to withstand for the duration of the test expressed by the following formula, when twice the normal voltage is induced on the winding at any frequency between 100 and 500 *Hz*, but the duration of the test is to be at least for 15 *seconds* and not over 60 *seconds*.

$$\text{Testing time } (second) = 60 \times \frac{2 \times \text{Rated frequency}}{\text{Test frequency}}$$

6. Insulation resistance test

Before and after the high voltage test, the insulation resistance test for all current-carrying parts are to be carried out and minimum values are to be given in the following.

Rated voltage U_n (V)	Minimum test voltage (V)	Minimum insulation resistance ($M\Omega$)
$U_n \le 1{,}000$	500	1
$1{,}000 < U_n \le 7{,}200$	1,000	$1 + \frac{U_n}{1{,}000}$
$7{,}200 < U_n \le 15{,}000$	5,000	

SECTION 7
Control-gears for Motors and Magnetic Brakes

701. Construction

1. General

(1) Control-gears for motors are to be of durable construction and provided with efficient means of starting, stopping, reversing and speed controlling of motors together with essential safety devices.

(2) Control-gears for motors are to have suitable protective enclosures depending on their loca-

Table 6.1.20 Limit of Temperature Rise of Transformers (Based on ambient temperature 45°C)

Part		Limit of temperature rise (°C)					
		Measuring method	Class A insulation	Class E insulation	Class B insulation	Class F insulation	Class H insulation
Windings	Dry type transformer	Resistance method	55	70	75	95	120
	Oil-immersed transformer	Resistance method	60	–	–	–	–
Oil		Thermometer method	45				
Core		Thermometer method	Temperature not injurious to insulation				

tions and to be so constructed that operators can safely handle them.

(3) Where intrinsically safe electrical appliances are built in controlgears for motors, they are to be arranged in compliance with the requirements in **902. 3** (3) and the wires for intrinsically safe circuits are to be speparated from those for other circuits, and to be shielded electrically if necessary. Suitable measures are to be taken to identify the wires for intrinsically safe circuits easily.

2. Grouped starters

(1) In case where control-gears for motors of essential services which are to be provided in duplicate are built in a grouped starter panel, the busbars, appliances and others are to be so arranged that one fault on the appliances or the circuits do not render the motors for the same use unusable simultaneously.

(2) Transformers for power supply to control circuits are to be provided for each motor or each group of motors incorporated in an apparatus.

3. Wearing parts of control-gears for motors

All wearing parts of control-gears for motors are to be readily accessible for inspection and maintenance.

4. Control-gears for motors above 0.5 kW

Motors above 0.5 kW are to be provided with the following control apparatus :

(1) Means to prevent undesired restarting after a stoppage due to low voltage or complete loss of voltage. This does not apply to motors, the continuous availability of which is essential to the safety of the ship and the automatically operated motors.

(2) Efficient means of isolation are to be provided so that all voltage may be cut off from the motor, except that where means of isolation (that provided at the switchboard, section board, distribution board, etc.) are adjacent to the motor.

(3) Means for automatic disconnection of the supply are to be provided in the event of excess current due to mechanical overloading of the motor. This does not apply to steering motors.

5. Magnetic contactors and overcurrent relays for motors

(1) Magnetic contactors are to be in compliance with the requirements in **Sec 8.**

(2) Overcurrent relays for motors are to have suitable characteristics in relation to the thermal capacities of motors.

702. Temperature rise

The temperature rises of controlgears for motors are not to exceed the values given in **Table 6.1.21** under the specified currents and rated voltage, except where required in the relevant Sections of this Chapter.

703. Emergency stopping apparatus

Means are to be provided for stopping the motors of forced and induced draft fans, oil fuel transfer pumps, oil fuel unit pumps, lubricating oil service pumps, thermal oil circulating pumps, oil separators(purifiers) and cargo pumps from accessible position outside the space where the motors are installed in case of fire in the space or in the vicinity thereof. But, each separate emergency stop control circuits of ventilators are to be provided for machinery space and accommodation spaces.

704. Starters for steering motors

1. Starters for steering motors are to be of low-voltage release type and arranged in such a way that the steering motors are re-started automatically and safely when electric power is restored after a power failure.

2. Running indicators and overload alarms for steering motors are to be provided in accordance with the relevant requirements in **Pt 5, Ch 7.**

705. Magnetic brakes

1. Magnetic brakes of waterproof type motors

Electrical parts of magnetic brakes applied for waterproof type motors are to be waterproof construction.

2. ***D.C.*** **shunt-wound brakes and** ***D.C.*** **compound-wound brakes**

D.C. shunt-wound brakes are to operate satisfactorily at 85 % of rated voltage at working temperature, and *D.C.* compound-wound brakes at the same conditions as above are to be operated satisfactorily at 85 % of starting current.

3. ***D.C.*** **series-wound brakes**

D.C. series-wound brakes are to release down at a current not less than 40 % of full-load current and in every case at the starting current, and are to set at a current 10 % or less of full-load current.

4. ***A.C.*** **magnetic brakes**

A.C. magnetic brakes are to be in accordance with the following requirements :

(1) *A.C.* magnetic brakes are to be operated satisfactorily at 80 % of rated voltage at working temperature.

(2) *A.C.* magnetic brakes are not to be noisy due to magnetic action in the working condition.

706. Clearance and creepage distances of control appliances

The clearance and creepage distances of control appliances (e.g., contactors, rheostats, control switches, limit switches, protection and control relays for motors, terminal boards, incorporating semi-conductors and their combinations) are to comply with the following requirements in (1) and (2) depending on the degree of protection of enclosures of the appliances or the atmosphere in which the appliances are installed.

(1) The minimum clearance and creepage distances of control appliances (e.g., electromagnetic contactors, control switches, terminal boards) are not to be less than the values given in **Table 6.1.22** if the appliances are designed and constructed in consideration of the moisture, dust, etc. or are operated in the ambient condition not accompanying the extremely high humidity and heavy deposit of dusts.

(2) The clearance and creepage distances of small control appliances of 15 A or less in rating current may be shortened to the values as deemed appropriate by the Society, depending on the degree of protection of enclosures of the appliances or the ambient condition in which the appliances are installed, notwithstanding the requirements in (1) above.

Table 6.1.21 Limit of Temperature Rise of Control-gears for Motors (Based on ambient temperature 45°C)

<table>
<tr><th colspan="4" rowspan="2">Item and part</th><th colspan="2">Limit of temperature rise (°C)</th></tr>
<tr><th>Thermometer method</th><th>Resistance method</th></tr>
<tr><td rowspan="12">Coils (air)</td><td colspan="3">Class A insulation</td><td>60</td><td>80</td></tr>
<tr><td colspan="3">Class E insulation</td><td>75</td><td>95</td></tr>
<tr><td colspan="3">Class B insulation</td><td>85</td><td>105</td></tr>
<tr><td colspan="3">Class F insulation</td><td>110</td><td>130</td></tr>
<tr><td colspan="3">Class H insulation</td><td>135</td><td>155</td></tr>
<tr><td colspan="3">Class C insulation</td><td>no limit</td><td>no limit</td></tr>
<tr><td rowspan="6">Single layer enamel windings</td><td colspan="2">Class A insulation</td><td>80</td><td>–</td></tr>
<tr><td colspan="2">Class E insulation</td><td>95</td><td>–</td></tr>
<tr><td colspan="2">Class B insulation</td><td>105</td><td>–</td></tr>
<tr><td colspan="2">Class F insulation</td><td>130</td><td>–</td></tr>
<tr><td colspan="2">Class H insulation</td><td>155</td><td>–</td></tr>
<tr><td colspan="2">Class C insulat</td><td>no limit</td><td>–</td></tr>
<tr><td rowspan="5">Contact piece</td><td rowspan="4">Mass form</td><td rowspan="2">Continuous use over 8 $hours$</td><td>Copper or copper alloy</td><td>40</td><td>–</td></tr>
<tr><td>Silver or silver alloy</td><td>70</td><td>–</td></tr>
<tr><td rowspan="2">Switch on & off one time or more in about 8 $hours$</td><td>Copper or copper alloy</td><td>60</td><td>–</td></tr>
<tr><td>Silver or silver alloy</td><td>70</td><td>–</td></tr>
<tr><td colspan="2">Multilayer form or knife form</td><td>Copper or copper alloy</td><td>35</td><td>–</td></tr>
<tr><td colspan="4">Busbar and connecting conductor (Bare or Class A insulation and higher)</td><td>60</td><td>–</td></tr>
<tr><td colspan="4">Terminals for external cables</td><td>45</td><td>–</td></tr>
<tr><td rowspan="5">Metallic resistors</td><td colspan="3">Moulded-case type</td><td>245</td><td>–</td></tr>
<tr><td rowspan="3">Those other than moulded-case type</td><td colspan="2">For continuous use</td><td>295</td><td>–</td></tr>
<tr><td colspan="2">For intermittent use</td><td>345</td><td>–</td></tr>
<tr><td colspan="2">For starter use</td><td>345</td><td>–</td></tr>
<tr><td colspan="3">Exhaust (approx. 25 mm above exhaust port)</td><td>170</td><td>–</td></tr>
<tr><td colspan="6">NOTES:
1. Measurement of temperature of voltage coil is in principle to be made by resistance method only.
2. Where the insulation of single layer enamel windings is higher in class than that of the adjacent parts, the temperature rise associated with the class of insulation for the adjacent parts is to be applied.
3. For single layer bare windings, the temperature rise associated with the class of insulating material on the adjacent part is to be applied.
4. Moulded-case type metallic resistor means such a type as to be buried in the insulating material so as no surface of metallic resistor being exposed.</td></tr>
</table>

(3) The requirements of above (1) and (2) are not applied to the following items :
(a) Spark gaps.
(b) Appliances used in secondary windings of induction motors.
(c) Oil-immersed appliances.
(d) Pilot lamp fittings and sockets.
(e) Small switches in living quarters.
(f) The sealed portion of the appliances which are of sealed construction.

707. Testing and inspection

1. General

Controlgears for motors are to meet the requirements of this Section in their construction and are to be tested in accordance with the requirements of th following **Pars 2** to **5**. However, the test required by **Par 2** may be omitted subject to the Society's permission for each controlgear which is produced in series having identical type with its first unit tested in the presence of Surveyor.

2. Temperature test

Controlgears for motors are to be subjected to the temperature test under normal working condition, and than the temperature rise is not to exceed the values given in **702.**

3. Operation test

Operation of instruments, switching gears, protective devices, etc. for controlgears for motors are to be confirmed.

4. High voltage test

Controlgears with components are to withstand the high voltage by applying the following voltage at commercial frequency for 1 *minute* between all current-carrying parts of switching gears including control devices and earth and between poles or phases. Instruments and auxiliary apparatus may be disconnected during the high voltage test.

Rated voltage of 60 *V* or less : 500 *V*
Rated voltage exceeding 60V : 1000 *V* + twice the rated voltage (minimum 1500 *V*)

5. Insulation resistance test

Immediately after the high voltage test, the insulation resistance between all current-carrying parts and earth and between the current-carrying parts of poles or phases are not to be less than 1 *megohm* when tested with direct current voltage of at least 500 *V*.

SECTION 8
Fuses, Circuit-breakers and Electromagnetic Contactors

801. General

Fuses, circuit-breakers and electromagnetic con-

Table 6.1.22 Minimum Clearance and Creepage Distances for Control Appliances

Rated insulating voltage (*V*) (*D.C.* & *A.C.*)	Clearance (*mm*)						Creepage (3)(4) (*mm*)					
	Less than 15*A*(5)		15*A* or over and 63*A* or under(5)		Exceeding 63*A*(5)		Less than 15*A*(5)		15*A* or over and 63*A* or under(5)		Exceeding 63*A*(5)	
	L–L(1)	*L–A*(2)	*L–L*(1)	*L–A*(2)	*L–L*(1)	*L–A*(2)	*a*	*b*	*a*	*b*	*a*	*b*
Not exceeding 60	2	3	2	3	3	5	2	3	2	3	3	4
Exceeding 60 and 250 or under	3	5	4	5	5	6	3	4	6	6	6	8
Exceeding 250 and 380 or under	4	6	4	6	6	8	4	6	6	6	6	10
Exceeding 380 and 500 or under	6	8	6	8	8	10	6	10	6	10	8	12
Exceeding 500 and 660 or under	6	8	6	8	8	10	8	12	8	12	10	14
Exceeding 660	10	14	10	14	10	14	10	14	10	14	14	20

NOTES: (1) to (5) marked in this Table are as follows
(1) "*L–L*" applies to clearances between bare live parts and between live part and earthed metal part.
(2) "*L–A*" applies to clearance between live part and metal part which accidentally becomes dangerous.
(3) Creepage distance is to be determined by type and shape of insulation. "*a*" applies to ceramic insulator(steatite and porcelain), and comparable other insulator which is particularly safe against leaked electricity provided with ribbed construction or vertical partitions proved to be equally effective as ceramic insulator through experiments having a tracking index greater than 140 *V* *e.g.*, phenol resins formed items. "*b*" applies to other insulation materials.
(4) In case where "*L–A*" is greater than the corresponding creepage "*a*" or "*b*", the creepage distances between live parts and insulated metals which operator may readily touch and which becomes live parts by the deterioration of insulation are to be "*L–A*" or more.
(5) Current value is to ve expressed by the rated current-carrying value.

tactors are to comply with Korean Industrial Standards or equivalent thereto, and in addition, they are also to comply with the requirements of this Section.

802. Fuse

1. Construction

(1) Fuses are to be of enclosed type and the construction is to be such that its enclosure is not broken nor burnt and the adjacent insulation is not deteriorated by flowing of fused metal or emitting of gases, when the fuse element has blown out.
(2) Fuses are to be easily exchangeable for their spare parts without the risk of getting electric shock or burn on setting fuses in and out.
(3) Each fuse is to be clearly indicated of its rated voltage and rated current, and in addition rated breaking capacity, fusing characteristics and current-limiting characteristics according to its kind. Such indication may be made in terms of value or symbol.

2. Performance

(1) The temperature rise on the connecting terminals of cables is not to exceed 45°C, when the fuses and fuse-holders has been fitted up to the normal working condition and 100% of the rated current is carried thereon.
(2) Fuses are to have the fusing characteristics corresponding to their kind, and under the circuit conditions specified in the standards referred to in **801.,** they are to be capable of breaking securely all currents whichever is below the rated breaking capacity and above the fusing current.

803. Circuit-breakers

1. Construction

(1) Circuit-breakers are to be of trip-free type and depending upon the field of their application, the trip attachments are to have a time-delay or an instantaneous overcurrent trip feature or both of them.
(2) The main contacts of the circuit-breakers are to be such as to have no undue burning and pitting. Arcing contacts except those of the moulded-case circuit-breakers are easily renewable.
(3) Instantaneous overcurrent trip devices are to be provided in each pole of the circuit-breakers and are to be so constructed as to be capable of tripping them directly by short-circuit current.
(4) Circuit-breakers are to be such that no accidental opening and closing occur due to the vibration of a ship, and furthermore, no malfunction is caused by the list of an angle of 30° in any direction.
(5) The fused circuit-breakers of moulded-case type are to be so constructed that single phasing does not occur in the event of blowing of fuses and that the fuses can be replaced easily without the risk of accidental touch to their live-parts.
(6) Each circuit-breaker is to be clearly indicated of its rated voltage and rated current, and in addition rated breaking capacity, rated making current and rated short-time current according to its kind. Each time-delay overcurrent trip device is to be indicated of its operating characteristics, except the moulded-case circuit-breakers.

2. Performance

(1) The temperature rise on the connecting terminals of cables is not to exceed 45°C when 100% of the rated current is carried thereon.
(2) All circuit-breakers are, according to their kind, to be such as to be able to securely break the overcurrent not more than the rated breaking capacity and safely make the circuit to carry the current not more than the rated making current under the circuit conditions specified in the standards referred to in **801.**
(3) The time-delay overcurrent trip devices of circuit-breakers for generator circuits are to be such that the readjustment of the current setting does not cause remarkable change to the time-delay feature.
(4) The characteristics of the time-delay overcurrent trip devices are not to be affected excessively by ambient temperature.

804. Electromagnetic contactors

1. Construction

(1) Electromagnetic contactors are to be such that no accidental opening and closing occur due to the vibration of a ship, and furthermore, no malfunction is caused by the list of an angle of 30° in any direction.
(2) The contact pieces and magnetic coils are to be readily replaceable.
(3) Each electromagnetic contactor is to be clearly indicated of its rated voltage, rated current, rated voltage of magnetic coil, interruption current capacity and closed circuit current capacity. Such indication may be made in terms of value or symbol.

2. Performance

(1) The temperature rise on each part of electromagnetic contactor is not to exceed the values specified in **702.** when current-carrying is made continuously with the full load current corresponding to the rated capacity supplied to the main contacts and with the rated voltage applied to the magnetic coil.
(2) Electromagnetic contactors are to have a suit-

able interruption current capacity and closed-circuit current capacity depending on their application.

805. Testing and inspection

Fuses, circuit-breakers and electromagnetic contactors are to be in compliance with the requirements in **109. 1** to **9.**

SECTION 9
Explosion-protected Electrical Equipment

901. General

1. Applicable standards

Explosion-protected electrical equipments are to comply with Korean Industrial Standards or equivalent thereto, and they are to comply with the requirements in this Section.

2. Kind of explosion-protected construction

The kind of explosion-protected construction used for electrical equipment on board ships is generally to be as follows :

(1) Flameproof type
(2) Intrinsically safe type
(3) Increased safety type
(4) Pressurized protected type

3. Materials

(1) Materials for explosion-protected construction are to have an adequate electrical, mechanical, thermal and chemical resistance against the environmental condition and flammable gases or vapours (hereinafter referred to as "gases") at the location of the electrical equipment concerned.
(2) Enclosures and outer fittings of portable appliances are to be of material which minimizes the risk of spark by friction, or to have a non-metallic strong cover with hanging strap.
(3) Insulating compounds and sealing compounds used for integral parts of explosion-protected construction are to be such that no harmful expansion, contraction, softening or crack is found during in service. And the insulating compounds applied to bare live-parts are to be flame-retardant.

4. Construction

(1) The glazed ports of lighting fittings and the inspection windows of other electrical apparatus of flameproof type, increased safety type and pressurized protected type are, as a rule, to be provided with robust metallic guards.
(2) In case where a gasket is used with a view to give watertightness to the explosion protected electrical equipment installed on weather decks and other similar spaces, the gasket is to be so fitted as not to impair the explosion-proof characteristics due to its deterioration or breakage.
(3) The leading-in part of cables is to be of a construction suitable for ship cables. Consideration is to be given so that the cables can be surely fixed at the leading-in part, except where the cables are installed in steel conduits.
(4) Electrical equipment associated with intrinsically safe circuits and located in dangerous spaces are in principle to be of totally enclosed construction.
(5) Explosion-protected electrical equipment is to be clearly indicated of its type and the kind of gases for which the equipment is designed. And the lighting fittings are also to be indicated of the kind of lighting bulb applicable thereto and its wattage.

5. Ambient temperature

Reference ambient temperature for explosion-protected electrical equipment is to be 50°C.

902. Special requirements

1. Flameproof electrical equipment

(1) Where flameproof lighting fittings are fitted with bulkheads penetrated through, they are to be so installed as not to impair the integrity of the bulkheads.
(2) In case where a drain discharging device is provided to the enclosure of flameproof construction, it is to be so constructed as not to impair the flameproof characteristics even with the device in the open position.

2. Increased safety electrical equipment

(1) Enclosures of increased safety lighting fittings are to be a robust construction made of non-hygroscopic flame-retardant or incombustible material, and also they are to be of watertight construction or equivalent thereto.
(2) The branch connection boxes of increased safety type are, as a rule, to be filled up with the insulating compounds specified in **901. 3**(3).

3. Intrinsically safe electrical equipment

(1) Electrical apparatus for interconnection between intrinsically safe circuits and non-intrinsically safe circuits (hereinafter referred to as "safety barrier") is to be composed of highly reliable components, and in addition it is to be so designed as to ensure the intrinsic safe characteristics even when one of the components is in disorder. Such safety barriers are to be located in a safe space.
(2) Feeder circuits of intrinsically safe equipment are to be connected to the source of electric power in such a manner as to have no risk of damaging the function of safety barriers due

to any electrical fault caused in other circuits than its own, for example, by means of using an isolating transformers.

(3) Intrinsically safe electrical equipment is to be installed independently of other electrical equipment. Where the combined installation with other equipment is necessary, earthed metallic partitions are to be provided between these equipment.

4. Pressurized protected electrical equipment

(1) When air is used as the pressurized medium, the air inlet is to be located in a safe zone.

(2) When air or inert gas is used as the pressurized medium, an interlock device is to be provided to ensure a displacement of air within the apparatus of at least 10 times the free volume of its enclosure and thus to obtain the required pressure before it can be energized.

(3) Pressurized protected electrical equipment is to be automatically disconnected from the source of electric power in the event of the loss of pressure within its enclosure. However, if this arrangement increases the hazard to the ship, it may be permitted for loss of pressure to operate an alarm device only.

903. Testing and inspection

Explosion-protected electrical equipment is to be in compliance with the requirements in **109. 1** to **7.**

SECTION 10
Lighting Fittings, Heating Appliances and Wiring Accessories

1001. General

Lighting fittings, heating appliances and wiring accessories are to comply with Korean Industrial Standards or equivalent thereto, and in addition they are also to comply with the requirements in this Section.

1002. Lighting fittings

1. Construction and location

(1) Enclosures are to be composed of metal, glass or synthetic resin having a sufficient mechanical, thermal and chemical resistivity and to have a suitable degree of protection depending on their location. Synthetic resin enclosures which support current-carrying parts are to be flame retardant.

(2) Terminal box and leading-in part of cables are to be of construction suitable for ship cables. Consideration is to be given so that the insulation of cables may not be deteriorated at an early stage due to the temperature rise on terminals and other parts.

(3) Lighting fittings installed in engine room or similar spaces which are exposed to the risk of mechanical damage are to be provided with suitable grilled metallic guards to protect their lamps and glass globes against such damage.

2. Fluorescent lighting fittings

(1) Reactors, capacitors and other auxiliaries are not to be mounted on surfaces which are liable to be subjected to high temperatures.

(2) Every capacitor of 0.5 *microfarad* or more is to be provided with a protective leak or other protective means which reduces the voltage of the capacitor to not more than 50 V within 1 *minute* after disconnection from the supply sources.

(3) Transformers are to be installed as close as practicable to the associated discharge lamp.

1003. Heating appliances

1. Construction and location

(1) In principle, no bare heating element is to be used.

(2) Where the heating element is employed in liquid, it is to be protected by anticorrosive metal sheath.

(3) The high temperature parts of electric heating appliances are to be so protected as to be kept from the risk of a combustible material to come in touch under normal working condition.

(4) Space heaters are to be installed in such a manner as to have no risk of dangerous heating of decks or bulkheads or other surroundings.

2. Control switches

Heating appliances are to be controlled by a fixed switch. Where a plug is used for the appliance, the fixed switch is to be placed in the immediate vicinity of the socket-outlet.

1004. Wiring accessories

1. Material

(1) Enclosures are to be of metal or of flame-retardant material.

(2) The insulating material of live parts is to be of flame-retardant and non-hygroscopic material.

2. Temperature rise

The temperature rise on live parts is not to exceed 30°C.

3. Switches

Switches are to be capable of breaking and making safely a load current equal to 150% of their rated current at the rated voltage.

4. Plugs and receptacles

(1) Receptacles of rated current exceeding 15 *amperes* are to be provided with a switch so interlocked that the plug cannot be inserted or withdrawn when the switch is in the "on" position.
(2) Where distribution systems of different voltages are in use, receptacles and plugs are to be of such design that an incorrect connection cannot be made.
(3) Each receptacles and plug having the rated voltage of 55 V and over for $D.C.$ and 55 V and over for $A.C.$ are to be provided with an additional contactor for earthing the casing or frame of appliance, except those for double insulated appliances having no non-current carrying metal parts for which earthing is required. The earthing contactors are to make contact in advance of the live contact pins when inserting the plug.

SECTION 11
Internal Communications

1101. Applicable standards

Each internal communication apparatus is to comply with Korean Industrial Standard or equivalent and above.

1102. Essential internal communication systems

Electric internal communication and signal systems forming part of the essential operating systems of the ship are to be as independent and self-sustaining as possible.

1103. Induced interference suppression

All communication cables are to be so arranged that unwanted interference and cross-talk is avoided.

1104. Protective devices

Where numerous internal communication circuits are branched from common feeder, each circuit and feeder is to be protected by the fuses and other means, and the rating of feeder is to be based on the connected load.

1105. General emergency alarm system

No switch is to be provided for feeder circuits of general emergency alarm system, except for operation switch. Where circuit breaker is used for overcurrent protection, suitable means are to be taken to prevent the circuit breaker from being kept "off" position.

SECTION 12
Semi-Conductor Rectifiers for Power

1201. General

1. The requirements in this Section are to be applied to the semi-conductor rectifiers for power (hereinafter referred to as "rectifiers") not less than 5 kW. Further, the rectifiers specified in this Section are to be taken as a rectifier including thyristor.

2. Accessories of the rectifier are to be in accordance with all applicable requirements in this Chapter.

1202. Construction and location

1. Construction

(1) Rectifier valve units, rectifier stacks or cells are to be so arranged that they can be removed from equipment without dismantling the complete unit.
(2) Air-cooled rectifiers are to be suitably installed or protected against the effects of salty air and humidity.
(3) Where mercury vapour are liable to be generated, self-cooling and air-cooled semi-conductor rectifiers are not to be used.
(4) Where rectifier elements are connected in series or parallel, they are so arranged that the voltage or current on each element will become equal as far as practicable.

2. Location

(1) Rectifiers are to be installed in such a manner that the circulation of cooling air is not impeded and that the temperature of the inlet air to the air-cooled rectifier stacks does not exceed the allowable value.
(2) Rectifiers are to be separated from resistors, steam pipes or other sources of radiant heat as far as practicable.

1203. Protective devices, etc.

1. Protective devices

(1) Where forced cooling is provided, the rectifier is to be so arranged that the rectifier can not remain loaded unless effective cooling is maintained.
(2) Where necessary, means are to be provided to guard against transient over-voltage caused by switching and breaking of the circuits and $D.C.$ voltage rise due to regenerative power.
(3) Protecting fuses for rectifier cells are to be coordinated with the character of rectifier cell as far as practicable.

2. Temperature of rectifier cells

The maximum permissible temperature rise of junction of rectifier cells is to be such a value as will be specified by the manufacturer. Where the information is not available, the maximum permissible temperature rise of junction of rectifier cells is not to exceed the following values :

Selenium : 70°C
Silicon : 150°C (thyristor : 125°C)

3. Transformers for rectifiers

Transformers for rectifier are to be of two separate windings.

1204. Thyristor control

1. Gate control circuits

Gate control circuits are to comply with the following requirements.

(1) Gate control circuits of thyristors are to be so arranged that they can generate the gate pulse not exceeding the gate rating and having the pulse width enough to fire all thyristors connected. The gate control circuits are also to be protected from misfire caused by electrostatic induction and electromagnetic induction.
(2) Where thyristors are connected in series or parallel, gate control circuits are to be so arranged that firing timings of each thyristor are not irregular.

2. Thyristor control for *D.C.* motor

Where *D.C.* motors are controlled by thyristor, the following requirements are to be applied.

(1) Where commutation of *D.C.* motor may be affected by the harmonics of thyristor output waveform, appropriate measures are to be taken to reduce such harmonics.
(2) Where electric sources may be affected by lower power factor resulted from the phase control of thyristor, means are to be provided to compensate it.
(3) In case where motors are operated in either direction of rotation by means of changing-over the field polarity, interlock is to be made so as to reverse the polarity of field after armature-current reaching zero, and in addition, suitable means are to be provided to limit electrical non-locked conditions of armature.

1205. Testing and inspection

1. General

Rectifiers and their accessories are to be tested in accordance with the following requirements. The test required by **Par 2,** however, may be omitted subject to the Society's permission for each product which is produced in series having identical type with its first unit tested in the presence of the Surveyor.

2. Temperature test

Temperature test of rectifiers and their accessories is to be carried out under normal working conditions, and the test results are to comply with the requirements in **1203. 2** not exceeding the values specified in the requirements in **702.** as well.

3. Operation test

Instruments, switching devices and protective devices are to be checked under operating conditions.

4. High voltage test

(1) Rectifiers are to withstand the high voltage by applying the following *A.C.* voltage for 1 *minute* between rectifier cells or live parts of accessories charged with main circuit potential and earth.

Testing voltage (V) = 1.5 EPi + 1000 (Minimum 2000 V)

Where : EPi = Peak reverse voltage

Where *D.C.* voltage is less than 100 V, minimum testing voltage may be 1500 V. Rectifier cell is to be short-circuited before the test.

(2) High voltage test between live parts and earth for accessories charged with auxiliary circuit potential is to be in accordance with the applicable requirements in **707. 4.**

5. Insulation resistance test

After the high-voltage test, insulation resistance between live parts of rectifiers and their accessories and earth is not to be less than 1 $M\Omega$ when tested with *d.c*, voltage of at least 500 V.

SECTION 13
Accumulator Batteries

1301. Applicable standards

Lead-acid accumulator batteries are to comply with Korean Industrial Standard or equivalent and above.

1302. Construction

The cells of all batteries are to be so constructed and secured as to prevent spilling of the electrolyte due to the vibration, inclination, etc., of the ship and to prevent emission of acid or alkaline spray.

1303. Location

1. Batteries are to be located where they are not exposed to excessive heat, extreme cold, spray, steam or other conditions which would impair performance or accelerate deterioration.

2. Alkaline batteries and lead acid batteries are not to be in the same compartment.

3. Batteries are not to be placed in living quarters.

4. Large batteries are to be installed in a space assigned to the batteries only or alternatively in a deck box if such a space is not available, the batteries may be installed in appropriate space.

5. Engine starting batteries are to be located as close as practicable to the engines served. If such batteries cannot be accomodated in the battery room, they are to be installed so that adequate ventilation is ensured.

1304. Electrical installation in battery compartment

1. Lighting fittings in battery rooms are to be of explosion-proof type.

2. Switches, fuses and other electrical equipment liable to cause an arc are not to be fitted in battery compartments.

3. Cables, with the exception of those appertaining to the battery or the local lighting, are not to be installed in battery compartments as a rule.

1305. Protection against corrosion

The interior of all battery compartments is to be protected with lead-sheet lining of 1.6 mm thick or more or corrosion-resistant paint in accordance with the following Paragraphs :

(1) The entire floor and all walls up to 150 mm high of battery rooms are to be lined with lead-sheet and the linings are to be watertight. Where approved by the Society, lead-sheet lining may be substituted by acid-resisting paint.
(2) Ceilings, walls other than those specified in (1), battery shelves and wooden crates are to be painted with acid-resisting paint.
(3) Battery tray and sulfuric acid bottle base are to be lined with lead-sheet.
(4) Ventilating ducts and fans are to be made of corrosion-resisting material or their interior surfaces are to be coated with corrosion-resisting paint.

1306. Ventilation

1. All rooms, lockers and boxes for accumulator batteries are to be arranged to avoid accumulation of inflammable gas. Where batteries are arranged in two or more tiers, all shelves are to have not less than 50 mm space, front and back, for circulation of air.

2. The ventilation of battery room may be conducted with either natural ventilation or ventilating fan.

3. The battery room is to be provided with effective air inlet near floor surface.

4. Ventilating fans are to be so constructed and be of a material such as not to arise sparking in the event of the impeller touching the fan casing.

5. Fan motor associated with a duct used to exhaust the air from a battery space is, in principle, to be placed outside of the duct.

6. Ventilating ducts terminating at least 1.25 m above in a gooseneck shape or equivalent are to be provided above the top of battery boxes. Holes for air inlets are to be provided on at least two opposite sides of the box.

1307. Charging facilities

1. For floating service or for any other conditions where the load is connected to the battery while it is on charge, the maximum battery voltage is not to exceed the safe value of any connected apparatus. A voltage regulator or other means of voltage control may be provided for this purpose.

2. Battery charging facilities by means of $D.C.$ generator and series resistor are to be provided with protection against reversal of current when the charging voltage is 20 % of the line voltage or higher.

SECTION 14
Emergency Electrical Equipment

1401. Application

1. A self-contained emergency source of electrical power is to provided.

2. The emergency source of electrical power, associated transforming equipment, if any, transitional source of emergency power, emergency switchboard and emergency lighting switchboard are to be located above the uppermost continuous deck and are to be readily accessible from the open deck. They are not to be located forward of the collision bulkhead, except where permitted by the Society in exceptional circumstances.

3. The location of the emergency source of electrical power, associated transforming equipment, if any, the transitional source of emergency power, the emergency switchboard and the emergency lighting switchboard in relation to the main source of electrical power, associated transforming equipment, if any, and the main switchboard are to be such as to ensure to the satisfaction of the

Society that a fire or other casualty in spaces containing the main source of electrical power, associated transforming equipment, if any, and the main switchboard, or in any machinery space of category A will not interfere with the supply, control and distribution of emergency electrical power. As far as practicable, the space containing the emergency source of electrical power, associated transforming equipment, if any, the transitional source of emergency electrical power and the emergency switchboard are not to be contiguous to the boundaries of machinery spaces of category A or those spaces containing the main source of electrical power, associated transforming equipment, if any, or the main switchboard.

4. Provided that suitable measures are taken for safeguarding independent emergency operation under all circumstances, the emergency generator may be used exceptionally, and for short periods, to supply non-emergency circuits.

1402. Capacity of emergency source of power

1. The electrical power available is to be sufficient to supply all those services that are essential for safety in an emergency, due regard being paid to such services as may have to be operated simultaneously.

2. The emergency source of electrical power is to be capable, having regard to starting currents and the transitory nature of certain loads, of supplying simultaneously at least the following services for the periods specified hereinafter, if they depend upon an electrical source for their operation:

(1) For a period of 3 *hours*, emergency lighting at every muster and embarkation station and over the sides as required by regulations III/11.4 and III/16.7, Amendments to SOLAS 1974(hereinafter reffered to as the "SOLAS Convention" in this Part).

(2) For a period of 18 *hours*, following emergency lighting.
(A) In all service and accommodation alleyways, stairways and exits, personnel lift cars and personnel lift trunks ;
(B) In the machinery spaces and main generating stations including their control positions ;
(C) In all control stations, machinery control rooms, and at each main and emergency switchboard ;
(D) At all stowage positions for firemen's outfits ;
(E) At the steering gear ; and.
(F) At the fire pump referred to in (6) at the sprinkler pump, if any, and at the emergency bilge pump, if any, and at the starting positions of their motors.
(G) In all cargo pump rooms of tankers

(3) For a period of 18 *hours*, the navigation lights and other lights required by the International Regulations for Preventing Collisions at Sea in force.

(4) For a period of 18 *hours* ;
VHF radio installation required by regulations IV/7.1.1 and IV/7.1.2, MF radio installation required by requlations IV/9.1.1, IV/9.1.2, IV/10.1.2 and IV/10.1.3, INMARSAT Ship Earth Stations required by regulation IV/10.1.1 and MF/HF radio installation as required by regulations IV/10.2.1, IV/10.2.2 and IV/11.1 of SOLAS Convention.

(5) For a period of 18 *hours*, except those services have an independent supply for the period of 18 *hours* from an accumulator battery suitably located for use in an emergency.
(A) All internal communication equipment as required in an emergency.
(B) The navigational equipment as required by regulation V/12 of SOLAS Convention where such provision is unreasonable or impracticable the Society may waive this requirement for ships of less than 5,000 *gross tonnage*.
(C) The fire detection and fire alarm system.
(D) Intermittent operation of the daylight signalling lamp, the ship's whistle, the manual fire alarms and all internal signals that are required in an emergency.

(6) For a period of 18 *hours*, one of the fire pumps required by regulation II-2 / 4 of SOLAS Convention if dependent upon the emergency generator for its source of power.

(7) For the period of time required by **Pt 5, Ch 7** the steering gear where it is required to be so supplied by that requirement.

(8) In a ship engaged regularly in voyages of short duration, the Society if satisfied that an adequate standard of safety would be attained may accept a lesser period than the 18 *hour* period specified in (2) to (6) but not less than 12 *hours*.

1403. Kind and performance of emergency source of electrical power

The emergency source of electrical power is to be either a generator or an accumulator battery, which is to comply with the following ;

(1) Where the emergency source of electrical power is a generator, it is to comply with the following :
(A) The emergency generator is to be driven by a suitable prime mover with an independent supply of fuel, having a flashpoint (closed cup test) of not less than 43°C ;
(B) The emergency generator is to be started automatically upon failure of the main source of electrical power supply unless a transitional source of emergency electrical power in accordance with (C) is provided; where the emer-

gency generator is automatically started, it is to be automatically connected to the emergency switchboard; those services referred to the requirements in **1404.** are then to be connected automatically to the emergency generator ;
(C) A transitional source of emergency electrical power as specified in **1404.** is to be provided unless an emergency generator is provided capable both of supplying the services mentioned in that paragraph and of being automatically started and supplying the required load as quickly as is safe and practicable subject to a maximum of 45 *seconds*.

(2) Where the emergency source of electrical power is an accumulator battery it is to be capable of:
(A) carrying the emergency electrical load without recharging while maintaining the voltage of the battery throughout the discharge period within 12% above or below its nominal voltage ;
(B) automatically connecting to the emergency switchboard in the event of failure of the main source of electrical power ; and
(C) immediately supplying at least those services specified in **1404.**

(3) Where electrical power is necessary to restore propulsion, the capacity is to be sufficient to restore propulsion to the ship in conjunction with other machinery, as appropriate, from a dead ship condition within 30 *minutes* after blakout.

1404. Transitional source of emergency electrical power

The transitional source of emergency electrical power where required by **1403**. is to consist of an accumulator battery suitably located for use in an emergency which is to :

(1) operate without recharging while maintaining the voltage of the battery throughout the discharge period within 12% above or below its nominal voltage ; and

(2) be of sufficient capacity and be so arranged as to supply automatically in the event of failure of either the main or the emergency source of electrical power for half an hour at least the following services if they depend upon an electrical source for their operation :
(A) The lighting required by **1402. 2** (1) to (3). For this transitional phase, the required emergency electric lighting, in respect of the machinery space and accommodation and service spaces may be provided by permanently fixed, individual, automatically charged, relay operated accumulator lamps ; and
(B) All services required by **1402. 2** (5) (A), (C) and (D) unless such services have an independent supply for the period specified from an accumulator battery suitably located for use in an emergency.

1405. Location, etc. of emergency source of electrical power

1. The emergency switchboard is to be installed as near as is practicable to the emergency source of electrical power.

2. Where the emergency source of electrical power is a generator, the emergency switchboard is to be located in the same space unless the operation of the emergency switchboard would thereby be impaired. No accumulator battery fitted in accordance with this regulation is to be installed in the same space as the emergency switchboard.

3. An indicator is to be mounted in a suitable place on the main switchboard or in the machinery control room to indicate when the batteries constituting either the emergency source of electrical power or the transitional source of electrical power are being discharged.

4. The emergency switchboard is to be supplied during normal operation from the main switchboard by an interconnector feeder which is to be adequately protected at the main switchboard against overload and short circuit and which is to be disconnected automatically at the emergency switchboard upon failure of the main source of electrical power. Where the system is arranged for feedback operation the interconnector feeder is also to be protected at the emergency switch board at least against short circuit.

5. In order to ensure ready availability of the emergency source of electrical power, arrangements are to be made where necessary to disconnect automatically non-emergency circuits from the emergency switchboard to ensure that electrical power is to be available automatically to the emergency circuits.

6. Emergency electrical system is to be provided with measures for periodic testing. The periodic testing is to include the testing of automatic starting arrangements.

1406. Starting arrangements for emergency generating sets

1. Emergency generating sets are to be capable of being readily started in their cold condition at a temperature of 0°C. If this is impracticable, or if lower temperatures are likely to be encountered, provision acceptable to the Society is to be made for maintenance of heating arrangements, to ensure ready starting of the generating sets.

2. Each emergency generatating set arranged to be automatically started is to be equipped with approved starting devices approved by the Society with a storage energy capability of at least three consecutive starts. The source of stored energy is to be protected to preclude critical depletion by the automatic starting system, unless a second independent means of starting is provided. In addition, a second source of energy is to be provided for an additional three starts within 30 *minutes* unless manual starting can be demonstrated to be effective.

3. The stored energy is to be maintained at all times, as follows :

(1) Electrical and hydraulic starting systems are to be maintained from the emergency switchboard.

(2) Compressed air starting systems may be maintained by the main or auxiliary compressed air receivers through a suitable non-return valve or by an emergency air compressor which, if electrically driven, is supplied from the emergency switchboard.

(3) All of these starting, charging and energy storing devices are to be located in the emergency generator space.

4. Where automatic starting is not required, manual starting is permissible, such as manual cranking inertia starters, manually charged hydraulic accumulators, or power charge cartridges, where they can be demonstrated as being effective.

5. When manual starting is not practicable, the requirements of **Pars 2** and **3** are to be complied with except that starting may be manually initiated.

SECTION 15 Lightning Conductors

1501. General

Lightning conductors are to be fitted on each mast of ships having wooden masts or topmasts.

1502. Size of lightning conductors

1. Lightning conductors are to be composed of continuous copper tape or rope having a section not less than 75 mm^2. Lightning conductors are to run as straight as possible and sharp bends are to be avoided.

2. The resistance of lightning conductor between the mast top and the point on the earth plate or hull is not to exceed 0.02 *ohms*.

SECTION 16 High Voltage Electrical Installations

1601. General

1. Application

(1) The requirements in this Section apply to A.C. three-phase supply systems with voltages in the range above 1 kV up to and including 15 kV. Nominal voltage is the voltage between phases.

(2) The high voltage electrical installations are to comply with the applicable requirements in this Chapter in addition to those in this Section.

2. High-voltage, low-voltage segregation Equipment with voltage above about 1kV is not to be installed in the same enclosure as low voltage equipment, unless segregation or other suitable measures are taken to ensure that access to low voltage equipment is obtained without danger.

1602. System Design

1. Distribution

(1) Network configuration for continuity of ship services
It is to be possible to split the main switchboard into at least two independent sections, by means of at least one circuit breaker or other suitable disconnecting devices, each supplied by at least one generator. If two separate switchboards are provided and interconnected with cables, a circuit breaker is to be provided at each end of the cable. Services which are duplicated are to be divided between the sections.

(2) Earthed neutral systems
In case of earth fault, the current is not to be greater than full load current of the largest generator on the switchboard or relevant switchboard section and not less than three times the minimum current required to operate any device against earth fault. It is to be assured that at least one source neutral to ground connection is available whenever the system is in the energised mode. Electrical equipment in directly earthed neutral or other neutral earthed systems is to withstand the current due to a single phase fault against earth for the time necessary to trip the protection device.

(3) Neutral disconnection
Means of disconnection are to be fitted in the neutral earthing connection of each generator so that the generator may be disconnected for maintenance and for insulation resistance measurement.

(4) Hull connection of earthing impedance
All earthing impedances are to be connected to the hull. The connection to the hull is to be so arranged that any circulating currents in the

earth connections do not interfere with radio, radar, communication and control equipment circuits.

(5) Divided systems
In the systems with neutral earthed, connection of the neutral to the hull is to be provided for each section.

2. Degrees of protection

(1) General
Each part of the electrical installation is to be provided with a degree of protection appropriate to the location, as a minimum the requirements of IEC Publication 60092-201.

(2) Rotating machines
The degree of protection of enclosures of rotating electrical machines is to be at least IP 23. The degree of protection of terminals is to be at least IP44. For motors installed in spaces accessible to unqualified personnel, a degree of protection against approaching or contact with live or moving parts of at least IP4X is required.

(3) Transformers
The degree of protection of enclosures of transformers is to be at least IP23 For transformers installed in spaces accessible to unqualified personnel a degree of protection of at least IP4X is required. For transformers not contained in enclosures, see **1607. 1.**

(4) Switchgear, controlgear assemblies and converters
The degree of protection of metal enclosed switchgear, controlgear assemblies and static convertors is to be at least IP32. For switchgear, control gear assemblies and static converters installed in spaces accessible to unqualified personnel, a degree of protection of at least IP4X is required.

3. Insulation

(1) Air clearance
In general, phase-to-phase air clearances and phase-to-earth air clearances between non-insulated parts of equipment are to be not less than those specified in Table as below;

Nominal Voltage(kV)	Minimum air clearance(mm)
3 (3.3)	55
6 (6.6)	90
10 (11)	120
15	160

(2) Creepage distances
Creepage distances between live parts and between live parts and earthed metal parts for standard components are to be in accordance with relevant IEC Publications for the nominal voltage of the system, the nature of the insultation material and the transient overvoltage developed by switch and fault conditions. For non-standardised parts within the busbar section of a switchgear assembly, the minimum creepage distance is to be at least 25 mm/kV and behind current limiting devices, 16 mm/kV.

4. Protection

(1) Faults on the generator side of circuit breaker
Protective devices are to be provided against phase-to-phase faults in the cables connecting the generators to the main switchboard and against interwinding faults within the generators. The protective devices are to trip the generator circuit breaker and to automatically deexcite the generator. In distribution systems with a neutral earthed, phase to earth faults are also to be treated as above.

(2) Faults to earth
Any earth fault in the system is to be indicated by means of a visual and audible alarm. Any earth fault in the system is to be indicated by means of a visual and audible alarm. In low impedance or direct earthed systems provision is to be made to automatic disconnect the faulty circuits. In high impedance earthed systems, where outgoing feeders will not be isolated in case of an earth fault, the insulation of the equipment is to be designed for the phase to phase voltage.

(3) Power transformers
Power transformers are to be provided with overload and short circuit protection. When transformers are connected in parallel, tripping of the protective devices at the primary side has to automatically trip the switch connected at the secondary side.

(4) Voltage transformers for control and instrumentation
Voltage transformers are to be provided with overload and short circuit protection on the secondary side.

(5) Fuses
Fuses are not to be used for overload protection.

(6) Low voltage systems
Lower voltage systems supplied through transformers from high voltage systems are to be protected against overvoltages. This may be achieved by:
i) direct earthing of the lower voltage system
ii) appropriate neutral voltage limiters
iii) earthed screen between the primary and secondary windings of transformers.

1603. Rotating machinery

1. Stator windings of generators

Generator stator windings are to have all phase ends brought out for the installation of the differential protection.

2 Temperature detectors

Rotating machinery is to be provided with temperature detectors in their stator windings to actuate a visual and audible alarm in a normally attended position whenever the temperature exceeds the permissible limit. If embedded temperature detectors are used, means are to be provided to protect the circuit against overvoltage.

3 Tests

In addition to the tests normally required for rotating machinery, a high frequency high voltage test in accordance with IEC Publication 60034-15 is to be carried out on the individual coils in order todemonstrate a satisfactory withstand level of the inter-turn insulation to steep fronted switching surges.

1604. Power Transformers

1. General

Dry type transformers have to comply with IEC Publication 60726. Liquid cooled transformers have to comply with IEC Publication 60076. Oil immersed transformers are to be provided with the following alarms and protections:

-liquid level (Low)-alarm
-liquid temperature (High)-alarm
-liquid level (Low)-trip or load reduction
-liquid temperature (High)-trip or load reduction
-gas pressure relay (High)-trip

1605. Cables

1. General

Cables are to be constructed in accordance with the I.E.C Publication 60092-353 and 60092-354 or other equivalent Standard.

1606. Switchgear and controlgear assemblies

1. General

Switchgear and controlgear assemblies are to be constructed according to the I.E.C Publication 60298 and the following additional requirements.

2. Construction

(1) Mechanical construction
Switchgear is to be of metal enclosed type in accordance with I.E.C Publication 60298 or of the insulation enclosed type in accordance with the I.E.C Publication 60466.

(2) Locking facilities
Withdrawable circuit breakers and switches are to be provided with mechanical locking facilities in both service and disconnected positions. For maintenance purposes, key locking of withdrawable circuit breakers and switches and fixed disconnectors is to be possible. Withdrawable circuit breakers are to be located in the service position so that there is no relative motion between fixed and moving portions.

(3) Shutters
The fixed contacts of withdrawable circuit breakers and switches are to be so arranged that in the withdrawable position the live contacts are automatically covered.

(4) Earthing and short-circuiting
For maintenance purposes an adequate number of earthing and short-circuiting devices is to be provided to enable circuits to be worked upon with safety.

3. Auxiliary systems

(1) Source of supply
If electrical energy and/or physical energy is required for the operation of circuit breakers and switches, a store supply of such energy is to be provided for at least two operations of all the components. However, the tripping due to overload or short-circuit, and under-voltage is to be independent of any stored electrical energy sources.

(2) Number of supply sources
At least one independent sources of supply for auxiliary circuits of each independent section of the system (see **1602. 1.** (1))are to be provided. Where necessary one source of supply is to be from the emergency source of electrical power for the start up from dead ship condition.

4. High voltage test

A power-frequency voltage test is to be carried out on any switchgear and controlgear assemblies. The test procedure and voltages are to be according to the IEC Publication 60298.

1607. Installation

1. Electrical equipment

Where equipment is not contained in an enclosure but a room forms the enclosure of the equipment, the access doors are to be so interlocked that they cannot be opened until the supply is isolated and the equipment earthed down. At the entrance of the spaces where high-voltage electrical equipment is installed, a suitable marking is to be placed which indicates danger of high-voltage. As regard the high-voltage electrical equipment installed outside a.m. spaces, the similar marking is to be provided.

2. Cables

(1) Runs of cables
In accommodation spaces, high voltage cables are to be run in enclosed cable transit systems.

(2) Segregation

High voltage cables are to be segregated from cables operating at different voltage ratings each other; in particular, they are not to be run in the same cable bunch, nor in the same ducts or pipes, or, in the same box. Where high voltage cables of different voltage ratings are installed on the same cable tray, the air clearance between cables is not to be less than the minimum air clearance for the higher voltage side in 2.3.1. However, high voltage cables are not to be installed on the same cable tray for the cables operating at the nominal system voltage of 1 kV and less.

(3) Installation arrangements
High voltage cables, in general, are to be installed on carrier plating when they are provided with a continuous metallic sheath or armour which is effectively bonded to earth; otherwise they are to be installed for their entire length in metallic castings effectively bonded to earth.

(4) Terminations
Terminations in all conductors of high voltage cables are to be, as far as practicable, effectively covered with suitable insulating material. In terminal boxes, if conductors are not insulated, phases are to be separated from earth and from each other by substantial barriers of suitable insulating materials.

(5) Marking
High voltage cables are to be readily identifiable by suitable marking.

(6) Test after installation
Before a new high voltage cable installation, or an addition to an existing installation, is put into service a voltage withstand test is to be satisfactorily carried out on each completed cable and its accessories. The test is to be carried out after an insulation resistance test. When a D.C. voltage withstand test is carried out, the voltage is to be not less than:
- 1.6 (2.5 Uo +2 kV) for cables of rated voltage (Uo) up to and including 3.6 kV, or
- 4.2 Uo for higher rated voltages

where Uo is the rated power frequency voltage between conductor and earth or metallic screen, for which the cable is designed.
The test voltage is to be maintained for a minimum of 15 *minutes*. After completion of the test the conductors are to be connected to earth for a sufficient period in order to remove any trapped electric charge. An insultation resistance test is then repeated. Alternatively, an A.C. voltage withstand test may be carried out upon advice from high voltage cable manufacturer at a voltage not less than normal operating voltage of the cable and it is to be maintained for a minimum of 24 *hours*.

SECTION 17
Electric Propulsion Unit

1701. General

1. Application

Rotating machines, controlgears, excitation apparatus, cables, etc. for the electric propulsion are to meet the requirements in this Section and also those in this Chapter.

2. Motor torque

(1) Torque available for manoeuvring a ship is to be capable of stopping or reversing of the ship in a reasonable time when the ship is running at the maximum service speed.
(2) Adequate torque margin is to be provided in *a.c* propulsion systems to guard against the motor to be pulled out of sychronism during rough weather and at the time of turning in a multiple-screw ship.

3. Protection against torsional vibration, etc.

Prime movers, generators, motors, shafting and propellers are to be such that harmful torsional vibrations or excessive electrical oscillations in alternating-current systems are not observed at any normal operating speed.

4. Protection against overload

Where arrangements permit a propulsion motor to be connected to the generating plant having a continuous rating greater than the motor rating, means are to be provided to prevent continuous operation at the overload or overtorque conditions not permitted to the motor and shafting.

5. Lubrication

(1) Lubrication of the bearings of propulsion motors and shafting is to be effective at all operational speeds including creep speeds.
(2) When a forced lubrication system is used for the bearings of rotating machines and prime movers, low oil pressure alarm is to be provided.

1702. Prime movers

1. General

Prime movers are to comply with the requirements of **Pt 5, Ch 2, Secs 2** and **3,** and their rated power in conjunction with their overloading facilities and load built-up facilities is to be adequate to supply the needed power during transitional changes in operating conditions of electrical equipment.

2. Speed governor

(1) Prime movers of any type are to be provided with a governor capable of maintaining the

pre-set steady speed within a range not exceeding 5% of the rated full-load speed for load changes from full-load to no load.

(2) The governors are to be such that they will automatically maintain the momentary speed within 10% of the rated speed when the full load is sud denly thrown off.

(3) In the case of parallel operation of generators, the governing system used are to permit stable operation to be maintained over the entire operational speed range of the prime movers.

(4) Where the speed control of the propeller requires speed variation of the prime mover, the governor is to permit a very gradual variation of speed within the necessary speed range and means are to be provided to enable local manual control as well as remote control of the governor.

(5) The overspeed governor is to be set to a speed in excess of the highest possible speed during periods of regenerated power, and the generator set including prime mover is to be so designed that no damage will be caused by an overspeed equal to that at which the governor is set.

1703. Rotating machines

1. General

(1) When variable speed rotating machines are fitted with an integral fan and have to be operated at speeds below the rated speed with full-load torque, full-load current, full-load excitation or the like, temperature limits according to **Table 6.1.4** are not to be exceeded.

(2) The rotors are to be so constructed that they will withstand for 2 $minutes$ at an overspeed in accordance with the requirements in **209. 5.** However, the overspeed of turbo-generators and electromagnetic slip-couplings is to be 120 % of the rated speed.

(3) The collector rings and commutators are to be suitably arranged to be maIntained easily. For purposes of inspection and repair, provision is to be made for easy access to each kind of coils and bearings, and for withdrawal and replacement of the field coils as well.

(4) Effective means are to be provided in rotating machines to prevent accumulation of moisture and condensation even when they are idle for appreciable periods.

2. Generators and motors

(1) For $A.C.$ generators and motors of 500 kW and above, embedded temperature detectors are to be provided in the stator windings, and the temperature indicator is to be mounted in a convenient position to read a temperature on the control board.

(2) For $D.C.$ motors liable to overspeed excessively, overspeed protection devices are to be provided, and the rotors are to be suitably constructed to prevent damage due to temporary overspeed.

3. Means of excitation

(1) Separately excited rotating machines are to be provided with at least 2 independent sources of excitation.

(2) The strength of shafts and couplings of exciter is to be suitable for the increased output necessary during manoeuvring and sudden short-circuit conditons.

4. Electromagnetic slip-couplings

(1) Means are to be provided to facilitate periodical checking of the air gaps of the magnetic circuit, and appropriate calibrated gauges are to be supplied for this purpose.

(2) Electromagnetic slip-couplings are to be at least of drip-proof type. Where they are of non-enclosed type, suitable means are to be taken to prevent accidental touch with rotating parts and ingress of foreign material.

1704. Control gear

1. General

(1) Control gears for propulsion equipment are to be designed for the appropriate voltages and are to include the apparatus necessary for starting, stopping, reversing and controlling the speed of motors together with essential instruments and safety devices.

(2) Where, on stopping or reversing the propeller, the regenerated energy transmitted by the propulsion motor is such as to cause a dangerous increase of speed in the prime mover, means are to be provided for suitably absorbing or limiting such energy.

(3) All levers, handles and their accessories for switches and contactors are to be of such proportions as to permit a satisfactory manual operation.

(4) All levers for operating contactors, line switches, field switches and the like are to be interlocked to prevent their wrong operation. These interlocks are to be of mechanical type as far as practicable.

(5) Where steam and oil guages are mounted on the main control assembly, provisions are to be made so that in case of leakage, steam and oil may not come into contact with the energized parts.

(6) When power-aided control is used, other suitable means are to be provided to restore control in a short time in the event of power failure.

(7) The controlgears are to be so arranged that in case of damage to the equipment outside the engine room, control can always be exe-

cuted from the engine room manoeuvring control stations.

2. Location of manoeuvring control

(1) Control of the propulsion machines may be carried out from the bridge or deck. Alternative control in the engine room is to be provided, Transfer of control to the engine room in an emergency is to be possible without excessive loss of time.

(2) When two or more control stations are provided, indicating lights are to be located at each control station to indicate which station is in control. Means are to be provided to make incapable of being operated simultaneously from different stations.

3. Main circuit and control circuit

(1) Propulsion system having two or more generator or motors respectively on one propeller shaft, is to be so arranged that any unit of them can be taken out of service and isolated electrically.

(2) Field circuits are to be provided with means of suppressing voltage rise when a field switch is opened.

4. Protection

(1) Over-current protective devices, if any, in the main circuits are to be set sufficiently high so that there is no possibility of their operating due to over-currents caused by manoeuvring or normal operation in heavy seas.

(2) Where separately driven $D.C.$ generators are connected electrically in series, means are to be provided to prevent reversal of the rotation of a generator at the failure of the driving power of its prime mover.

(3) In excitation circuits, there is to be no overload protection causing the opening of the circuit.

(4) Means are to be provided to detect sudden short circuit currents and to protect against phase unbalance. When damage likely to cause to the electrical equipment is more serious than the possible consequences of losing propulsion power, consideration is to be given to providing means for rapid reduction of the magnetic fluxes of the generators or motors.

(5) Means for earth leakage detection are to be provided for the main propulsion circuit, and these are to be arranged to operate an alarm upon the occurrence of an earth fault.

(6) Insulated excitation circuits are to be provided with earth leakage detection which may consist of voltmeters or lamps.

5. Control gears for electromagnetic slip-couplings

Control gears for electromagnetic slip-couplings are to include a two-pole disconnecting switch, short-circuit protection and an ammeter for the coupling excitation circuit. Interlocking gear is to be provided to prevent the coupling from being energized when the driving machine control levers are in an inappropriate position. Such control-gear may be combined with the prime mover speed control and reversing gears.

6. Instruments

(1) The following instruments, where required, are to be mounted in the main control assembly or any other location :

(A) For $A.C.$ systems

- Ammeter, voltmeter, indicating wattmeter and field ammeter for each propulsion generator,
- Field ammeter for each synchronous motor,
- Speed indicator for each propeller shaft,
- Temperature indicator for reading directly the temperature of each propulsion generator stator and motor stator.

(B) For $D.C.$ systems

- Ammeter for the main circuit,
- Ammeter for each generator and motor field circuit,
- Voltmeter for reading voltage in each generator, motor and exciter,
- Speed indicator for each propeller shaft.

(2) Where control outside the engine room is used, instruments necessary for operation and monitoring of the main propulsion system are to be installed at a convenient location near such a station.

1705. Cables

Conductors of cables and wiring are to consist of not less than 7 strands and conductors of a cross sectional area smaller than 1.5mm^2 are not to be installed except cables or wiring for automatic equipment not directly connected to main circuits.

1706. Testing and inspection

After electric propulsion plants are installed on board ship, sea trial is to be carried out.

SECTION 18
Tests after Installation on Board

1801. Insulation resistance test

1. Electric propulsion, auxiliary power and lighting circuits

Each circuit of electric propulsion, auxiliary power and lighting is to have insulation resistances not less than the values in **Table 6.1.25** between conductors and between each conductor and earth.

2. Internal communication circuits

Insulation resistances of internal communication

Table 6.1.25 Insulation Resistance

Load	Insulation resistance
Up to 5 A	2 $M\Omega$
Up to 10 A	1 $M\Omega$
Up to 25 A	400,000 Ω
Up to 50 A	250,000 Ω
Up to 100 A	100,000 Ω
Up to 200 A	50,000 Ω
Over 200 A	25,000 Ω

NOTE:
During the above test, any or all electric heaters, small appliance and the like connected thereto may be disconnected from the circuit.

circuits are to comply with the following requirements:

(1) Each circuit of 100 V and above is to have an insulation resistance not less than 1 $M\Omega$ between conductors and between each conductor and earth.
(2) For circuits below 100 V, the insulation resistance is to be at least 1/3 $M\Omega$.
(3) During the test for (1) and (2) any or all appliances connected thereto may be disconnected from the circuit.

3. Generators and motors

The insulation resistance of each generator and motor under working temperature is to be in accordance with the requirements in **209. 6.**

4. Switchboards

The insulation resistance of each switchboard under working temperature is to be in accordance with the requirements in **307. 5.**

1802. Performance test

1. Generators

Generators are to be tested as follows:

(1) The operation of overspeed trip and other safety devices is to be demonstrated.
(2) If generators are intended to operate in parallel, they are to be tested over a range of loading sufficient to demonstrate that load sharing and parallel operation are satisfactory. Voltage regulation is to be satisfactory.
(3) All generators are to be run at full rated load for a duration sufficient to demonstrate that temperature rises, commutation, absence of vibration and others are satisfactory.

2. Switchboards

All switches, circuit-breakers and associated equipment on the switchboard are to be operated on load to demonstrate suitability, and also section boxes and distribution boxes are to be tested as above.

3. Motors

Motors are to be tested as follows :

(1) Motors and their controlgears are to be examined under working condition that wiring, capacity, speed and operation are satisfactory.
(2) Motors driving various auxiliary machinery pumps, etc. are to be operated to demonstrate that operating characteristics are satisfactory.
(3) Motors driving cargo winches and windlasses are to hoist and lower their specified loads.

4. Lighting system

Lighting system is to be tested as follows :

(1) Circuits are to be tested to demonstrate that all lighting fittings, branch boxes, switches, plugs, receptacles and other connected fittings are in suitable operating condition.
(2) Emergency lighting circuits are is to be tested in the same manner as specified in (1) above.

5. Electric heaters and electric cooking ranges

Electric heaters, electric cooking ranges and the like are to be tested to demonstrate that the heating elements function satisfactorily.

6. Internal communication systems

Each internal communication system is to be throughly tested to demonstrate its specified functioning. Particular attention is to be paid to the tests of operation of the ship's essential electric communication systems which include engine order telegraphs, helm indicators, fire alarms, emergency signals, morse signal lamp, navigation light indicator panel and telephones.

7. Voltage drop

During above tests, it is to be ascertained that the voltage drop of feeder circuits does not exceed the values specified in **403. 2.**

SECTION 19
Spare Parts, Tools and Instruments

1901. Spare parts

1. General

(1) For the rotating machines and controlgears intended for electric propulsion plants, the spare parts mentioned in **Tables 6.1.26, 6.1.28** and **6.1.30** are to be supplied.
(2) For ship's service generators, essential service motors and their controlgears and switchboards, the spare parts mentioned in **Tables**

6.1.26 to 6.1.30, so far as applicable, are recommended to be supplied as a standard.

(3) Quantity mentioned in (1) and (2) is the quantity of spare parts for identical installation per ship.

(4) For steering gear motors and motor-generators, if no stand-by machine is installed, spare parts in **Table 6.1.27** are required in addition to the spare parts for motors enumerated in **Table 6.1.26.**

2. Emergency lighting fittings

Where the voltage of emergency lighting circuits are different from that of general service, 1 for each 2 lamps are to be supplied as the spare.

1902. Testing instruments

Ships having electrical equipment of 50 kW and above are to be provided with a 500 $Volt$ insulation resistance measuring instrument in order that the insulation may be tested at regular intervals. In addition, the following portable instruments are recommended :

(1) One portable voltmeter, $A.C.$ or $D.C.$ or both as required.

(2) One portable ammeter, $A.C.$ or $D.C.$ or both as required, with shunts or current transformers as required.

1903. Disassembling tools

Where special tools are required to adjust or to disassemble electrical equipment, one set of each tool is to be provided.

1904. Storing method

All spare parts, instruments and tools are to be packed in suitable wooden boxes or corrosion-protected steel boxes and are to be marked to indicate the contents on the surface of boxes and are to be stored in suitable locations. Where lockers are provided to store these spare parts, individual boxes may be omitted. ⚓

Table 6.1.26 Spare Parts for Generators, Exciters and Motors

Spare parts	Quantity (ea)	Remarks
Bearing or bearing linings	1 for each 4 or less	Including oil rings
Brush holders	1 for each 10 or less	
Springs	1 for each 4 or less	For brush holder
Brushes	1 for each 1	
Field coils	1 for each 10 or less	For $D.C.$ machines only. Excluding uninsulated interpoles coils
Resistors for field rheostat and discharge resistors	See **Table 6.1.28**	For generators and exciters
Armatures of cargo winch	1 for 6 or more	Stator in case of $A.C.$ cage-rotor motor. Rotor in case of $A.C.$ wound-rotor motor.
Slip-rings	1 for each kind and size	Required for rotating machines for electric propulsion only.

Table 6.1.27 Additional Spare parts for Steering Gear Motors without Stand-by Motor-Generator

Spare parts		Quantity (ea)
$D.C.$	Armatures of motors and motor-generators	1 for each size (incl. shaft and coupling)
$A.C.$	Stators of cage-rotor motors	1
	Rotors of wound-rotor motors	1 (incl. shaft and coupling)

Table 6.1.28 Spare parts for Controlgear

Spare parts	Quantity (ea)	Remarks
Contact pieces	1 for each 2 sets or less	For arcing and wear parts only
Springs	1 for each 4 or less	
Operating and shunt coils	1 for each 10 or less	
Resistors	1 for each 10 or less	For each kind and size
Fuses and their elements	See **Table 6.1.30**	
Lenses and lamps for pilot lamps	See **Table 6.1.30**	

Table 6.1.29 Spare Parts for Brakes

Spare parts	Quantity (ea)	Remark
Shoe linings and rivets	1 for each 4 or less	
Springs	1 for each 4 or less	
Coils	1 for each 10 or less	

Table 6.1.30 Spare Parts for Switchboards, Section Boards and Distribution Boards

Spare parts	Quantity (ea)	Remarks
Fuses (not renewable)	1 for each 1	Need not exceed 20
Fuse (renewable)	1 for each 10	Need not exceed 10
Fuse elements	1 for each 1	
Arcing contacts	1 for each 1	Need not exceed 10
Springs	1 for each 1	Need not exceed 10
Complete trip element assembly for moulded case thermal type circuit-breakers	1 for each 10 identical trip elements or less	Applicable where interchangeable elements are used
Complete moulded case thermal type circuit-breakers	1 for each group of 10 identical breakers or less	Applicable where non-interchangeable trip elements are used
Potential coils	1 for each kind	
Resistors	1 for each kind	
Lenses of pilot and signal lamps	1 for each 10 identical lenses or less	
Lamps for pilot and singnal lamps	1 for each 1	

CHAPTER 2
AUTOMATIC AND REMOTE CONTROL SYSTEMS

Section

SECTION 1
Automatic and Remote Controls

101. General

1. Application

(1) The requirements in this Chapter apply to the systems of automatic or remote control which are used to control the following machinery and equipment.
(A) Main engine
(B) Controllable pitch propeller
(C) Steam generating set
(D) Electric generating set
(E) Auxiliary machinery associated with machinery and equipment listed in (A) to (D)
(F) Fuel oil systems
(G) Bilge systems
(H) Deck machinery

(2) Where considered necessary by the Society, the requirements in this Chapter are correspondingly applied to the systems of automatic or remote control which are used for controlling machinery and equipment not listed in (1) (A) to (H).

2. Terminology

Terms used in this Chapter are defined as follows:

(1) **Monitoring station** (excluding control station) is a position where measuring instruments, indicators, alarms, etc. for the machinery and equipment are centralized and necessary information to grasp the operating condition of them can be obtained.
(2) **Control station** is a position which has a function as a monitoring station and from which the machinery and equipment can be controlled.
(3) **Main control station** is a control station from which the main engine is normally controlled.
(4) **Sequential control** is a pattern of control that can be carried out automatically in the predetermined sequence.
(5) **Program control** is a pattern of control that desired values can be changed in the predetermined schedule.
(6) **Local control** is direct manual control of the machinery and equipment performed at or near their locations, receiving the necessary information from the measuring instruments, indicators and so on.
(7) **Safety system** is a system which operate automatically, in order to prevent damages to the machinery and equipment in case where serious impediments to functioning should occur on them during operation so that one of the following actions will take place.
(A) Starting of stand-by machinery or equipment.
(B) Reduction of outputs of the machinery or equipment.
(C) Shutting off the fuel or power supplies thereby stopping the machinery or equipment.

3. Drawings and data

Drawings and data to be submitted are generally, as follows:

(1) Drawings and data concerning automation
(A) List of measuring points
(B) List of alarm points
(C) Control devices and safety devices
(a) List of controlled objects and controlled variables
(b) Kinds of sources of control energy (self-actuated, pneumatic, electric, etc.)
(c) List of conditions for emergency stopping, speed reduction (automatic or demand for reduction), etc.

(2) Following drawings and data for the automatic control devices and remote control devices for main engines:
(A) Operating instructions of main engines such as starting and stopping, changeover of direction of revolution, increase and decrease of output, etc.
(B) Arrangements of safety devices (including those attached to the engines) and pilot lamps
(C) Controlling diagrams

(3) Following drawings and data for the automatic control devices and remote control devices for boilers:

(A) Operating instructions of sequential control, feed water control, pressure control, combustion control and safety devices
(B) Diagrams for automatic combustion control devices and automatic feed water control devices

(4) Diagrams and operating instructions for automatic control devices for electric generating sets (automatic load sharing devices, preference tripping devices, automatic starting devices, automatic synchronous making devices, sequential starting devices, etc.)
(5) Panel arrangements of monitoring panels, alarming panels and control stands at respective control stations

102. System design

1. System design

(1) Control systems, alarm systems and safety systems are to be so designed that one fault does not result in other faults as far as practicable and the extent of the damage could be kept to a minimum.
(2) Control systems, alarm systems and safety systems are to be designed on the fail-to-safe principle. The characteristics of fail-to-safe is to be evaluated on the basis not only of the respective systems themselves and associated machinery and equipment, but also the total safety of the ship.
(3) Systems of automatic or remote control are to be sufficiently reliable under service conditions.
(4) Cables for signals are to be installed in such a manner that harmful induced interference can be avoided.
(5) It is to be possible for essential auxiliaries for propulsion of ships and for safety of lives and ships to be controlled from a local position.

2. Supply of power

(1) Supply of electric power
The supply of electric power is to be in accordance with the following:
(A) Electric supply circuits to control systems, alarm systems and safety systems are not to branch off from the power circuits and lighting circuits, except that the electric power to the control systems, alarm systems and safety systems may be supplied from the power circuits to the machinery and equipment they serve.
(B) The electric power to alarm systems and safety systems for electric generating sets is also to be supplied from an accumulator battery.

(2) Supply of oil pressure
The supply of control oil pressure is to be in accordance with the following:
(A) Sources of oil pressure are to be capable of supplying stably necessary pressure and quantity of purified oil.
(B) Overpressure preventive devices are to be provided on the delivery side of oil pressure pumps.
(C) Two or more sets of oil pressure pumps for the control of main engines and main shaftings are to be provided and they are to be so arranged that in case where one of the pumps in operation becomes out of action standby pump(s) may start automatically or may be readily remotely started. In this case, the oil pressure pumps are not to be used for the control of other machinery and equipment than main engines and main shaftings.

(3) Supply of pneumatic pressure
The supply of control air is to be in accordance with the following:
(A) Control systems are to be provided with an air reservoir having a capacity capable of supplying air to control devices at least for five minutes in the event of failure of the control air compressor.
(B) Where starting air reservoirs for main propulsion diesel engines are used as control air reservoirs, pressure reducing valves are to be duplicated.
(C) There are to be two or more sets of air compressors which may be used as a source of control air. Each air compressor is to have redundant capacity even in the event of failure of either one of them.
(D) Control air is to pass through a filter and, if necessary, a drier so that solid, oil and water may be removed to a minimum.
(E) Control air pipes are to be independent of general service air pipes and starting air pipes.

3. Environmental conditions

Systems of automatic or remote control are to be capable of withstanding the environmental conditions of the places where they are installed.

4. Control systems

(1) Independency of control systems
Control systems for main engines, boilers, electric generating sets and auxiliaries for main propulsion of the ship are to be independent each other or designed such that failure of one system does not degrade the performance of another system.
(2) Interconnection devices
In case of plural main engines, electric generating sets or important auxiliaries which are designed to be operated simultaneously in multiple under the same condition, interconnection devices may be provided between the control devices of these installations.
(3) Control characteristics
Remote control devices and automatic control

devices are to have control characteristics in conformity with the dynamic properties of the machinery and equipment they serve and to be considered not to invite malfunction and hunting due to disturbance.

(4) Interlock
Control devices are to be provided with suitable interlocking arrangements in order to prevent damages to the machinery and equipment due to anticipated malfunction and maloperation of the machinery and equipment.

(5) Change-over to manual operating
Change-over to manual operating is to comply with the following requirements:
(A) Main engines, boilers, electric generating sets and auxiliaries for main propulsion of the ship are to be so arranged as to be manually started, operated and controlled even in the event where automatic control devices become out of action.
(B) Automatic control devices are generally to be provided with provisions to stop manually the automatic function of these devices.
(C) The provisions specified in (B) are to be capable of stopping the automatic function of the automatic control devices, even where any part of the automatic control devices become out of action.

(6) Cancellation of remote control function
For remote control devices, the function of remote control is to be capable of being manually cancelled.

(7) Indication of control locations
In case where the machinery and equipment are capable of being operated from more than one station, the following requirements in (A) and (B) are to be complied with. However, this requirement need not be complied with in case the safety of the machinery and equipment and the safety at the time of maintenance work can be obtained by means of other measures considered appropriate by the Society.
(A) At each control station there is to be an indicator showing which station is in control of the machinery and equipment.
(B) Control of the machinery and equipment is to be possible only from one station at a time.

5. Alarm systems

(1) Function of alarm systems is to comply with the following requirements:
(A) In case where an abnormal condition is detected devices to issue visual and audible alarms (hereinafter referred to as “alarm devices” in this Part) are to operate.
(B) In case where arrangements are made to silence audible alarms they are not to extinguish visual alarms.
(C) Two or more faults are to be indicated at the same time.
(D) Audible alarms for machinery and equipment are to be clearly distinguishable from other audible alarms such as general alarm, fire alarm, CO_2 flooding alarm, etc.

(2) Function of the alarm systems provided in the monitoring station for main engines is to comply with the following requirements, in addition to the requirements in (1).
(A) The visual indications of visual alarms are to remain until the fault has been corrected.
(B) The acceptance of any alarm is not to inhibit another alarm.
(C) If an alarm has been acknowledged and a second fault occurs prior to the first being rectified, alarm devices are again to operate.
(D) Manual stopping of each alarm system is to be clearly indicated.

(3) Visual alarms are to be such that each abnormal condition of the machinery and equipment is readily distinguishable and so arranged that acknowledgement is clearly noticeable.

6. Safety systems

(1) Constitution of systems
Constitution of safety systems is to comply with the following requirements:
(A) The safety systems are to be, as far as practicable, provided independently of the control systems and alarm systems.
(B) The safety systems for the main engines, boilers, electric generating sets and auxiliaries for main propulsion of the ship are to be independent each other.

(2) Function of safety systems
Function of the safety systems is to comply with the following requirements:
(A) The alarm systems which have functions prescribed in **Par 5** are to operate when the safety system is put into action.
(B) In case where the safety system is put into action and the operation of the machinery or equipment is stopped, they are not to automatically restart before manual reset is made.

(3) Override arrangement
Where arrangements are provided for overriding a safety system, the following requirements in (A) and (B) are to be complied with:
(A) Visual indication is to be given at the relevant control stations of the machinery and equipment when an override is operated.
(B) The override arrangements are to be such that inadvertent operation is prevented.

7. Computers and computerized systems

Computers used for the control systems, alarm systems and safety systems for the machinery and equipment, considered necessary by the Society, are to comply with the following requirements.

(1) Reliability and maintenability
The reliability and maintenability of the sys-

tems utilizing computers are not to be inferior to those of the systems not relying upon computers.

(2) Computers

(A) The composition of computers is to be so planned that the extent of effect due to a failure of part of circuits or components is limited to a minimum as far as possible.

(B) Each component is to be protected against overvoltage (electric noise) which may intrude from an input or output terminal.

(C) Central processing units and important associating apparatus are to have self-monitoring function.

(D) Important programs and data are to be made not to come to extinction in case where electric supply from outside may temporarily stop.

(E) Computers are to be so composed as to restart in a short time in accordance with the planned order when power is restored after a power failure.

(F) Spare parts for the important composing elements which require special technique for repair work, are to be supplied by easily replaceable units.

(G) Change-over to the back-up means is to be possible easily and surely.

(3) Back-up means

(A) In case where the control of fuel (governor control, electronic injection control and so on) and remote control for the main engines are carried out by one computer, a standby computer which can be changed over and put into action in a short time in the event of failure of the computer in service is to be provided.

(B) The important safety systems utilizing computers are to be provided with back-up means which can be used in a short time in the event of failure of the computer in service.

(4) Composition of systems utilizing computers

The separation of control systems and safety systems utilizing computers is, as a rule, to comply with the requirements in **4**(1) and **6**(1), but where this is impracticable special consideration will be given each case.

103. Automatic and remote control of main engines

1. Application

The requirements in this Article apply to the devices for remote or automatic control by which the main engines or controllable pitch propellers are controlled from the navigating bridge, main control stations and so on (hereinafter referred to as “remote control devices for the main engines” in this Part)

2. Remote control devices for main engines

(1) General

The remote control devices for main engines are to be complied with the following requirements:

(A) The remote control devices for main engines are to be capable of controlling the propeller speed and the direction of thrust (the blade angle of propellers in the case of controllable pitch propellers) by means of a simple operation.

(B) The remote control devices for main engines are to be provided for each propeller. with automatic performance of all associated services, including, where necessary, means of preventing overload of the propulsion machinery, In case where, however, two or more propellers are controlled at the same time, these propellers may be controlled by means of one remote control device.

(C) In case where the speed of the main diesel engines is controlled by governors, the governors are to be adjusted so that main engine may not exceed 103% of the maximum continuous revolutions. The governors are to be capable of maintaining the safe minimum speed.

(D) In case where the program control is adopted, the program for increase and decrease of output is to be so designed that undue mechanical stresses and thermal stresses do not occur in any parts of machinery.

(E) In the remote control stations and monitoring stations for the main engines, the following instruments are to be provided:

(a) Indicators for propeller speed and direction of rotation in the case of solid propellers.

(b) Indicators for propeller speed and pitch position in the case of controllable pitch propeller.

(F) In the remote control stations for main engines, alarm devices necessary for the control of main engines are to be provided.

(2) Transfer of control

The remote control devices for main engines are to comply with the following requirements with respect to transfer of control:

(A) Each control station for main engines is to be provided with means to indicate which of them is in control.

(B) Remote control of the main engines is to be possible only from one location at a time.

(C) Transfer of control is to be possible only with order by the serving station and acknowledgement by the receiving station except for the following cases.

(a) Transfer of control between local control station for main propulsion machinery and main control station or sub-control station

(b) Transfer of control during the stopping condition of the main propulsion machinery.

(D) The transfer of control between the navigating bridge and the local or main control station is to be possible only in the local or main control station.

(E) Means are to be provided to prevent the propelling thrust from altering significantly when transferring control from one location to another except for the transfer of control described in (C) (a) and (D)

(3) Failure of remote control systems of main engines

The following requirements are to be complied with in case of failure of remote control devices for main engines:

(A) In the remote control stations for main engines alarm devices which operate in the event of failure of the remote control devices for main engines are to be provided.

(B) In the event of failure of the remote control devices for main engines, the main engines are to be possible to control locally.

(C) In the event of failure of the remote control devices for main engines, the preset speed and direction of the propeller thrust are to be maintained until the control is in operation at the main control station or the local control station, unless this is considered impracticable by the Society.

(D) In the event of failure of the remote control devices for main engines, the transfer of control to the main control station or the local control station is to be possible by a simple operation.

(E) Remote control stations for main engines are to be provided with independent emergency stopping devices for the main engines, which are effective in the event of failure of the remote control devices for main engines.

(4) Remote starting of main engines

Starting by means of remote control devices for main engines is to comply with the following:

(A) The number of starting of main engines is to satisfy the number specified in **Pt 5, Ch 6, 1001.**

(B) The remote control devices for main engines arranged to automatically start are to be so designed that the number of automatic consecutive attempts which fail to produce a start is limited to three times. In the event of failure of starting, a visual and audible alarm is to be issued at the relevant control station and the main control station or monitoring station for the main engines.

(C) Where compressed air is used for starting of the main engines, alarm devices to indicate the low starting air pressure are to be provided at the remote control station and the monitoring station for the main engines.

(D) The low starting air pressure mentioned in (C) for the operation of alarm devices is to be set at a level to permit further main engines starting operations.

3. Bridge control devices

The remote control devices for the main engines provided on the navigating bridge (hereinafter referred to as “bridge control devices” in this Part) are to comply with the following requirements:

(1) Even when the main engines are controlled from the navigating bridge, the telegraph orders at the navigating bridge are to be indicated in the main control station.

(2) The bridge control devices are to be provided with either one of the following devices in order to prevent prolonged running of main engines in critical speed range:

(A) Devices to make to pass automatically and rapidly through the critical speed range; or

(B) Alarm devices which operate in case where the main engines operate exceeding a predetermined period in the critical speed range.

4. Safety measures

(1) Safety measures for main engines

Safety measures for main engines are to comply with the following requirements:

(A) The following safety measures are to be taken to the remote control devices for the main engines:

(a) Necessary interlocking devices are to be provided to prevent serious damage due to misoperation.

(b) Where the auxiliaries for propulsion of the ship are driven by electric motors, the main engines are to be so designed as to stop automatically in the event of failure of the main source of electric power or to be capable of being stopped.

(c) The main engines are to be so arranged as not to re-start automatically when electric power is restored after the failure of the main source of electric power whereas the main engines were stopped.

(d) The remote control devices for main engines are to be so designed that the engines may not be abnormally overloaded in the event of failure of them.

(B) Stopping devices for main engines are to be provided at the monitoring station for main engines.

(2) Safety systems of main engines

Safety systems of main engines are to comply with the following requirements:

(A) A device to shut off the fuel or steam supply to the main engines (this device hereinafter being referred to as “safety device”) is not to be automatically activated except in cases which could lead to complete breakdown, serious damage or explosion.

(B) The safety systems for main engines are to be so designed as not to lose their function or as not to fail to safe, even in the event of failure of main electric source or air source.

(3) Self-reversing diesel engines

As least the following safety measures are to be taken to the remote control devices for self-reversing diesel engines:
(A) Starting operation is to be possible only when the camshaft is surely at the position of “Ahead” or “Astern”.
(B) During reversing operation, fuel is not to be injected.
(C) Reversing operation is to be conducted after “Ahead” revolution is reduced to a predetermined value.

(4) Multi-engines to single shaft
At least the following safety measures are to be taken to the remote control devices for multi-engines coupled to a single shaft:
(A) Each engine is to be provided with an overload preventive device.
(B) Each engine is not to be subjected to an abnormally unbalanced load.

(5) Engines with clutch
At least the following safety measures are to be taken to the remote control devices for engines with clutch and the overspeed preventive devices specified in **Pt 5, Ch 2, 203.** and **304.** are to be provided:
(A) In multi-engines coupled to a single shaft, the clutch is to be disengaged when the engine is stopped in an emergency. While multi-engines are operating in different directions of rotation their clutches are not to be engaged simultaneously.
(B) Engaging and disengaging of clutches are to be carried out below a predetermined value of the number of revolutions of the main engines.

(6) Engines driving controllable pitch propellers
At least the following safety measures are to be taken to the remote control devices for engines driving controllable pitch propellers and the overspeed preventive devices specified **Pt 5, Ch 2, 203.** and **304.** are to be provided:
(A) Overload preventive devices are to be provided.
(B) Starting of engines or engaging of clutches is to be performed while the propeller blades are in a neutral position.

104. Automatic and remote control of boilers

1. General

(1) The systems of automatic control for both combustion and feed water of oil-fired boilers are to comply with the requirements in **Pars 2** to **5** respectively.
(2) The systems of automatic control for either combustion or feed water of oil-fired boilers are to comply with the relevant requirements in **Par 2** or **3** as well as the requirements in **Pars 4** and **5.**
(3) Automatic control of boilers other than oil-fired boilers or having a special feature will be considered in each case.
(4) In case where boilers are remotely controlled, control devices and monitoring devices necessary for the operation of the boilers are to be provided at the relevant control stations.
(5) Remote water level indicators are to comply with the requirements in **Pt 5, Ch 5, 129.**

2. Automatic combustion control systems

(1) General
Automatic combustion control systems are to comply with the following requirements:
(A) The automatic combustion control systems are to be able to control so as to obtain planned steam amount, steam pressure and steam temperature and to secure stable combustion.
(B) The devices to control the fuel supply to meet the load imposed are to be capable of ensuring stable combustion in the controllable range of fuel supply.
(C) Where combustion control is carried out according to the pressure of the boiler, the upper limit of this pressure is to be lower than the set pressure of the safety valves.

(2) Combustion control devices for intermittent operation
The combustion control devices for intermittent operation are to comply with the following requirements and they are to operate according to the planned sequence:
(A) Before ignition on the pilot burner or before ignition on the main burner if the pilot burner is not fitted, the combustion chamber and flue are to be prepurged by air of not less than four times the volume of combustion chamber and flue up to the boiler uptake. For small boilers with only one burner, prepurge for not less than 30 *seconds* will be accepted.
(B) In case of direct ignition which is the method of ignition that the main burner is fired by ignition spark, opening of the fuel valve is not to precede the ignition spark.
(C) In case of indirect ignition which is a method of ignition that the main burner is fired by pilot burner, opening of the fuel valve for pilot burner (hereinafter referred to as “ignition fuel valve”) is not to precede the ignition spark, and opening of the fuel valve for main burner (hereinafter referred to as “main fuel valve”) is not to precede the opening of ignition fuel valve.
(D) Firing is to be surely carried out within the planned period. Main fuel valve is to be so designed as to close after opening of the valve not exceeding 10 *seconds* in the case of direct ignition and 15 *seconds* in the case of indirect ignition if the firing on the main burner has failed.
(E) Firing on main burners is to be carried out at their low firing position.
(F) After closure of the main fuel valve, post-

purge is to be carried out for not less than 20 *seconds* to ensure adequate combustion air to completely burn all fuel oil remaining between the fuel oil valve and the burner nozzle. This requirement need not be complied with in the case of auxiliary boilers where approved by the Society.

(3) Combustion control devices for the control of the number of firing burners
The combustion control devices for the control of the number of firing burners are to comply with the following requirements:
(A) Each burner is to be fired and extinguished according to the planned sequence. However, the base burner may be fired by manual operation and other burners may be fired by flame of a burner(s) already fired.
(B) The remaining fuel in the extinguished burner is to be automatically burnt up in order not to interfere the restarting. However, while the pilot burner is not fired, the remaining fuel in the base burner is not to be removed by steam or air when it is in place.
(C) The burners for main boilers are to be capable of being fired and extinguished from the main control station, except for the firing of base burner.

(4) Other combustion control devices
Other combustion control devices will be considered in each case by the Society, as well as they are to comply with the relevant requirements in (2) and (3).

3. Automatic feed water control devices

(1) The automatic feed water control devices are to be capable of controlling automatically the feed water in order to maintain the water level in the boilers in a predetermined range.

(2) Main boilers are to be provided with not less than three water level detectors used for feed water control device, remote water level indicator, low water level safety device and low-water level alarm device.

4. Safety measures

(1) Safety devices
Safety devices are to comply with the requirements in **Pt 5, Ch 5, 133. 1.**

(2) Heating of fuel oil
In case where heated fuel oil is used, an automatic temperature control device is to be provided to the heater and the boiler is to be provided with a device to shut off automatically the fuel supply to the burners or an alarm device which operates when the temperature of fuel oil falls below a predetermined value.

5. Alarms

Alarm devices are to comply with the requirements in **Pt 5, Ch 5, 133. 2.**

105. Automatic and remote control of electric generating sets

1. General

(1) Electric generating set arranged to be automatically or remotely started is to be provided with interlocking devices necessary for safe operation.

(2) Electric generating set arranged to be automatically started is to be so designed that the number of automatic consecutive attempts which fail to produce a start is limited to two times and to be provided with an alarm device which operate at the time of the failure of starting.

(3) Where automatic start of the standby generating set with automatic connection to the switchboard busbars is provided, automatic closure on to the busbars is to be limited to one attempt, in the event of the original power failure being caused by short circuit.

(4) Automatic control and remote control systems for the electric generating set, whose generator is driven by the main propulsion machinery and supplies electrical power to the electrical installations necessary for normal operating and living conditions and is operated while the main propulsion machinery is controlled by the bridge control devices, are to comply with the requirements in **Pt 6, Ch 1, 201. 2** in addition to those in this Article.

106. Automatic and remote control of auxiliary machinery

1. Automatic operation of air compressors

In case where air compressors for starting and air compressors for controlling are automatically operated, alarm devices are to be provided to indicate pressure drop in air reservoirs.

2. Automatic starting and stopping of bilge pumping arrangements

In case where the bilge pumps are capable of being started and stopped automatically, alarm devices are to be provided to indicate high level of bilge in the relevant bilge wells and running of pumps for a long time.

3. Thermal oil installations

Thermal oil installations arranged to be automatically controlled are to comply with the following:

(1) Standby pumps
Pumps listed in the following of the thermal oil installations for important use are to be provided in two sets or more. The standby pumps are to be so arranged that they can start automatically or are capable of being started without delay from the relevant monitoring station when the discharge pressure or flow rate from the working pump falls below

a predetermined value or when the pump stops.
(A) Thermal oil circulating pumps
(B) Fuel oil supply pumps

(2) Control devices
Control devices are to comply with **104. 2**(1) and (2), and also with **Pt 5, Ch 5, 202. 1** and **2.**

(3) Safety devices
Safety devices are to comply with **Pt 5, Ch 5, 201.** and **202. 5.**

(4) Alarm devices
Thermal oil installations are to be provided with alarm devices which operate in the following cases:
(A) When the safety devices required in (3) have operated.
(B) When the temperature of fuel at the inlet of burner has falled.

4. High temperature alarm for oil heaters

In case where temperature for fuel oil and lubricating oil is automatically controlled, high temperature alarm devices are to be provided, except where oils are not heated above the flashpoint.

5. Opening and closing devices for sea valves

In case where sea valves to be fitted on the shell plating below the load water line are remotely or automatically controlled, other opening and closing devices which can be easily operated even in the event of failure of the automatic or remote control devices are to be provided.

6. Liquid level alarm systems for fuel oil tanks

In case where fuel transfer to fuel oil tanks is automatically controlled, the receiving tanks are to be provided with high and low level alarm systems.

7. Mooring arrangements

In case where mooring arrangements are provided with remote control devices, the mooring arrangements are to be capable of being locally operated.

8. Fuel oil filling arrangements

In case where arrangements for filling fuel oil into respective fuel oil tanks from the outside of the ships (hereinafter referred to as “fuel oil filling arrangements” in this Part) are provided with remote control devices, the fuel oil filling arrangements are to be such as not to interfere with filling of fuel even in the event of failure of the remote control devices.

107. Tests

1. Type approval

Automatic equipment (e.g. systems of automtic devices, units and sensors) considered necessary by the Society is to be type approved, in principle, according to the test methods approved by the Society before being taken into use.

2. Shop tests of automatic equipment

After being assembled, the systems of automatic devices among automatic equipment which have been type approved according to **Par 1** are to be subjected to the following tests and the procedures of the tests are to be deemed appropriate by the Society.

(1) External examination
(2) Operation tests and performance tests
(3) Insulation resistance tests and high voltage tests (to be applied to electric devices, electronic devices and so on)
(4) Pressure tests (to be applied to hydraulic devices, pneumatic devices and so on)
(5) Other tests considered necessary by the Society.

3. On-board tests

The systems of automatic or remote control of the machinery and equipment are to be, after installed on board, confirmed that they operate effectively, respectively under as far practical condition as possible. However, part of these tests may be carried out during sea trials.

4. Sea trials

(1) Main engines
The control systems for main engines are to be subjected to the following tests:
(A) The main engines are to be subjected to starting tests, ahead-astern tests and running tests in the whole range of output, by means of the remote control devices from the main control station.
(B) In addition to output increase and decrease tests, the operation tests of the main engines using the bridge control devices are to be carried out at the discretion of the Society.
(C) In case where there are other control stations for main engines such as navigating bridge, the test on transfer of control for main engines is to be carried out during ahead and astern operations of the main engines. In case where, however, considered appropriate by the Society, the test on transfer of control to the local control stations may be carried out during stoppage of the main engines.
(D) After completion of the test on transfer of control specified in (C), it is to be shown that the main engines can be smoothly operated from the respective control stations.

(2) Boilers
The control systems for boilers are to be subjected to the following tests:
(A) With respect to the main boilers, it is to be confirmed that the feed water control devices, combustion control devices and so on can operate stably in response to load varia-

tion of the main boilers, and the main boilers can supply steam stably to the main engines, electric generating sets and auxiliaries for propulsion of the ship, without local manual operation.

(B) With respect to auxiliary boilers used for important use, it is to be confirmed that they can supply steam stably to the auxiliaries for propulsion of the ship without manual operation.

(C) In case where an exhaust gas economizer is used as a source of steam supply to a turbine for driving a generator and steam supply from a boiler is carried out automatically in the case of low power condition of the main engines, operation tests of automatic control devices for this system are to be carried out.

(3) Electric generating sets
In case where generators which supply electric power to the loads necessary for propulsion of ships and whose motive power is relying upon the propulsion systems, the systems of automatic or remote control of electric generating sets are to be subjected to operation tests.

SECTION 2
Ships Provided with Centralized Machinery Automatic Systems and Ships Provided with Unattended Machinery Automatic Systems

201. General

1. Application

The requirements in this Section apply to the following ships:

(1) The ships intended to be registered as ships provided with centralized machinery automatic systems (hereinafter such ships are referred to as “CMA–Ships” in this Section).

(2) The ships intended to be registered as ships provided with unattended machinery automatic systems (hereinafter such ships are referred to as “UMA–Ships” in this Section).

(3) Alarm systems and safety systems for gas turbines, coal-burning boilers, etc. of ships specified in (1) and (2) above will be specially considered in each case by the Society.

2. Terminology

Terms used in this Section are defined in **101. 2,** and also as follows:

(1) **Centralized control station** is a room specially provided for the purpose of operation, monitoring and controlling of main engines, generating sets, auxiliaries for propulsion of the ship and other auxiliaries considered necessary by the Society.

(2) **Unmanned machinery operation** is an operation of machinery and equipment specified in **101. 1**(1) (A) to (G) without watchkeeping personnel with the specific duty of the operation and surveillance during a predetermined period.

3. Drawings and data

For CMA–Ships and UMA–Ships, the following drawings and data are to be submitted:

(1) Drawings and data specified in **101. 3**

(2) Construction and arrangement of fire detection systems required in **202. 3**(2)

(3) Schedules of on-board tests and sea trial

202. Additional requirements for CMA–Ships

1. Centralized monitoring and controlling systems

(1) CMA–Ships are to be provided with the centralized control station which is so arranged that the safety for the machinery operation will be equivalent to that under direct supervision under all sailing conditions including manoeuvring.

(2) Following devices are to be provided in the centralized control station:

(A) Remote control devices and monitoring devices for main engines.

(B) Remote control devices and monitoring devices for boilers. In this case, the remote control devices are to be in accordance with the following:

(a) For main boilers: Control devices for the control of the number of firing burners and combustion control devices, this does not include the ignition of the main boilers. Where, however, the combustion and the number of the firing burners are automatically controlled, these control devices need not be fitted.

(b) For auxiliary boilers: Remote control devices for boilers which are required to be operated to supply steam to the turbines of exhaust gas turbo-generator set in order to maintain stable electric power in the case of low power condition of the main propulsion machinery. However, where the boilers are arranged to operate automatically, the remote control devices may be dispensed with.

(C) Remote control devices and monitoring devices for electric generating sets. In case where the equipment specified in **203. 3** is provided, the remote control devices may be dispensed with.

(D) Remote starting and stopping devices and monitoring devices for pumps necessary for operation of main engines. In case where the standby pumps for these pumps are arranged to start automatically, the remote starting and stopping devices may be dispensed with.

(E) Remote starting and stopping devices and monitoring devices for air compressors for starting of main engines and for controlling. In case where these air compressors are arranged to operate automatically, the remote starting and stopping devices may be dispensed with.
(F) Alarm devices to indicate the operation of the safety systems and faults of the machinery specified in **103.** to **106.** and **202.**
(G) Emergency stopping devices for main engines specified in **103. 2**(3) (E).
(H) Communication means specified in **Pt 5, Ch 1, 106.** and engineers' alarm specified in **Pt 5, Ch 1, 107.**
(i) Bilge alarm devices specified in **202. 2**(1) and (3).
(j) Fire alarm devices.
(k) Other devices considered necessary by the Society.

2. Prevention of flooding

(1) Bilge wells in the spaces where main engines, main shaftings, boilers, electric generating sets and auxiliaries for propulsion of the ship are situated and other spaces considered necessary by the Society are to be large enough to accommodate easily the normal drainage during operation of the machinery installations and high liquid level alarm devices are to be provided at two or more places so that the increase of bilge can be detected at normal angles of heel and trim, except for such spaces that the Society appreciated that there is no fear of flooding.
(2) Where bilge pumps are capable of being started and stopped automatically, small bilge wells may be accepted in consideration of the operating frequency of the pump.
(3) Where bilge pumps are capable of being started and stopped automatically, alarm devices are to be provided to indicate either one of the following conditions:
(A) When the influx of liquid is greater than the pump capacity.
(B) When the pump is operating more frequently than that would be normally expected.
(4) The location of the controls of any valve serving a sea inlet, a discharge below the load water line or a bilge discharge system is to be so sited as to allow adequate time for operation in case of influx of water to the spaces with the ship in the fully loaded condition, having regard to the time likely to be required in order to reach and operate such controls.

3. Fire safety measures

(1) Fuel oil arrangements and lubricating oil arrange ments installed in the spaces where main engines, boilers, electric generating sets and auxiliaries for propulsion of the ship are situated and other spaces which are considered necessary by the Society, are to comply with the requirements in the following (a) to (e), in addition to the requirements in **Pt 5, Ch 6, Secs 8** and **9.**
(A) Fuel oil piping system and lubricating oil piping system are, if necessary, to be shielded or appropriately protected in order to prevent, as far as practicable, scattering or leaking oil from touching the hot surfaces or from entering into the air inlets. The number of joints of piping sYstems is to be limited to a minimum.
(B) Leaked oils from high pressure fuel oil pipes are to be collected in suitable tanks or the like which are provided with high liquid level alarm devices.
(C) Where fuel oil service tanks are filled automa tically or by remote control, means are to be provided to prevent overflow spillages.
(D) Equipment (except for tanks) which treats flammable liquids, e.g, fuel oil purifiers, which, whenever practicable, is to be installed in a special space reserved for purifiers and their heaters, is to have arrangements to prevent overflow spillages.
(E) In case where fuel oil service tanks or settling tanks are fitted with heating arrangements, a high temperature alarm device is to be provided, if the flashpoint of the fuel oil can be exceeded.
(2) Fire detectors are to be provided at spaces where main engines, boilers, electric generating sets, auxiliaries for propulsion of the ship, steering gears, main switchboards and other equipment handling oils, and at the spaces which are deemed necessary by the Society.
(3) Except for the spaces of restricted height and where their use is specially appropriate, fire detector systems using only thermal type are not to be used.
(4) The fire detection system is to be so designed and the detectors mentioned in (2) so positioned as to detect rapidly the onset of fire in any part of these spaces and under any normal conditions of operation of the machinery installations and variations of ventilation as required by the possible range of ambient temperatures.
(5) The fire detection systems are to have self-monitoring properties and to be provided with equip ment for periodical testing.
(6) Electric power to the fire detection system is to be supplied automatically from the emergency source of electric power by a separate circuit in the case of loss of main source of electric power.
(7) The fire alarm devices are to initiate audible and visual alarms distinct in both respects from the alarms of any other system not indicating fire in sufficient places to ensure that the alarms are heard and observed on the navigating bridge and by a responsible engineer officer.

4. System design

(1) Constitution of systems
Constitution of systems is to comply with the following requirements:
(A) Control systems, alarm systems and safety systems are to be independent each other as far as practicable.
(B) Safety systems for the operation of safety devices are to be, in any case, independent of other systems.
(C) Means are to be provided for the safety systems to investigate the cause of the action of the safety systems.

(2) Alarm systems
Function of alarm systems is to comply with the following requirements:
(A) Alarm systems are to be designed with selfmonitoring properties.
(B) Alarm systems are to be capable of being tested during normal machinery operation.
(C) Where practicable, means are to be provided at convenient and accessible positions to permit the sensors to be tested without affecting the operation of the machinery.
(D) For the detection of transient faults which are subsequently self-correcting, alarms audible and visual are required to lock in until accepted.

(3) Constitution of computerized systems
Computers used for the control systems, alarm systems and safety systems are to comply with the following:
(A) The independency of the control systems, alarm systems and safety systems is to be, as a rule, in accordance with the requirements in (1), **102. 4**(1) and **6**(1) but where this is impracticable, consideration will be given in each case by the Society.
(B) With respect to the alarm systems using computers, alternative alarm systems are to be provided, or back-up means for computers are to be arranged .

5. Main propulsion diesel engines

(1) Safety devices
Safety devices are to be provided to shut off automatically fuel supply to the main propulsion diesel engines for the following conditions:
(A) Overspeed
(B) Abnormal low pressure of lubricating oil to main bearings and a thrust bearing.
(C) Abnormal low pressure of lubricating oil to crosshead bearings
(D) Abnormal low pressure of lubricating oil to camshaft
(E) Abnormal high temperature of thrust bearing pads or of bearing outlet lubricating oil
(F) Abnormal high concentration of oil mist in crankcase

(2) Reduction of speed or load
Means are to be provided to reduce the speed of or load to the main propulsion diesel engines automatically for the following conditions. Where, however, approved means, such as an alarm device demanding speed or load reduction are provided, reduction of speed or load may be effected by manual operation.
(A) High temperature or fire in the scavenge air chamber (only for 2 stroke cycle engines)
(B) High concentration of oil mist in the crankcase or high temperature of bearing
(C) Low pressure of lubricating oil to main bearings and a thrust bearing
(D) Low pressure of lubricating oil to crosshead bearings
(E) High temperature of thrust bearing pads or of bearing outlet lubricating oil
(F) Low flow of lubricating oil at each cylinder lubricator
(G) Low pressure of piston coolant inlet
(H) High temperature of piston coolant at each cylinder outlet
(I) Low flow rate of piston coolant at each cylinder outlet
(J) Low pressure of cylinder cooling water inlet
(K) High temperature of cylinder water at each cylinder outlet
(L) High temperature of exhaust gas at each cylinder outlet
(M) Other fault conditions considered necessary by the Society

(3) Prevention against crankcase explosion
Main propulsion diesel engines are to be provided with oil mist detectors, monitoring devices of bearing temperature, or alternatively other devices which are considered equivalent to those by the Society, but this requirement need not be complied with in the case of small-sized engines where approved by the Society.

(4) Standby pumps
Standby pumps for pumps for propulsion of the ship are to be so arranged as to start automatically or as to be capable of being remotely started from the centralized control station immediately in the following conditions:
(A) In lubricating oil pumps; when the delivery pressure or flow rate of the pumps in operation falls below a predetermined value.
(B) In cooling pumps (pumps used for cylinders, pistons, fuel valves and coolers) and fuel oil supply pumps; when the delivery pressure or flow rate of the pumps in operation falls below a predetermined value or when the pump stops.

(5) Alarms
Main propulsion diesel engines are to be provided with alarm devices which will operate in the event of the abnormal conditions given in **Table 6.2.1.**

6. Main propulsion steam turbines

(1) Safety devices
Safety devices are to be provided to shut off

Table 6.2.1 Main Propulsion Diesel Engines

		Monitored variables	Alarms	Remarks
Main propulsion diesel engine (and gearing)	Temperature	Cyl. coolant outlet, each cyl.	H	
		Piston coolant outlet, each cyl.	H	
		Fuel valve coolant outlet	H	
		L.O. inlet	H	
		Thrust bearing or L.O. outlet	H	
		Reduction gear L.O. inlet	H	not required when L.O. system is integrated with propulsion engine system.
		F.O. injection pump inlet or viscosity	H L	applied when viscosity control of F.O. is performed
		Exhaust gas outlet, each cyl. or deviation of each cyl. from average temperature	H	
		Scavenge air high temp. or fire	O	applied to two-stroke engines
		Air cooler air outlet	H L	
		Turbocharger each bearing L.O. outlet	H	in case of engines with a separate L.O. system
		Camshaft L.O. inlet	H	in case of crosshead engines with a separate L.O. system
	Pressure	Cyl. cooling water inlet	L	or flow L
		Piston cooling water inlet	L	
		Fuel valve coolant inlet	L	
		Piston cooling oil inlet	L	or flow L. not required when L.O. for propulsion engine system is used
		L.O. inlet	L	
		Pressure difference between inlet and outlet of L.O. strainer	H	
		Turbo charger L.O. inlet	L	not required when L.O. system is integrated with propulsion engine system.
		Reduction gear L.O. inlet	L	
		F.O. injection pump inlet	L	
		Starting air at engine inlet	L	not required when an indicator is provided to show that inter-mediate valve or automatic starting valve is open or closed.
		Cooling sea water or flow	L	
		Main bearing and thrust bearing L.O. inlet	L	
		Crosshead bearing L.O. inlet	L	in case of crosshead engines with a separate L.O. system
		Camshaft L.O. inlet	L	
	Others	Flow in cyl. lubricator	L	or stop of each lubricator, one sensor per lubricator unit
		Oil mist concentration in crankcase	H	or bearing temp. H, not required for small engines
		Failure of engine starting	O	
		Leakage from F.O. injection pipe	O	
		Oily contamination of cylinder cooling water System	O	in case where main engine cooling water is used in fuel and lubricating oil heater exchangers
		Overspeed	O	
		Wrong way	O	in case of self reversing engines
		Control-Safety-Alarm system power supply failure	O	

NOTES:
"H" and "L" mean high and low
"O" means abnormal condition occured. Same meaning is applied in **Table 6.2.1** to **6.2.8**

automatically steam supply to the main propulsion steam turbines in the following conditions:
(A) Over-speed
(B) Loss of lubricating oil pressure
(C) Low main condenser vacuum
(D) Stop of all the main boilers

(2) Reduction of speed or load
Means are to be provided to reduce the speed of or load to the main propulsion steam turbines automatically for the following conditions. Where, however, approved means, such as an alarm device demanding speed or load reduction, are provided, reduction of speed or load may be effected by the manual operation.
(A) Excessive vibration of rotor shafts or casings
(B) Excessive axial displacement of rotor shafts
(C) High condensate level in the main condenser
(D) Excessive drop of steam pressure at the inlet of the turbine

(3) Standby pumps and scooping
Standby pumps and scooping are to comply with the following requirements:
(A) Standby pumps for pumps for propulsion of the ship are to be so arranged as to start automatically or as to be capable of being remotely started from the centralized control station immediately in the following conditions:
(a) In lubricating oil pumps; when the delivery pressure or flow rate of the pumps in operation falls below a predetermined value.
(b) In condensate pumps, cooling water (oil) pumps (including circulating pumps for the main condenser) and drain pump; when the delivery pressure or flow rate of the pumps in operation falls below a predetermined value or when the pump stops.
(B) Where a scoop system is adopted, circulating pumps are to be so arranged as to start or stop automatically in either of the following conditions (a) to (c). However, this automatic start and stop will not be required if alarm devices for the indication of the following conditions adopted and changeover devices to the circulating pump are provided in the centralized control station.
(a) When the ship speed rises above or falls below a predetermined value.
(b) When the vacuum of the main condenser rises above or falls below a predetermined value.
(c) When the value determined by an other method than (a) and (b) considered by the Society rises above or falls below a predetermined value.

(4) Spinning devices
Means are to be provided to prevent the risk of distortion of the rotors, by automatic spinning or other suitable method if the propulsion turbine is stopped for a long time.

(5) Alarms
Propulsion steam turbines are to be provided with alarm devices which will operate in the event of the abnormal conditions given in **Table 6.2.2.**

7. Main boilers and auxiliary boilers

(1) Safety measures
Safety measures for boilers are to comply with the following requirements:
(A) Boilers are to be provided with the safety devices specified in **104. 4**(1).
(B) A self-closing valve is to be provided in the feed water piping of the main boiler, and is to operate automatically in the event of abnormal rise of the water level in the main boiler.
(C) Safety devices for low water level in the main boilers are to be put into action by means of a signal from either one of the two low water level detectors which are independent

Table 6.2.2 Main Propulsion Steam Turbines

Monitored variables			Alarms	Remarks
Main propulsion steam turbine (and gearing, main condenser)	Temperature	L.O. inlet	H	
		Rotor bearing or L.O. outlet	H	
		Rotor thrust bearing or L.O. outlet	H	
		Reduction gear bearing or L.O. outlet	H	
		Thrust bearing or L.O. outlet	H	
	Pressure	L.O. inlet	L	
		Main condenser vacuum	L	
		Gland steam	H L	
		Cooling sea water pressure or flow	L	
	Other	Main condenser, level	H	applied when the main condenser is situated on the same level on which the turbine is situated.
		Rotor vibration or casing vibration	H	Sensors for safety systems may be used.
		Rotor axial displacement	H	

Table 6.2.3 Boilers

Monitored variables			Alarms	Remarks
Boiler	Temperature	F.O to burners	L	or F.O. heater outlet for aux. boiler.
		Gas air heater or economizer outlet	H	applied to main boilers.
		Superheater steam outlet	H	
		Air supply casing and exhausts(uptakes)	H	applied to main boilers
	Pressure	Steam drum or superheater outlet	H	
		Forced draft	L	or stop of driving unit.
		F.O. to burners (atomizing press.)	L	applied to water tube boiler with max. working pressure exceeding 1 MPa not used for only heating and general use.
		Atomizing medium	L	
	Others	Water level	H L	
		Stop of air preheater driving unit	O	applied to main boilers
		Feed water pressure at feed water pump outlet	L	applied to water tube boiler with max. working press. exceeding 1 MPa.
		Feed water pump inlet, salinity	H	applied to ships provided with steam turbine driving generator.

Table 6.2.4 Electric Generating Sets

Monitored variables			Alarms	Remarks
Diesel engine for generator	Temperature	L.O. inlet	H	
		Coolant outlet	H	or low pressure / flow L of coolant inlet
		F.O. injection pump inlet or viscosity	H L	required when F.O. viscosity is controlled.
	Pressure	L.O. inlet	L	
		Coolant outlet or flow	L	or high temperature H of coolant outlet.
	Other	Oil mist concentration in crankcase	O	or bearing temp. H, not required for small engines.
		Leakage from F.O. injection pipe	H	
Steam turbine for generator	Temper-ature	L.O. inlet	H	
	Pressure	L.O inlet	L	
		Steam inlet	L	For steam turbine ship, applied only where extracted steam is used.
		Exhaust steam	H	
Generator	Electricity	Ampere	H	
		Voltage	H L	Sensors for controllers may be used.
		Frequency or number of revolution	H	
Propulsion generator	Electricity	Current	H	
		Voltage	H L	Sensors for controllers may be used.
		Frequency or rotational speed of generator in rpm	H	
	Temperature	Bearing L.O inlet	H	Applicable to the forced lubrication system
		Stator winding or compensating pole winding	H	Applicable to 500 kW or more
		Cooling air or cooling water outlet	H	
	Pres-sure	Bearing L.O. inlet	L	Applicable to the forced lubrication system

each other. However, another detectors may be used for other purpose.

(2) Standby pumps
Standby pumps for the following pumps necessary for operation of the main boilers and important auxiliary boilers are to be so arranged as to start automatically or as to be capable of being remotely started from the centralized control station immediately when the delivery pressure or flow rate of the pumps in operation falls below a predetermined value or when the pump stops.
(A) Feed water pumps
(B) Fuel injection pumps

(3) Alarms
Boilers are to be provided with alarm devices which will operate in the event of the abnormal conditions given in **Table 6.2.3.**

8. Electric generating sets

(1) Safety devices
Safety devices for electric generating sets are to comply with the following requirements:
(A) Diesel engines driving generators are to be provided with safety devices to shut off automati cally fuel oil supply to the engines in the following conditions:
(a) Over-speed
(b) Loss of lubricating oil pressure
(c) Abnormal high temperature (or low pressure or flow rate) of the cooling water at the outlet
(d) Abnormal high concentration of oil mist in crankcase (for engines having a maximum continuous power of not less than 2250 kW or a cylinder bore of more than 300 mm)
(B) Steam turbines driving generators are to be provided with safety devices to shut off automatically steam supply to the turbines in the following conditions:
(a) Over-speed
(b) Loss of lubricating oil pressure
(c) Abnormal high exhaust gas pressure or low condense vacuum
(d) Abnormal vibration (except where the steam is supplied by the main boiler)

(2) Alarms
Electric generating sets are to be provided with alarm devices which will operate in the event of the abnormal conditions given in **Table 6.2.4.**

9. Thermal oil installations

(1) Safety devices
Thermal oil installations are to be provided with the safety devices specified in **106. 3**(3).

(2) Alarms
Thermal oil installations are to be provided with alarm devices which will operate in the event of the abnormal conditions given in **Table 6.2.5.**

10. Controllable pitch propellers

(1) Standby pumps
Standby pumps for operation of the controllable pitch propellers are to be so arranged as to start automatically or as to be capable of being remotely started from the centralized control station immediately when the delivery pressure or flow rate of the pumps in operation falls below a predetermined value or when the pump stops.

(2) Alarms
Controllable pitch propellers are to be provided with alarm devices which will operate in the event of the abnormal conditions given in **Table 6.2.6.**

11. Prime movers driving auxiliary machinery

(1) Safety devices
Prime movers driving auxiliaries for propulsion of ships are to be so arranged as to stop in the following conditions:
(a) Over-speed
(b) Loss of lubricating oil pressure

(2) Alarms
Prime movers driving auxiliaries for propulsion

Table 6.2.5 Thermal Oil Installations

Monitored variables			Alarms	Remarks
Thermal oil installations	Fuel	Burner inlet, press.	L	
		Burner inlet, temp.	L	
	Thermal fluid	Temp.	H	
		Flow or pressure difference between outlet and inlet of heater	L	
		Expansion tank, level	L	
	Others	Flame failure	O	

Table 6.2.6 Controllable Pitch Propellers

Monitored variables			Alarms	Remarks
CPP	Hydraulic oil	Tank, level	L	
		Pressure	L	

Table 6.2.7 Engines Driving Auxiliary Machinery

Monitored variables			Alarms	Remarks
Diesel engines	Temperature	L.O. inlet	H	
		Cooling water outlet	H	or cooling water inlet, pressure (or flow) L
		F.O. injection pump inlet or viscosity	H L	applied when viscosity control of F.O. is necessary.
	Pres-sure	L.O. inlet	L	
		Cooling water inlet (or flow)	L	or cooling water outlet temp. H
	Others	Leakage from F.O. injection pipe	O	
		Oil mist concentration in crankcase	H	or bearing temp. H, not required for small engines.
Steam turbines	Temper-ature	L.O. inlet	H	
	Pressure	L.O. inlet	L	
		Steam inlet	L	For steam turbine ship, applied only when extracted steam is used.
		Exhaust steam	H	

of ships are to be provided with alarm devices which will operate in the event of the abnormal conditions given in **Table 6.2.7.**

12. Other machinery

(1) Air compressors
Air compressors are to be so arranged as to stop automatically in the event of loss of lubricating oil pressure.

(2) Heat exchangers
The following heat exchangers used for main engines, main boilers, important auxiliary boilers, generators and prime movers driving auxiliaries for propulsion of ships are to be provided with temperature control devices in order to regulate the temperatures of lubricating oil, cooling water/oil and fuel oil in a predetermined range:
(A) Lubricating oil coolers
(B) Coolers for cylinder cooling water
(C) Coolers for piston cooling water/oil
(D) Coolers for fuel valve cooling water/oil
(E) Fuel oil heaters
(F) Heaters for fuel oil purifiers
(G) Heaters for lubricating oil purifiers

(3) Alarms
Air compressors and heat exchangers in this Paragraph are to be provided with alarm devices which will operate in the event of the abnormal conditions given in **Table 6.2.8.**

13. Propulsion motors

(1) Safety devices
Safety devices are to be provided to shut off automatically power supply to the propulsion motors in the following conditions:
(A) Over-speed
(B) Loss of lublicating oil pressure
(C) Loss of control of the semiconductor converter
(D) Others as deemed necessary by the Society

(2) Reduction of speed or load
Means are to be provided to reduce the speed of or load to the propulsion motors automatically for the following conditions. Where, however, approved means, such as an alarm device demanding speed or load reduction are provided, reduction of speed or load may be effected by manual operation.
(A) Over-speed
(B) High temperature of stator winding or inter pole winding
(C) Abnormal stopping of the cooling fan for the semiconductor coverter
(D) Actuation of the semiconductor protective device for the semiconductor converter
(E) Others as deemed necessary by the Society

(3) Standby pumps
Standby pumps for the pumps necessary for operation of propulsion motors such as lubricating oil pumps and cooling water pumps are to be so arranged as to start automatically or as to be capable of being remotely started from the centralized control station immediately when the delivery pressure or flow rate of the pump in operation falls below a predetermined value.

(4) Alarms
Propulsion motors are to be provided with alarm devices which will operate in the event of the abnormal conditions given in **Table 6.2.9.**

Table 6.2.8 Other Machinery

Monitored variables			Alarms	Remarks	
Auxiliaries	-	Distilling plant, salinity	H		
		Purifier, malfunction	O		
		F.O. or L.O. heater outlet, temperature	H	or heater outlet, flow L	
		Condensate pump outlet, pressure	L	or stop of driving unit	for steam turbine ship
		Condensate pump outlet, salinity	H		
		Drain pump outlet, salinity	H		
		External desuperheater, steam temperature	H L	L is required when the steam is used for the aux. turbine relating to propulsion.	
		Deaerator, level	H L		
Tanks	F.O.	Settling tank, level	H L	H is required in case of automatic filling only. L is required to tanks having capacity not enough to 24 *hours* continuous operation.	
		Service tank, level	H L		
		Drain tank, level	H		
		Sludge tank, level	H		
		Settling tank, temperature	H	applied to tanks where heating coils are provided.	
		Service tank, temperature	H		
	L.O. and control oil	Sump tank for propulsion engine, level	L		
		Drain tank, level	H		
		Sludge tank, level	H		
		Gravity tank, level	L	applied to oil bath type stern tube bearing, exhaust gas turbocharger and reduction gears for propulsion turbines	
	Water	Cooling water expansion (make-up) tank, level	L		
		Purifier water tank, level	L		
		Cascade tank, level	L	applied to diesel ship	
		Atmospheric drain tank, level	H L	applied to steam turbine ship	
		Distilled water tank, level	L		
	Air	Starting air tank for propulsion engine, pressure	L		
		Starting air tank for generator diesel engine, pressure	L	applied to steam turbine ship	
Controls	-	Hydraulic control system, pressure	L	not required when they are Integrated with engine's L.O. system.	
		Pneumatic control system, pressure	L	not required when starting air is used with decompressing.	
		Hydraulic coupling oil in main shafting system, pressure	L		
		Control electric power, failure	O		
Bilge	-	Bilge level in machinery room and shaft tunnel	H	in the machinery room, at least two positions are to be monitored.	
		Influx of liquid is greater than the pump capacity or the pump is operating more frequently than would normally be expected	O		
Main shaftings	Temperature	Stern tube aft bearing or bearing oil in oil bath	H	or stern tube outlet oil when forced circulation system is used. applied to oil lubrication system.	
	Others	Critical speed	O		

Table 6.2.9 Electrical Equipment for Propulsion in Electric Propulsion Ships

Monitored variables			Alarms	Remarks
Propulsion motor	Temperature	Bearing L.O. inlet	H	Applicable to the forced lubrication system
		Stator winding/interpole winding	H	Applicable to 500 kW or more
		Cooling air or cooling water outlet	H	
	Pressure	Bearing L.O. inlet	L	Applicable to the forced lubrication system
		Cooling water inlet	L	Applicable to the closed circuit cooling system
	Others	Overload	O	
		Insulation of excitor circuit	L	
		Insuiation of power circuit	L	
		Loss of control power	O	
Semiconductor converter	Electricity	Output current	H	
		Output voltage	H L	Sensors for controllers may be used
		Output frequency	H	
	Temperature	Cooling air or cooling water outlet	H	
	Pressure	Cooling water inlet	L	Applicable to the closed circuit cooling system
	Others	Operation of protective device for semiconductor	O	
		Stopping of cooling fan	O	
		Loss of control power	O	

203. Additional requirements for UMA–Ships

1. General

(1) UMA–Ships are to be designed and arranged as to ensure that the safety of the ship is equivalent under all sailing conditions including manoeuvring to that of a ship operated with watchkeeping personnel at all times. The arrangements are to be capable of performing unmanned machinery operation for at least 24 consecutive *hours*.

(2) UMA–Ships are to comply with this Article in addition to those in **202.**

2. Bridge control systems

(1) Following devices are to be provided on the navigating bridge, in addition to the bridge control devices specified in **103. 3.**

(A) Bypass devices to temporarily override the function of the program control devices or other devices considered appropriate by the Society which are provided according to the requirement in (2) and an indicator to show the activation of the bypass devices.

(B) Override arrangement complying with the requirements in **102. 6**(3) for the safety system which is provided to stop the main engines automatically in the event of other abnormal condition than specified in **202. 5**(1) or **6**(1).

(C) Override arrangement complying with the requirements in **102. 6**(3) for the automatic reduction of speed of or load to the main engines specified in the **202. 5**(2) or **6**(2).

(D) Alarm devices for main engines, electric generating sets and auxiliaries for propulsion of the ship. The visual alarms may be displayed as group alarms. However, the visual alarms for automatic stoppage and for automatic reduction of speed of the main engines are to be displayed separately.

(E) Approved means such as alarm devices demanding speed or load reduction other than the group alarms specified in (d), in case where the reduction of speed of or load to the main engines specified in **202. 5**(2) and **6**(2) is performed manually.

(F) Bilge alarm devices.

(2) The bridge control devices are to be provided with program control devices or other approved means to ensure that the main engines will not suffer undue mechanical stress and thermals stress and the speed of the main engines is easily increased and decreased or easily increased. In case where, however, specially approved by the Society taking the kind of engines and so on into consideration the program control devices or other approved means may be dispensed with.

3. Continuity of electric source

(1) Where the electric power can normally be supplied by one generator, the main source of electric power are to comply with the following:

(A) Suitable load shedding arrangements are to be provided to ensure the integrity of supplies to service required for propulsion and steering as well as the safety of the ship in case where the generator is overloaded.
(B) In the case of loss of electric power of the generator in operation, adequate provision is to be made for automatic starting and connecting to the main switchboard of a standby generator of sufficient capacity to permit propulsion and steering and to ensure the safety of the ship with automatic re-starting of the important auxiliaries including sequential operations.
(C) The standby generator specified in (B) is to be capable of supplying electric power in not more than 45 *seconds* after the loss of electric power.

(2) If the electric power is normally supplied by more than one generator simultaneously in parallel operation, provision is to be made, for instance by load shedding, to ensure that, in case of loss of one of these generating sets, the remaining ones are kept in operation without overload to permit propulsion and steering, and to ensure the safety of the ship.

4. Standby pumps and scooping

(1) The standby pumps specified in **102. 2**(2)(C), **106. 3**(1), **202. 5**(4), **6**(3)(A), **7**(2), **10**(1) and **13**(3) are to be arranged so as to be automatically started in the event of failure of the pumps in operation.
(2) Where scoop system is adopted, transfer between the scoop system and the circulating pump is to be performed automatically.

5. Air compressors

(1) Starting air compressors are to be capable of operating automatically so as to maintain the pressure in the starting air reservoirs in a predetermined range.
(2) Air compressors used for charging the control air reservoirs are to be capable of operating automatically so as to maintain the pressure in the control air reservoirs in a predetermined range.

6. Means of communication

A means of vocal communication is to be provided between the navigating bridge, centralized control station, local control station and engineers' accommodations, which are to be operable even in the event of failure of the main electric power supply.

7. Alarm systems

Alarm systems are to comply with the following requirements in addition to those in **202. 4**(2).

(1) Alarm systems are to be arranged with automatic change-over to an independent standby power supply in the event of loss of the normal power supply.
(2) Failure of the normal power supply and standby power supply specified in (1) is to be indicated by independent alarms.
(3) Alarm devices are to be provided on the engineers' accommodations to indicate the fault of the main engines, electric generating sets and auxiliaries for propulsion of the ship. For this requirement the visual alarms may be displayed as group alarms.
(4) Alarm devices provided on the engineers' accommodations are to comply with the following requirements:
(A) Alarm devices are to be provided in engineers' public rooms.
(B) Alarm devices are to be provided in the respective private rooms for engineers and to have connection to each of the engineers' cabines through a selector switch, to ensure connection to at least one of those cabines.
(C) Alarm devices are to be capable of activating the engineers' alarm required by **Pt 5, Ch 1, 107.** if an alarm function has not received attention locally within a limited time.
(5) Audible alarm devices which will provide warning of faults in the machinery and equipment specified in **101. 1**(1) (A) to (G) are to be installed in the spaces where the main engines, boilers, electric generating sets, etc. are situated.
(6) The local silencing of the audible alarms on the navigating bridge or engineers' accommodations is not to silence the audible alarm required in (5) and is not to stop the alarm devices in the centralized control station.
(7) Where unmanned machinery operation is adopted, for faults in the machinery and equipment specified in **101. 1**(1) (A) to (G), alarm systems are to be such that the navigating officer on watch is made aware when:
(A) a fault has occured,
(B) the fault is being attended to, and,
(C) the fault has been rectified. However, communication system specified in **203. 6** will be accepted as a substitute for the alarm for (c).

8. Remote starting of fire pumps

There is to be immediate water delivery from the fire main system at a suitable pressure, either by remote starting of one of the main fire pumps with remote starting from the navigating bridge and fire control station, or permanent pressurization of the fire main system by one of the main fire pumps, except that the Society may waive this requirement for ships of less than 1,600 *gross tonnage* if the arrangement of the machinery space access makes it unnecessary.

204. Tests

1. Onboard tests

In CMA–Ships and UMA–Ships, the tests specified in **107. 3** are to be carried out in accordance with the schedules of onboard tests submitted in advance, and the set value for alarms, set points for operation of safety systems and so on are to be recorded in the schedules which are to be kept onboard.

2. Sea trials of CMA–Ships

At the sea trials, the tests specified in **107. 4** and other tests considered necessary by the Society are to be carried out in accordance with the schedule of sea trial submitted in advance.

3. Sea trials of UMA—Ships

(1) In the sea trials, the tests specified in **Pars 2** and **3** and other tests considered necessary by the Society are to be carried out in accordance with the schedule of sea trials submitted in advance.

(2) The main engine is to show that they can be safely and surely operated in the starting tests and ahead-astern tests and in the whole range of output, by means of the bridge control devices.

(3) The main boilers are to be subjected to the following tests during running at normal speed:
(A) It is to be confirmed that troubles such as abnormal rise of steam pressure, destruction of superheaters by fire and so on would not occur in the event of emergency stop of the main engines in the condition that the function of automatic combustion devices is stopped.
(B) It is to be confirmed that the controlling equipment maintains a safe condition or acts to the safe side, when the power source for the automatic control devices are stopped.

(4) The electric generating sets are to be subjected to the following tests while running at normal sea going speed:
(A) In case where only one electric generating set is normally used, stopping the main source of electric power by tripping the circuit breaker, it is to be confirmed that automatic starting of standby generator, automatic making of air circuit breakers and sequential starting of important auxiliaries are performed.
(B) In case where two electric generating sets are normally used, tripping the circuit breaker for one set, it is to be confirmed that preference tripping of non-important loads is performed, and propulsion and steering of the ship is maintained.

(5) The important auxiliaries are to be subjected to the following tests while controlling the main engines from the navigating bridge:
(A) Automatic starting tests of the pumps speci fied in **203. 4.**
(B) Operation tests of alarm devices, safety devices and so on, stopping the auxiliary machinery such as the pumps specified in **203. 4,** and preheaters and draft fans for main boilers, in a condition that the automatic starting devices for them is cancelled. And the tests of air preheaters and draft fans for main boilers are to be carried out while running at normal sea going speed.
(C) While running at normal sea going speed, it is to be confirmed that the control air reservoirs are capable of supplying air for at least five *minutes* after operation of low pressure alarm for control air in a condition that the automatic starting function of control air compressor is stopped.

(6) The exhaust gas economizer for supplying steam to turbine driving generator is to be subjected to the following tests:
(A) Operation tests such as steam supply from boilers and automatic starting of diesel engine driving generators, putting back rapidly the handle of main propulsion machinery to the stop position, while running at normal speed.
(B) When the main engines are put into action expeditiously, it is to be confirmed that no critical condition occurs to water separator drums, piping, steam turbines and so on.

(7) In steam turbine ships, it is to be tested that the main propulsion machinery can continue running when stopped the funtion of the water level control device for deaerator, while running at normal sea-going speed.

(8) After completion of tests of automatic devices and automatic equipment performing unmanned machinery operation under a condition as far similar to the normal sea going condition as practicable, it is to be confirmed that the machinery can be safely and surely monitored and controlled. In this case, except where the operation mode is changed over, the running condition of the machinery is not to be adjusted by means of manual operation from the centralized control station or the local control station.

SECTION 3
Automation Equipment

301. General

1. Application

(1) The requirements in this Section apply to the automatic equipment of ships which are intended to be registered as a ship provided with the provision for the purpose of man-saving specified in **302.** to **304.** (hereinafter referred to as “automation equipment”), in addition to the requirements for UMA–Ships.

(2) The systems of automatic and remote control of machinery and equipment installed on the ships provided with the automation equipment are to comply with the requirements in this

Section, in addition to those in **203.**

2. Classes of automation equipment

The automation equipment of ships provided with such equipment are to be grouped as follows according to the extent of the automation equipment.

(1) Class 1 automation equipment
(2) Class 2 automation equipment
(3) Class 3 automation equipment

3. Plans and documents

The following plans and documents are to be submitted for approval.

(1) Plans showing the construction and layout of the automation equipment
(2) Plans and documents with respect to the automatic and remote control of the automation equipment
(3) Particulars of the automation equipment.
(4) Other plans and documents considered necessary by the Society

302. Class 1 automation equipment

The ships intended to be registered as ships provided with Class 1 automation equipment are to be provided with the automation equipment specified in following **Pars 1** to **7.** However, the equipment which considered acceptable by the Society may be omitted in consideration of the purpose of the ship, the method of the cargo handling and so on.

1. Remote-controlled ballasting / deballasting arrangement

The remote-controlled ballasting/deballasting arrangements are to comply with the following requirements:

(1) Ballast pumps are to be provided with the following remote control devices, alarm devices, etc. at suitable positions and to be capable of being monitored and controlled in those positions:
(A) Speed control devices or start/stop devices of ballast pumps.
(B) Control devices necessary for ballasting and deballasting, such as opening and closing of valves.
(C) Monitoring devices for ballast tank level.
(D) Audible and visible alarm devices which operate in the following cases where ballast pumps or prime movers driving a ballast pump are located in dangerous spaces:
(a) When the lubricating oil pressure of pumps or prime movers falls abnormally (only in the case of forced lublication system).
(b) When the temperature of the bearings or the lublication oil of pumps or prime movers rises abnormally.
(c) When the temperature of stuffing box provided at the penetration parts of the bulkhead between the engine room and the cargo pump room rises abnormally.

(2) Steam turbines driving ballast pumps are to be provided with the following devices:
(A) An automatic shut-off device which operates in the overspeed of the turbine and its alarm device.
(B) An alarm device which operates in the case of abnormal increase of exhaust pressure of the turbines.

2. Automatic steering system

When the steering gear is operated with automatic pilot, the automatic steering system is to comply with the following requirements:

(1) Running indication of the automatic pilot is to be provided.
(2) The function of compass and other equipment necessary to maintain the maneuverability of ship is not to be affected.
(3) Changing over from automatic to manual steering and vice versa is to be possible at the bridge.
(4) Except for the course setting control, the actuation of any other control is not to be significantly affect the course of the ship.
(5) Means are to be incorporated to prevent unnecessary activation of the rudder due to abnormal yaw motion.
(6) The automatic pilots are to enable automatically the ship to keep a preset course by interlocking with a magnetic compass or gyrocompass.
(7) When changing over from manual to automatic steering, the automatic pilot is to be capable of bringing the ship to the preset course.
(8) Means are to be incorporated to enable rudder angle limitation, and also to be available to indicate when the angle of limitation has been reached.
(9) Audible and visual alarms are to be issued on the navigating bridge when the heading direction of a ship is deviated exceeding the course deviation of a preset amount.
(10) Audible and visual alarms are to be issued on the navigating bridge in order to indicate the failure in the power supply to the automatic pilot and the alarm system specified in (9) above.
(11) Any other items considered necessary by the Society.

3. Romote-controlled handling system for liquid cargo in bulk

The remote-controlled handling system for liquid cargo in bulk is to comply with the following requirements:

(1) For ships carrying liquid cargoes in bulk, cargo-handling centralized control stations are to be provided.
(2) Steam turbines driving cargo pumps are to be

provided with the following devices:

(A) An automatic shut-off device which operates in the overspeed of the turbine and its alarm device.

(B) An alarm device which operate in the case of abnormal increase of exhaust pressure of the turbine.

(3) At cargo-handling centralized control stations, the following remote control devices and alarm devices are to be provided:

(A) Control devices for controlling the number of revolutions of cargo pumps.

(B) Control devices necessary for loading and unloading of cargoes such as opening and closing of valves.

(C) Monitoring devices for cargo tank level.

(D) Audible and visible alarm devices which operate in the following cases in case where ballast pumps or their prime movers are located in dangerous spaces:

(a) When the lublicating oil pressure of pumps or prime movers falls abnormally (only in the case of forced lublication system).

(b) When the temperature of bearings or lubricating oil of pumps or prime movers rises abnormally.

(c) When the temperature of stuffing box at the penetrating part of pump room bulkheads (in case where pumps are driven by the prime movers installed in the engine room) has become high.

(d) When the temperature of casings of cargo oil pumps has become high.

(E) Other devices deemed necessary by the Society.

4. Power-driven opening and closing devices

Side ports, ramp ways and steel hatch covers of hatchways on weather decks (except for those of pontoon type) (hereinafter referred to as "side port, etc.") are to be provided with power-driven opening and closing devices in compliance with the following requirements:

(1) At the place where opening and closing operation is carried out, the operation necessary for opening and closing of the relevant side ports, etc. is to be easily executed.

(2) At the place where opening and closing operation is carried out, the open or closed condition of side ports, etc. is to be capable of being confirmed.

(3) In case where deemed necessary by the Society, appropriate measures to maintain the safety at the time of opening and closing operation are to be taken.

5. Automatic recording devices for main engine

Automatic recording devices for main engine are to be capable of recording the lubricating oil pressure, the cooling water temperature and other necessary information in order to ascertain the operating condition of main engine automatically.

6. Remote-controlled mooring arrangements

Remote-controlled mooring arrangements are to comply with the following requirements:

(1) Mooring winches are to be provided with the remote control devices to be capable of effectively controlling releasing and winding of mooring lines.

(2) The remote control devices specified in (1) above are to be capable of handling three or more mooring lines respectively at bow and stern on the positions where the devices are installed.

7. Air-conditioning arrangements for control stations

Air-conditioning arrangements for control stations are to have sufficient capacity to maintain a normal environmental condition in the control stations and are to be provided with alarm devices which give visual and audible alarms in the event of abnormal operation of the air-conditioning arrangements.

303. Class 2 automation equipment

The ships intended to be registered as ships provided with Class 2 automation equipment are to be provided with the automation equipment specified in the following **Pars 1** to **7** in addition to those in **302.** However, the equipment which considered acceptable by the Society may be omitted in consideration of the purpose of the ship, the method of the cargo handling and so on.

1. Remote-controlled fuel oil filling arrangements

Remote-controlled fuel oil filling arrangements(limited to the case of filling fuel oil for main engines) are to be provided with the following remote control devices, alarm devices, etc. at suitable positions and to be capable of being monitored and controlled in those positions. However, the devices specified in (1) may be omitted when the Society considers acceptable in consideration of the valve arrangements and fuel oil tanks. In this case, the devices specified in (2) and (3) are not required.

(1) Remote control devices for opening and closing of valves.

(2) Level monitoring devices for fuel oil tanks (except for portable tanks in the engine room).

(3) High level alarm devices for the fuel oil tanks (except for portable tanks in the engine room).

(4) Speed control devices for the pumps when fuel oil is filled by pumps provided on board.

2. Centralized monitoring device for refrigerating containers

The contralized monitoring device for the refrigerating containers is to be capable of carrying out the following functions for carrying refrigerating containers loaded with refrigerated cargo:

(1) Monitoring of operating condition of the refrigerating machinery, working condition of the defrosting device and inside temperature of refrigerating containers are to be clearly indicated.
(2) An alarm device which gives visual and audible alarms in the event of the abnormal conditions of inside temperature of refrigerating containers is to be provided.

3. Cargo hose handling winches

For oil tanker, the cargo hose handling winch is to be easily operated in connecting and disconnecting the cargo hoses with manifolds.

4. Automatic deck washing arrangements

For ships carring coals, ores or similar cargoes in bulk, the automatic deck washing arrangement are to be of fixed type and are to comply with the following requirements:

(1) The automatic deck washing arrangements are to be capable of washing decks and hatch covers.
(2) The deck washing machines are to have enough strength against its working pressure and enough corrosion resistance to sea water.
(3) The pipes for washing water are to be firmly fixed to the hull.

5. Remote-controlled mooring arrangements at ship-sides

Remote-controlled mooring arrangements at ship-sides are to be capable of effectively controlling three or more mooring lines both at the bow and at the stern of the ship. And they are to be located where leaving and berthing of the ship is visible by the operators.

6. Power-operated pilot ladder winding appliances

The power-operated pilot ladder winding appliances are to be capable of operating easily to wind the ladder for pilots at the control position.

7. Emergency towing rope winches

For ships carrying dangerous goods exclusively, the emergency towing rope winches are to be easily operated in heaving and releasing the emergency towing ropes, which are arranged at the time of berthing.

304. Class 3 automation equipment

The ships intended to be registered as ships provided with Class 3 automation equipment are to be provided with the automation equipment specified in the following **Pars 1** to **7** in addition to those in **302.** and **303.** However, the equipment which considered acceptable by the Society may be omitted in consideration of the purpose of the ship, the method of the cargo handling and so on.

1. Centralized monitoring systems for machinery

The centralized monitoring systems for machinery are to be capable of clearly indicating the lubricating oil pressure, the cooling water temperature and other necessary information in order to monitor the conditions of main engines, prime movers for driving generators (excluding emergency generators), main boilers, essential auxiliary boilers and other machinery which affects the propulsion of ships at the navigating bridge.

2. Centralized control systems for machinery

The centralized control systems for machinery are to be capable of effectively controlling main engines, prime movers for driving generators (excluding emergency generators), main boilers, essential auxiliary boilers and other machinery which are necessary in order to operate these machinery at the navigating bridge.

3. Remote control arrangement for main engines and steering gear at the outside of the navigating bridge

The remote control arrangements for main engines and steering gear are to be capable of effectively starting, stopping, reversing and speed controlling of main engines and effectively controlling the rudder angle at the control station outside of the navigating bridge.

4. High level alarm devices for cargo hold bilge

For ships deemed necessary by the Society, high level alarm devices which will operate in the event that the bilge reaches the pre-determined level, are to be provided.

5. Independent remote-controlled mooring arrangements

The independent remote-controlled mooring arrangements are to be capable of controlling each drum of mooring winches independently at the remote control position, in addition to the requirement in **302. 6.**

6. Towing rope winches

Towing rope winches are to be effectively operated by one man in heaving and releasing the towing ropes at the control position.

305. Tests

1. On-board tests

After installation on board, the automation equipment is to be tested under the condition as close to the actual operation as practicable and confirmed that each equipment functions appropriately. However, the tests may be carried out at the sea trial, when their testing items are considered impracticable to be conducted at occasions other than the sea trials.

2. Sea trials

In the sea trials, performance tests of specific automation equipment are to be carried out, in addition to the tests specified in **204.** of UMA–Ships in accordance with the schedule of sea trial submitted in advance. ⚓

CHAPTER 3
DYNAMIC POSITIONING SYSTEM

Section

Section 1
Genral

101. General

1. **Application** The requirements in this Chapter apply to the ships intended to be registered as ships provided with dynamic positioning system.

2. **Related requirements** In addition to complying with the requirements in this Chapter, those are to be applied respectively such as follows: For machinery installations, **Pt 5**; For electrial installtions, **Pt 6 Ch 1**; For Automatic and remote control systems, **Pt 6 Ch 2.**

3. **Classes of dynamic positioning system** Dynarnic positioning system is classed as follows:

(1) DPS(0)
(2) DPS(1)
(3) DPS(2)
(4) DPS(3)

102. Terminology

Terms used in this Chapter are defined as follows:

(1) **Dynamic positioning system** comprise the following sub-systems, control panels, and back-up systems which are necessary to dynarnically positioning the ship.
(A) Thruster units
(B) Electrical equipment
(C) Control systems
(a) Control system
(i) Remote control system
(ii) Automatic control system
(b) Measuring system
(c) Control panel

(2) **Thruster units** comprise the followings:
(A) Thruster, power transmission gears driving thruster, thruster control hardware for control of thruster speed, pitch and heading
(B) Main propellers and other propulsion units when these are included in dynarnicpositioning control mode.

(3) **Electrical installations** comprise all units necessary to supply the dynamic positioning system with power.

(4) **Control system** comprises all central hardware and software necessary to dynamically position the vessel.

(5) **Remote control system** is a semi-automatic control system, which enables the operator to give a defined thrust (force and direction) and a turning moment to the vessel.

(6) **Measuring system** comprise all hardware and softwarefor the following reference system and environmental sensor to supply information and corrections necessary to give position and heading reference.
(A) Reference system
(a) Position reference system
Position reference system is to incorporate suitable position measurement techniques which may be by means of the followings.
- Acoustic device
- Radio
- Radar
- Inertial navigation
- Satellite navigation
- Taut wire
- or, other acceptable means depending on the service conditions for which the ship is intended
(b) Heading reference system
Gyrocompass or equivalent means
(B) Environmental sensor
(a) Vertical reference sensor to measure the pitch and roll of the ship
(b) Means to ascertained the wind speed and direction acting on the ship

(7) **Control panels** comprise centrally and locally situated panels for operating the dynamic positioning system.

(8) **Performance capability rating** is calculated by the data specified in **103. 2** of the Rules and this rating indicates the percentage of time that a ship is capable of holding heading and position under a standard set of environmental conditions.

103. Drawings and data

1. **General** In the case of the ships intended to be registered as ships provided with dynamic positioning system, the drawings and data to be submitted for approval before the commencement of

work are generally as follows:

(1) Drawings
(A) Plans showing the construction and layout of the dynamic positioning system
(B) Plans with respect to the automatic and remote control of the dynamic positioning system
(a) Functional block diagrams of the control system
(b) Functional block diagrams of the measuring system
(c) Details of monitoring functions of the control system and measuring system together with a description of the monitoring functions
(d) Details of the overall alarm system
(e) Details of the control stations, e.g. control panels and consoles, including the location of the control stations
(C) Electrical diagrams for control system and measuring system
(2) Data
(A) Equipment list of dynamic positioning system (Name of equipment, model, type, Manufacturer)
(B) Failure modes and effect analysis(F. M. E. A.) data (in the case of the ships intended to be registered as ships provided with DPS(2) or DPS(3))
(C) Operation manuals (including details of the dynamic positioning system operation, installation of equipment, maintenance and fault finding procedures together with a section on the procedure to be adopted in emergency)
(D) Test schedules including the methods of testing and the test facilities

2. Performance capability rating In addition to the requirements in **Par 1** above, the following data is to be submitted when the assignment of the supplimentary notation PCR is required:

(1) Drawings
(A) Lines plan
(B) General arrangement
(C) Details of thruster arrangement
(2) Data
(A) Thruster power and thrusts
(B) Details of between thruster and thruster, between thruster and hull, and between tllruster and current interaction
(C) Design maximum environmental conditions
(D) Details of sea current loads, wave drift forces and wind forces on ship
(E) Allocation logic

SECTION 2
Requirements of Dynamic Positioning System

201. General

The ships intended to be registered as ships provided with dynamic positioning system are to be provided dynamic positioning system specified in **202.** and **203.** of the Rules.

202. Requiremnets of dynamic positioning system

1. Thruster

(1) Design and location of thruster
(A) Thrusters are to be designed to minimize potential interference with other thrusters, sensors, hull or other surfaces which could be encountered in the service for which the ship is intended.
(B) Thruster intakes are to be located at sufficient depth to reduce the possibility of ingesting floating debris and vortex forrnation.
(2) Perfomance of thruster
The response and repeatability of thrusters to changes in propeller pitch, speed or direction of rotation are to be suitable for maintaining the area of operation and the heading deviation specified.
(3) Alarm for thruster
Each thruster unit is to be provided with a high power alarm. The setting of this alarm is to be adjustable and below the maximum thruster output.

2. Electrical installations

(1) Electrical generating system
(A) Capacity of electrical generating system For electrically driven thruster, the total capacity of electrical generating system is to be not less than the maximum auxiliary load. This may be achieved by parallel operation of two or more generating sets provided that the requirements of **Ch 1, 201. 2** of the Rules are complied with.
(B) Continuity of electric source
When the electrical power requirements are supplied by one generator set, on loss of power there is to be provision for automatic starting and connection to the switchboard of a stand-by set and automatic restarting of essential auxiliary services.
(2) Electrical supply for thruster auxiliaries, control computers and measuring system
Thruster auxiliaries, control computers and measuring systems are to be served by individual circuits. Services that are duplicated are to be separated throughout their length as widely as is practical and without the use of common feeders, transformers, converters, protective devices or control circuits.
(3) Electrical supply for actuating mechanism
Steerable thrusters and thrusters having variable pitch propellers are to be provided with two independent supplies of motive power to the pitch and direction actuating mechanisms.
(4) Common source
Where the electrical auxiliary services necessary for maintaining the ship normally in oper-

ational and habitable conditions, and the electrial service necessary for operating 'e the dynamic positioning thrusters are supplied from a common source, the following requirements are to be complied with:

(A) The voltage regulation and current sharing requirements defined in **Ch 1, 205. 4.** and **5** or **206. 2** and **4** are to be maintained over the full range of power factors that may occur in service.

(B) Where silicon controlled converters (inverter, cycloconverter, rectifier, etc.) are used to feed the thruster motor and the instantaneous value of the line-to-line voltage wave-form on the a.c. auxiliary system busbars deviates by more than 10 percent of the maximum value of the fundamental harmonic, the electricalauxiliary services necessary for maintaining the ship nomally in operational and habitable conditions are to be capable of withstanding the additional temperature rise due to the harmonic distortion. Control systems, alarms and safety equipment are to operate satisfactorily with the maximum supply system waveform distortion, or be provided with suitably filtered or converted supplies.

(C) When the control system incorporates volatile memory, it is to be supplied via uninterruptible power supply.

(5) Number and rating of transformers
The number and ratings of power transformers are to be sufficient to ensure full load operation of the dynamic positioning system even when one transformer is out of service.

(6) Alarm for electrical generating system
An alarm is to be initiated at the dynamic positioning control stations when the total electrical load of all operating thruster units exeeds a preset persentage of the running generators capacity. This alarm is to be adjustable between 50 and 100 percent of the full load capacity having regard to the nurnber of electrical generators in service.

3. Control system

(1) General Minimum number of control system, reference system and environmental sensor for dynamic positioning system is to be in accordance with the **Table 6.3.1**:

(2) Control system
The control system for dynamic positioning operation is to be stable throughout its operational range and is to meet the specified performance and accuracy criteria.

(3) Measuring system
(A) Measuring systems are to be provided to ensure the specified area of operation and heading deviation can be effectively maintained.
(B) Set point for the desired heading
The deviation from the desired heading is to be adjustable, but is not to exeed the specified limits. Arrangements are to be provided to fix and identify the set point for the desired heading.
(C) Validation for measuring system
Suitable processing and comparative techniques are to be provided to validate the. control system inputs from position reference systems and other environmental sensors, to ensure the optimum performance of the dynamic positioning system.

(4) Indicators
Indicators of the following are to be provided at each station from which it is possible to control the dynamic positioning system.
(A) The heading and location of the vessel relative to the desired reference point or course
(B) Vectorial thrust output of thrusters, indivi-

Table 6.3.1 Minimum Number of Control System, Reference System and Environmental Sensor

Class	Control system		Reference system		Environmental sensor	
			Position reference system	Heading reference system	Vertical reference sensor	Means to ascertained the wind and direction
DPS(0)	Remote control system(1)	1sets	1sets	1 set	1 set	each 1 set
DPS(1)	Automatic control system(2) Remote control system(1)(2)	1sets 1sets	2sets(3)	2 set(3)	2 set(3)	each 2 set(3)
DPS(2)	Automatic control system(2)	2sets	3sets(3)(4)	2 set(3)	2 set(3)	each 2 set(3)
DPS(3)	Automatic control system(2) Emergency automatic control system(2)	2sets 1sets	3sets(3)(4)	3 set(3)	2 set(3)	each 2 set(3)

NOTES:
(1) To be provided to maintain the desired heading of the ship.
(2) To be arranged to operate independently so that a failure in one control system will not render the other control system inopeative.
(3) To be arranged to operate independently so that a failure in on reference system(or enviromental sensor) will not render the other reference system(or environmental sensor) inopeative.
(4) To be provided with at least two different measurement techniques.

sual and total
(C) Operational status of reference systems and environmental sensors
(D) Environmental conditions, e.g. wind strength and direction
(E) Available status of standby thruster units

(5) Alarms
Alarms are to be provided for the following fault conditions:
(A) Control computer system fault
(B) Automatic changeover to a standby control computer system
(C) Abnormal signal errors revealed by the validity checks required by (3) (C) of the e Rules
(D) When the ship deviates from its predetermined area of operation
(E) When the ship deviates from its predetermined heading limits
(F) Taut wire excursion limit
(G) Fault of reference system
(H) Fault of environmental sensor
(I) Automatic changeover to a standby reference system or environmental sensor.

203. Additioal requirements for dynamic positioning system

1. DPS (1)

(1) In the event of a failure of a reference system or environmental sensor, the control systems are to continue operating on signals from the remaining reference systems or environmental sensors without manual intervention.
(2) The area of operation is to be adjustable, but is not to exeed the specific lirnits which are to be based on a percentage of water depth, or if applicable a defined absolute surface movement. Arrangements are to be provided to fix and identify the set point for the area of operation.
(3) In the event of failure of the most effective thruster the ship is to be capable of maintaining its predetermined area of operation and desired heading in the environmental conditions for which the ship is designed and classed.
(4) A manually initiated emergency alarm, clearly distinguishable from all other alarms associated with the dynamic positioning system is to be provided at the dynamic positioning control station to warn all relevant personnel in the event of a total. loss of dynamic positioning capability. In this respect consideration is to be given to additional alarms being provided at locations such as the master's accommodation and operational control stations.
(5) For electrically driven thruster units, the following requirements are to be complied with:
(A) With one generating set out of action, the capacity of the remaining generating sets is to be not less than the maximum dynamic positioning load with the most effective thruster inoperative together with all electrical auxiliary services necessary for maintaining the ship in normal operational and habitable conditions.
(B) Where generating sets are arranged to operate in parallel, the supplies to, essential services are to be protected by the tripping of non-essential loads as required by **Ch 1, 305. 10** of the Rules and additionally, on loss of a running generating set, a reduction in thrust demand may be accepted provided the, arrangements are such that a sufficient level of dynamic position capability is retained to permit the manoeuverability of the ship.
(C) Indication of absorbed electrical power and available on-line generating capacity is to be provided at the main dynamic positioning control station.
(D) Means are to be provided to prevent starting of thruster motors until sufficient electrical generating capacity is available.

2. DPS(2)

(1) The requirements of **Par 1** above are to be complied with.
(2) In the event of a failure of the working system the standby control system is to be arranged to changeover automatically without manual intervention and without any adverse effect on the ship's station keeping performance.
(3) The electrical power distribution arrangements, control systems and machinery auxiliary systems are to be such that no sigle fault can result in more than a 50 percent loss of dynamic positioning capability. This is to be verified by means of F.M.E.A.
(4) For electrically driven thruster units, the following requirements are to be complied with:
(A) The requirements as specified in 1 (5) of the Rules.
(B) To carter for operating conditions whereby all the generator sets required by (A) above are not being utilized, provision is to be made for automatic starting synchronization and load sharing of a non-running generator before the load reaches the alarm level required by **202. 2** (6) of the Rules.
(5) Control, alarm and safety systems are to incorporate a computer based consequence analysis which may be continuous or at predetermined intervals and is to analyse the consequence of predetermined failures to verify that position and heading deviation remain within acceptable limits. In the event of a possible hazardous condition being indicated from the consequence analysis an alarm is to be initiated.

3. DPS(3)

(1) The requirements of **Par 2** above are to be complied with.

(2) Thruster unitsare to be installed in separate machinery compartments such that in the event of a loss of any one such compartment the ship will retain at least 50 percent of its designed dynamic positioning capability.
(3) The electrical power generating sets are to be arranged so that they are located in at least two separate machinery compartments.
(4) The switchboard supplying the dynamic positioning system is to be split into at least two equal sections each fitted in a separate compartment and capable of being connected by bus section switches.
(5) An emergency automatic control system is to be provided at an emergency control station, in a compartment separate from that for the main control station.
(6) Arrangements are to be provided such that in the event of a failure of the working and standby control systems a smooth transfer of control to the emergency control system may be effected from the emergency control station by manual means.
(7) The control and indication unit of one of the position reference systems required by the **Table 6.3.1** is to be located at the emergency control station. A repeater control and indication unit from this system is to be located at the main control station.
(8) An independent heading reference system among those required by **Table 6.3.1** is to be located at the emergency control station to provide heading reference to the emergency automatic control system.
(9) Signals from the environmental sensors required by **Table 6.3.1** are to supply the emergency automatic control system.
(10) The emergency automatic control system is to be supplied from its ownindependent uninterruptible power supplies.

SECTION 3
Testing and Inspection

301. Hydraulic Test

Thruster housing is to be tested at a hydraulic pressure of not less than 1.5 times the maximum service immersion head of water or 1.5 bar, whichever is greater.

302. On-board tests

After installation on board, the dynamic positioning system is to be tested under the condition as close to the actual operation as practicable and confirmed that each equipment functions appropriately. However, the tests may be carried out at the sea trial, when their testing items are considered impracticable to be conducted at occasions other than the sea trials.

303. Sea trials

In the sea trials, performance tests of the dynamic positioning system are to be carried out in accordance with the sea trial schedule including the followings approved by the Society.

(1) Response of the system to simulated failures of major items of control and mechanical equipment, including loss of electrical power.
(2) Response of the system under a set of predetermined manoeverse for changing of the followings:
- location of area of operation
- heading of the ship.
(3) Continuous operation of the system over a period of four to six *hours*.

304. Maintaining records and data regarding the performance capability of the dynamic positioning system

Records and data regarding the performance capability of the dynamic positioning system are to be maintained on board the ship and are to be made available at the time of the periodical survey. ⚓

PART K

FIRE PROTECTION

CHAPTER 1
FIRE PROTECTION

SECTION 1
General

101. Application

1. Construction and arrangement for fire protection are to be as specified in this Chapter. However, the construction and arrangement for fire protection in ships which come under one of the following (1) to (4) will be specially considered:

(1) Cargo ships of less than 500 tons gross tonnage;
(2) Ships not propelled by mechanical means;
(3) Fishing vessels

2. With respect to cargo ships of 500 tons gross tonnage and over, except fishing vessels, which are not engaged in international voyage and are for restricted service, the requirements in this Chapter for construction and arrangement for fire protection may be modified by the Society.

3. The Society may require additional construction and arrangement for fire protection corresponding to the purpose and construction in such ships as those for carriage of passengers.

4. With respect to the construction and arrangement for fire protection,attention is to be paid to compliance with the International Convention and the National Regulations of the country in which the ship is registered or to be registered, in addition to the requirements in this Chapter.

102. Equivalency

Alternative construction, equipment, arrangement and materials will be accepted by the Society, provided that the Society is satisfied that such construction, equipment, arrangement and materials are equivalent to those required in this Chapter.

103. Plans and documents

The following plans and documents are to be submitted to the Society for approval before the work is commenced.

(1) Plans of construction for fire protection (details of construction for fire protection and arrangements of closing appliances of openings, etc.)
(2) Plans for details of escape route and width of escape route, etc.
(3) Other plans and documents deemed necessary by the Society.

104. Definitions

For the purpose of this Chapter, the definitions are to be in compliance with the followings:

(1) **"Non-combustible material"** is a material which neither burns nor gives off inflammable vapours in sufficient quantity for self-ignition when heated to approximately 750°C, this being determined in accordance with the Guidances for Approval of Manufacturing Process and Type Approval, Etc. (hereinafter referred to as "the Guidances") given by the Society. Any other material is deemed as a combustible material.

(2) **"Standard fire test"** is a test in which specimens of the relevant bulkheads or decks are exposed in a test furnace to the temperatures corresponding approximately to the "standard time-temperature curve". The test methods for "A" class division and "B" class division are to be in accordance with the Guidances given by the Society.
The "standard time-temperature curve" means the time-temperature curve defined by the formula:

$$T = 345\,log_{10}(8t+1) + 20$$

where :
T = the average furnace remperature (°C)
t = the time (minutes)

(3) **""A" class divisions"** are divisions formed by bulkheads and decks which comply with the requirements specified in the following (a) to (d). A test of a prototype bulkhead or deck

of the division is to be required in accordance with the Guidances given by the Society, to ensure that the division is in compliance with those requirements with respect to the fire integrity and temperature rise of the division.
(a) They are to be constructed of steel or other equivalent materials;
(b) They are to be sufficiently stiffened;
(c) They are to be so constructed as to be capable of preventing the passage of smoke and flame to the end of the one-hour standard fire test;
(d) They are to be insulated with non-combustible materials approved by the Society or any organization deemed appropriate by the Society such that the average temperature of the unexposed side will not rise more than 140°C above the initial temperature, nor will the temperature, at any point including any joint, rise more than 180°C above the initial temperature, within the time corresponding to the respective classes listed below:

"A" Class	Time
A-60	60 *minutes*
A-30	30 *minutes*
A-15	15 *minutes*
A-0	0 *minutes*

(4) "**"B" class divisions**" are divisions formed by bulkheads, decks, ceilings or linings which comply with the requirements specified in the following (a) to (c). A test of a prototype division is to be required in accordance with the Guidances given by the Society, to ensure that the division is in compliance with those requirements with respect to the fire integrity and temperature rise of the division.
(a) They are to be constructed as to be capable of preventing the passage of flame to the end of the first half hour of the standard fire test;
(b) They are to be insulated so that the average temperature of the unexposed side will not rise more than 140°C above the initial temperature, nor will the temperature, at any point including any joint, rise more than 225°C above the initial temperature, within the time corresponding to the respective classes listed below:

"B" Class	Time
B-15	15 *minutes*
B-0	0 *minutes*

(c) All materials used for construction and assembly of divisions are to be non-combustible materials approved by the Society or any organization deemed appropriate by the Society, with the exception the combustible veneers may be permitted provided they meet other requirements of the Rules.

(5) "**"C" class divisions**" are divisions constructed of non-combustible materials approved by the Society or any organization deemed appropriate by the Society. The divisions need to meet neither the requirements with respect to the passage of smoke and flame nor the limitations in respect of the temperature rise.

(6) "**Continuous "B" class ceilings or linings**" are "B" class ceilings or linings which terminate only at "A" or "B" class divisions.

(7) "**Other equivalent materials**" in the terms "steel or other equivalent materials" mean any non-combustible material which, by itself or due to insulation provided, keeps structural and heat integrity properties equivalent to steel at the end of the applicable exposure to the standard fire test (e.g, aluminium alloy with appropriate insulation).

(8) "**Cargo ship**" is a ship except those which carry more than 12 passengers.

(9) "**Tanker**" is a cargo ship which carries flammable liquid cargoes in bulk.

(10) "**Ro-ro spaces**" are spaces not normally subdivided in any way extending to either substantial length or the entire length of the ship in which goods can be loaded and unloaded normally in a horizontal direction.

(11) "**Open ro-ro spaces**" are ro/ro cargo spaces either open at both ends, or open at one end and provided with adequate natural ventilation effective over their entire length through permanent openings in the side plating or on the top of deck plating to the satisfaction of the Society.

(12) "**Closed ro-ro spaces**" are ro/ro spaces which are neither open ro/ro cargo spaces nor weather decks.

(13) "**Oil fuel unit**" is the equipment used for the preparation of oil fuel for delivery to an oil-fired boiler (including inert gas generators), or equipment used for the preparation for delivery of heated oil to an internal combustion engine (including gas turbines), and includes any oil pressure pumps, filters and heaters dealing with oil at a pressure of more than 0.18 MPa *gauge*.

(14) "**Control stations**" are spaces where the ship's radio, main navigation equipment or the emergency source of power is located or where the fire indicating or fire control equipment is centralized.

(15) "**Cargo area**" is a part of the ship that contains cargo tanks, slop tanks and cargo pump rooms including pump rooms, cofferdams, ballast and void spaces adjacent to cargo tanks and also deck areas throughout the entire length and breadth of the part of the ship over

the above-mentioned spaces.

(16) "**Public spaces**" are those portions of the accommodation which are used for halls, dining rooms, lounges and similar permanently enclosed spaces.

(17) "**Accommodation spaces**" are those spaces used for public spaces, corridors, lavatories, cabins, offices, hospitals, cinemas, games and hobbies rooms, barbershops, pantries containing no cooking appliances and similar spaces.

(18) "**Service spaces**" are those spaces used for galleys, pantries containing cooking appliances, lockers, mail and specie rooms, store-rooms, workshops other than those forming part of the machinery spaces and similar spaces and trunks to such spaces.

(19) "**Machinery spaces of category A**" are those spaces and trunks to such spaces which contain:
(a) internal combustion machinery used for main propulsion; or
(b) internal combustion machinery used for purposes other than main propulsion where such machinery has in the aggregate a total power output of not less than 375kW[510PS]; or
(c) any oil-fired boiler or oil fuel unit; or
(d) oil-fired equipment other than boilers, such as inert gas generators, incinerators, waste disposal units, etc.

(20) "**Machinery spaces**" are all machinery spaces of category A and all other spaces containing propelling machinery, boilers, oil fuel units, steam and internal combustion engines, generators and major electrical machinery, oil filling stations, refrigerating, stabilizing, ventilation and air conditioning machinery, and similar spaces, and trunks to such spaces.

SECTION 2
Construction for Fire Protection

201. General

1. The space containing the fire pump is not to be contiguous to the boundaries of machinery spaces of category A or those spaces containing main fire pumps. Where this is not practicable, the common bulkhead between the two spaces is to be insulated to a standard of structural fire protection equivalent to that required for a control station in **304.**

2. No direct access is to be, in principle, permitted between the machinery space and the space containing the emergency fire pump and its source of power. In case where this is impracticable, the access means are to be ensured by means of an airlock, each of the two doors being self-closing, or through a watertight door capable of being operated from a space remote from the machinery space and the space containing the emergency fire pump and unlikely to be cut off in the event of fire in those spaces. In such cases, a second means of access to the space containing the emergency fire pump and its source of power is to be provided.

3. In case where the fire-extinguishing medium for the fixed gas fire-extinguishing systems is stored outside a protected space, it is to be stored in a room which is to be situated in a safe and readily accessible position and is to be effectively ventilated to the satisfaction of the Society. Any entrance to such a storage room is preferably to be from the open deck and in any case is to be independent of the protected space. Access doors are to open outwards, and bulkheads and decks which form the boundaries between such rooms and adjoining enclosed spaces are to be gastight, including doors and other means of closing any opening therein. The boundaries of this storage room are to have fire integrity required for a control station in application of **Tables 8.1.1** and **8.1.2.**

4. The requirements in the following (1) to (6) are to apply to machinery spaces:

(1) The number of skylights, doors, ventilators, openings in funnels to permit exhaust ventilation and other openings to machinery spaces are to be reduced to a minimum consistent with the needs of ventilation and the proper and safe operation of the ship.

(2) Skylights are to be of steel and are not to contain glass panels. Suitable arrangements are to be made to permit the release of smoke in the event of fire from the space to be protected.

(3) Windows are not to be fitted on the machinery space boundaries. Glass windows, however, may be fitted on the walls of control rooms which do not form the boundaries of machinery spaces.

(4) Means of control are to be provided for:
(a) Opening and closing skylights, closing openings in funnels which normally allow exhaust ventilation, and closing ventilator dampers;
(b) Permitting the release of smoke;
(c) Closing power-operated doors or actuating release mechanism on doors other than power-operated watertight doors;
(d) Stopping ventilating fans; and
(e) Stopping forced and induced draught fans, oil fuel transfer pumps, oil fuel unit pumps and other similar fuel pumps.

(5) The means of control required in (4) are to be located outside the space concerned, where they will not be cut off in the event of fire in the space they serve.

(6) In case where an access to any machinery space of category A from an adjacent shaft tunnel is provided at a low level, there is to

Table 8.1.1 Fire Intergrity of Bulkheads Separating Adjacent Spaces

Spaces	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Control stations (1)	A-0[5]	A-0	A-60	A-0	A-15	A-60	A-15	A-60	A-60	⁎	A-60
Corridors, lobbies (2)		C	B-0	A-0[3] B-0	B-0	A-60	A-0	A-0	A-0	⁎	A-30
Accommodation spaces (3)			C[1,2]	A-0[3] B-0	B-0	A-60	A-0	A-0	A-0	⁎	A-30
Stairways (4)				A-0[3] B-0	A-0[3] B-0	A-60	A-0	A-0	A-0	⁎	A-30
Service spaces (low risk)(5)					C	A-60	A-0	A-0	A-0	⁎	A-0
Machinery spaces of category A(6)						⁎	A-0	A-0[7]	A-60	⁎	A-60[6]
Other machinery spaces (7)							A-0[4]	A-0	A-0	⁎	A-0
Cargo spaces (8)								⁎	A-0	⁎	A-0
Service spaces (high risk) (9)									A-0[4]	⁎	A-30
Spaces on open decks (10)											A-0
Ro-ro and vehicle spaces(11)											⁎[8]

NOTES:
The superscripts to the notations for fire integrity and asterisks are as specified below:
1 : In the methods IIC and IIIC of fire protection, "C" class bulkheads are not required.
2 : "B-0" class divisions are to be provided in the space where the area protected by the method IIIC exceeds 50 m^2 or between a group of spaces contained in the subdivisions protected by the method IIIC.
3 : For clarification of application, refer to **303.** and **305.**
4 : In case where the adjacent spaces are of the same category, the bulkheads of the class specified in the table are required only when the adjacent space is used for a different purpose. For example, in case of category (9), a galley next to a galley does not require a bulkhead, but a galley next to a paint room requires "A-0" class bulkhead.
5 : Bulkheads separating the wheelhouse, chart room and radio room each other may be of "B-0" class.
6 : In case where no dangerous goods are intended to be carried or where dangerous goods are stowed not less than 3 m horizontally apart from the bulkhead, the bulkhead may be of "A-0" class.
7 : As for cargo spaces intended to carry dangerous goods, the requirements in **312.** apply instead of this **Table.**
8 : Bulkheads separating ro-ro spaces are to be capable of being closed reasonably gastight and in case where deemed reasonable and practicable by the Society, these divisions are to have "A" class fire integrity.
⁎ : Where an asterisk appears in the **Table,** the division is required to be of steel or other equivalent materials, but is not required to be of "A-0" class.

Table 8.1.2 Fire Integrity of Decks Separating Adjacent Spaces

Spaces above deck / Spaces below deck	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Control stations (1)	A-0	A-0	A-0	A-0	A-0	A-60	A-0	A-0	A-0	⁎	A-60
Corridors, lobbies (2)	A-0	⁎	⁎	A-0	⁎	A-60	A-0	A-0	A-0	⁎	A-30
Accommodation spaces (3)	A-60	A-0	⁎	A-0	⁎	A-60	A-0	A-0	A-0	⁎	A-30
Stairways (4)	A-0	A-0	A-0	⁎	A-0	A-60	A-0	A-0	A-0	⁎	A-30
Service spaces (low risk)(5)	A-15	A-0	A-0	A-0	⁎	A-60	A-0	A-0	A-0	⁎	A-0
Machinery spaces of category A (6)	A-60	A-60	A-60	A-60	A-60	⁎	A-60[9]	A-30	A-60	⁎	A-60
Other machinery spaces (7)	A-15	A-0	A-0	A-0	A-0	A-0	⁎	A-0	A-0	⁎	A-0
Cargo spaces (8)	A-60	A-0	A-0	A-0	A-0	A-0	A-0	⁎	A-0	⁎	A-0
Service spaces (high risk)(9)	A-60	A-0	A-0	A-0	A-0	A-60	A-0	A-0	A-0[4]	⁎	A-30
Spaces on open decks (10)	⁎	⁎	⁎	⁎	⁎	⁎	⁎	⁎	⁎	⁎	⁎
Ro-ro and vehicle spaces(11)	A-60	A-30	A-30	A-30	A-0	A-60	A-0	A-0	A-30	⁎	⁎[8]

NOTES:
The superscripts to the notations for fire integrity and asterisks are as specified below:
4, 8 : In the Notes to **Table 8.1.1,** "bulkhead" is to be read as "deck".
9 : As for the machinery spaces of category (7), in case where the Society deems there is little risk of fire, insulation need not be fitted.
⁎ : As specified in the Notes to **Table 8.1.1.**

be provided in the shaft tunnel, near the watertight door, a light steel fire-screen door operable from each side.

5. As far as practicable, fuel oil tanks are to form a part of the ship's structure and are to be located outside the machinery spaces of category A. In case where fuel oil tanks, other than double bottom tanks, are necessarily located adjacent to or within the machinery spaces of category A, the tanks are to comply with the following (1) to (3):

(1) at least one of the vertical sides of the tanks is to be contiguous to the machinery space boundaries, and the area of the tank boundary common with the machinery spaces is to be kept to a minimum;

(2) the bottom of tanks is to have a common boundary with the double bottom tanks; and

(3) where such tanks are situated within the boundaries of machinery spaces of category A, they are not to contain fuel oil having a flashpoint of less than 60°C.

In principle, the use of free standing fuel oil tanks is to be avoided. However, where such tanks are necessarily employed, they are to be placed in an oil-tight spill tray of ample size having a suitable drain pipe leading to a suitably sized spill oil tank.

6. In case where "A" class divisions are penetrated for the passage of electric cables, pipes, trunks, ducts, etc., or for the provisions of girders, beams or other structural members, arrangements are to be made to ensure that the fire resistance is not impaired.

7. (1) In case where "B" class divisions are penetrated for the passage of electric cables, pipes, trunks, ducts, etc., or for the fitting of ventilation terminals lighting fixtures and similar devices, arrangements are to be made to ensure that the fire resistance is not impaired.

(2) Pipes penetrating "A" or "B'' class divisions are to be of materials approved by the Society having regard to the temperature such divisions are required to withstand.

8. Materials readily rendered ineffective by heat are not to be used for overboard scuppers, sanitary discharges and other outlets which are close to the waterline and where the failure of the materials in the event of fire would give rise to danger of flooding.

9. In spaces where permeation of oil is possible, the surface of insulation is to be impervious to oil or oil vapours.

10. As for the machinery spaces of UMA ships, in case where deemed necessary by the Society having regard to the danger of fire in the spaces, fire protecting measures deemed appropriate by the Society are to be provided.

11. For the protection of cargo tanks carrying crude oil and petroleum products having a flashpoint not exceeding 60°C, materials readily rendered ineffective by heat is not to be used for valves, fittings, tank opening covers, cargo vent piping, and cargo piping so as to prevent the spread of fire to the cargo.

12. The requirements for helicopter facilities are to be in accordance with the Guidances relating to the Rules given by the Society.

SECTION 3
Requirements for Cargo Ships

301. Application

The construction and arrangement for fire protection for cargo ships are to be in accordance with the requirements in this Section as well as those in **Secs 1** and **2.**

302. Construction

1. The hull, superstructures, structural bulkheads, decks and deckhouses are to be constructed of steel or other equivalent materials.

2. The insulation of aluminium alloy components of "A" or "B" class divisions, except structures deemed non-load bearing by the Society, is to be such that the temperature of the structural core does not rise more than 200°C above the ambient temperature at any time during the applicable exposure to the standard fire test.

3. The insulation of aluminium alloy components of columns, stanchions and other structural members supporting lifeboat and liferaft stowage, launching and embarkation areas, and "A" and "B" class divisions, is to be in compliance with the requirements specified in the following (1) and (2) respectively:

(1) As for the members supporting lifeboat and liferaft stowage, launching and embarkation areas, and "A" class divisions, the temperature is not to rise above the limit specified in **Par 2** within one hour after the commencement of the standard fire test; and

(2) As for the members supporting "B" class divisions, the temperature is not to rise above the limit specified in **Par 2** within 30 minutes after the commencement of the standard fire test.

4. Crowns and casings of machinery spaces of category A are to be of steel construction adequately insulated and in case where openings are provided on the crowns and casings, they are to be suitably arranged and protected to prevent the spread of fire.

5. As for the protection of accommodation spaces and service spaces, one of the methods specified in the following (1) to (3) is to be adopted:

(1) Method ⅠC - All internal divisional bulkheads are constructed as non-combustible "B" or "C" class division without the installation of any automatic sprinkler system including fire detecting and fire alarming equipment in the accommodation spaces and service spaces.
(2) Method ⅡC - All spaces in which fire might be expected to originate are provided with an automatic sprinkler system including fire detecting and fire alarming equipment of approved type for the purpose of fire detecting and extinguishing.
(3) Method ⅢC - All spaces in which fire might be expected to originate are provided with a fixed fire detecting and alarming system of approved type. The area of the accommodation spaces divided by "A" or "B" class divisions, however, is not to exceed $50m^2$ in any case, unless the Society would accept specially the increase of the area for public spaces.

6. The requirements for the use of non-combustible materials in construction of the boundary bulkheads of machinery spaces, control stations, service spaces, etc., those for the insulation of these bulkheads and those for the protection of stairway enclosures and corridors are commonly to apply to three kinds of protecting methods specified in **Par 5.**

303. Bulkheads within the accommodation spaces and service spaces

1. The bulkheads required to be "B" class divisions are to extend from deck to deck and to the shell or other boundary walls, unless continuous "B" class ceilings or linings are fitted on both sides of the bulkheads in which case the bulkheads may terminate at the continuous ceiling or lining.

2. Method ⅠC - Bulkheads not required to be "A" or"B" class divisions in accordance with the requirements in this Chapter, are to be of at least "C"class construction.

3. Method ⅡC - Even if bulkheads are not required to be "A" or "B" class divisions in accordance with the requirements in this Chapter, in case where "C" class divisions are required in accordance with **Tables 8.1.1** and **8.1.2,** they are to be of at least "C" class construction.

4. Method ⅢC - Even if bulkheads are not required to be "A" or "B" class divisions in accordance with the requirements in this Chapter, in case where "C" class divisions are required in accordance with **Tables 8.1.1** and **8.1.2,** they are to be of at least "C" class construction. The area of the accommodation spaces divided by "A" or "B" class divisions, however, is not to exceed $50m^2$ in any case, unless the Society would accept specially the increase of the area for public spaces.

304. Fire integrity of bulkheads and decks

1. The application of **Tables 8.1.1** and **8.1.2** specified for the fire integrity of bulkheads and decks which separate the adjacent spaces, is to be in accordance with the following requirements. In application of the standard of fire integrity, the respective spaces are classified into the following categories (1) to (11) in accordance with the risk of fire. The title of each category is intended to be typical rather than restrictive.

Category	Description
(1) Control stations	· Spaces containing emergency source of power and lighting · Wheelhouse and chart room · Radio room · Spaces containing fire indicating equipment, fire alarming equipment and fire control equipment · Control station for propulsion machinery provided outside the machinery space
(2) Corridors and lobbies	–
(3) Accommodation spaces	· Excluding corridors and lobbies
(4) Stairways	· Interior stairways, lifts and escalators (excluding those wholly contained within the machinery spaces) and enclosures thereto. In this connection, a stairway which is enclosed only at one level is to be regarded as part of the space from which it is not separated by the fire door.
(5) Service spaces (low risk)	· Lockers and store rooms not having provisions for the storage of flammable liquids and having areas less than $4m^2$ and drying rooms and laundries
(6) Machinery spaces of category A	–
(7) Other machinery spaces	· Machinery spaces excluding the machinery spaces of category A
(8) Cargo spaces	· Spaces for cargoes (including cargo oil or other liquid cargo tanks), trunks and hatchways, excluding ro-ro spaces listed in Category (11)
(9) Service spaces (high risk)	· Galleys, pantries containing cooking appliances, paint and lamp rooms, lockers and store rooms having areas of $4m^2$ or more, spaces for the storage of flammable liquids, and workshops other than those forming part of the machinery spaces

(10) Spaces on open decks	· Spaces on open decks, enclosed promenades without risk of fire and spaces outside the superstructures and deckhouses
(11) Ro-ro spaces	· Spaces as defined in **104.** (10) and spaces other than ro-ro spaces intended for carriage of motor vehicles with fuel in their tanks for their own propulsion

2. Continuous "B" class ceilings or linings, in association with the decks or bulkheads protected by them, may be accepted as contributing, wholly or in part, to the fire integrity required for the divisions.

3. External boundaries which are required to be of steel or other equivalent materials in accordance with the requirements in **302. 1** may be fitted with windows and side scuttles, unless required for "A" class fire integrity in this Section. The materials of the doors provided in the boundaries of this kind may be to the satisfaction of the Society.

4. Terminal points and intersections of insulated bulkheads and decks are to be properly treated to the satisfaction of the Society taking into consideration heat transmission.

305. Protection of stairways and lift trunks in accommodation spaces, service spaces and control stations

1. Stairways which penetrate only one layer of deck are to be protected at least at one level by at least "B-0" class divisions and self-closing doors. Lifts which penetrate only one layer of deck are to be enclosed by "A-0" class divisions with steel doors at both levels. Stairways and lift trunks which penetrate more than one layer of deck are to be enclosed by at least "A-0" class divisions, and further, be protected by self closing doors at all levels.

2. In ships provided with accommodation for 12 persons or less, where stairways penetrate two or more layers of deck and where at least two escape routes direct to the open deck are provided at every accommodation level, the Society may reduce the "A-0" class divisions required in accordance with the requirements in **Par 1** to "B-0" class divisions.

3. Stairways are to be of steel framing construction except where the Society permits the use of other equivalent materials.

306. Doors in fire-resisting divisions

1. The fire resistance of doors is to be equivalent to that of the division in which they are fitted. Doors and door frames in "A" class divisions are to be constructed of steel. Doors in "B" class divisions are to be of non-combustible materials. Doors fitted in boundary bulkheads of machinery spaces of category A are to be of reasonably gastight and self-closing type. In ships constructed in accordance with the method ⅠC, the Society may permit the use of combustible materials for doors separating interior sanitary spaces for individual use such as shower rooms from cabins.

2. Doors required to be of self-closing type are not to be fitted with holdback hooks. However, release devices provided with remote control means of fail-safe type may be used.

3. In corridor bulkheads, ventilation openings may be provided only in the lower half of or under the doors of cabins and public spaces. In this case, the aggregated area of ventilation openings is not to exceed 0.05 m^2. In case where ventilation openings are provided in the doors, grilles made of non-combustible materials are to be fitted thereupon.

4. Watertight doors need not be insulated.

307. Ventilation systems

1. Ventilation ducts are to be of non-combustible materials. Ducts, however, not exceeding 2 m in length and not exceeding 0.02 m^2 in cross-sectional area need not be of non-combustible materials, subject to the conditions in the following (1) to (3):

(1) These ducts are to be of a material which has low flame-spread characteristics;

(2) Ducts are to be only used at the end part of the ventilation system;

(3) Ducts are not to be situated less than 600 mm, measured along the duct, apart from the penetrating part in an "A" or "B" class division.

2. At the location where the ventilation ducts with a cross-sectional area exceeding 0.02 m^2 pass through "A" class bulkheads or decks, the openings of the penetrated parts are to be lined with steel sheet sleeves unless the ducts passing through the bulkheads or decks are of steel in the vicinity of the penetrated parts. The sleeves and ducts at the penetrated parts are to comply with the conditions in the following (1) and (2):

(1) The sleeves are to be not less than 3 mm in thickness and to be not less than 900 mm in length. The length of sleeves in case where they pass through the bulkhead is, in principle, to be not less than 450 mm on each side of the bulkhead. The ducts, or the sleeves lining such ducts are to be heat-insulated. The insulation is to have fire integrity equivalent to that of bulkhead or deck through which the duct passes. The Society may accept any equivalent penetration protection.

(2) Ducts exceeding 0.075 m^2 in cross-sectional area are to be fitted with fire dampers of self-closing type and capable of being closed man-

ually from both sides of the bulkhead or deck, in addition to the requirements in (1). The damper is to be provided with an indicator which shows whether the damper is open or closed. Where, however, ducts pass through the spaces enclosed by "A" class divisions, without serving those spaces, fire dampers are not required, provided that the relevant ducts have the fire integrity equivalent to that of divisions through which the ducts pass.

3. Ducts provided for the ventilation of machinery spaces of category A, galleys, vehicle spaces or ro-ro spaces are not to pass through accommodation spaces, service spaces and control stations, unless the ducts are in compliance with either one of the conditions specified in the following (1) or (2):

(1) (a) The ducts are to be constructed of steel and the thickness is to be at least 3 mm where the width or diameter is 300mm or less, is to be at least 5 mm where the width or diameter is 760 mm or over and is to be not less than that determined by linear interpolation where the width or diameter is over 300 mm and less than 760 mm;
(b) The ducts are to be suitably supported and stiffened;
(c) Fire dampers of self-closing type are to be fitted close to the boundaries penetrated; and
(d) The ducts are to be insulated to "A-60" class from machinery spaces, galleys, vehicle spaces or ro-ro spaces to a point at least 5 m beyond each fire damper.

(2) (a) The ducts are to be constructed of steel in accordance with the requirements in (1) (a) and (b); and
(b) The ducts are to be insulated to "A-60" class throughout the accommodation spaces, service spaces and control stations.

4. Ducts provided for ventilation to accommodation spaces, service spaces or control stations are not to pass through machinery spaces of category A, galleys, vehicle spaces and ro-ro spaces, unless in compliance with either one of the conditions specified in the following (1) or (2):

(1) (a) The ducts at the parts where they pass through machinery spaces of category A, galleys, vehicle spaces or ro-ro spaces are to be constructed of steel in accordance with the requirements in **3** (1) (a) and (b);
(b) Fire dampers of self-closing type are to be fitted close to the boundaries penetrated; and
(c) The fire integrity of the machinery spaces, galleys, vehicle spaces or ro-ro spaces is to be maintained at the penetrated parts.

(2) (a) The ducts as the parts where they pass through machinery spaces of category A, galleys, vehicle spaces or ro-ro spaces are to be constructed of steel in accordance with the requirements in **3** (1) (a) and (b); and
(b) The ducts are to be insulated to "A-60" . class in machinery spaces, galleys, vehicle spaces, and ro-ro spaces.

5. Ventilation ducts with a cross-sectional area exceeding 0.02 m^2 passing through "B" class bulkheads are to be lined with steel sheet sleeves not less than 900 mm in length. The length of the sleeves is, in principle, to be not less than 450 mm at each side of the bulkheads, except where the ducts are of steel for the length of 450 mm on each side of the bulkheads.

6. As for control stations outside machinery spaces, practicable equipment to ensure that ventilation, visibility and clearing of smoke are maintained, in order to supervise the machinery and equipment in the control stations and to continue of function effectively in the event of fire, is to be provided. The control stations are to be provided with two sets of independent air supply systems, which are to be arranged to minimize the risk of drawing in smoke simultaneously. Where approved by the Society, these requirements need not apply to the control stations which are located open decks and have openings to those decks, or where the local closing arrangements are equally effective.

7. Exhaust ducts from galley ranges are to be provided with stopping devices for exhaust fans operable from the galley. And further, where the ducts pass through accommodation spaces or spaces containing combustible materials, they are to be "A" class divisions and to be provided with the devices specified in the following (1) to (2):

(1) Grease traps readily removable for cleaning; and
(2) Fire dampers located in the lower end of the ducts.

8. Main inlets and main outlets of ventilation systems are to be capable of being closed from outside the spaces being ventilated.

9. Mechanical ventilation systems for accommodation spaces, service spaces, cargo spaces, control stations and machinery spaces are to be capable of being stopped from a readily accessible position outside the space being served. This position must not be readily cut off in the event of fire in the spaces ventilated. The means provided for stopping the mechanical ventilation system for the machinery spaces are to be entirely separated from the means provided for ventilation of other spaces.

10. The mechanical ventilation system for the space containing an independent source of power for an emergency fire pump is to be capable of preventing, as far as practicable, smoke from the machinery space fire from entering or being drawn into the space.

11. The ventilation of the machinery spaces is to be sufficient to prevent accumulation of oil vapour under normal condition.

12. The following arrangements are to be tested in accordance with the Guidances given by the Society.

(1) Fire dampers, including relevant means of operation.

(2) Duct penetrations through “A” class divisions. Where steel sleeves are directly joined to ventilation ducts by means of rivetted or screwed flanges or by welding, the test is not required.

308. Restricted use of combustible materials

1. Materials for exposed surfaces of corridors and stairways enclosures and those of exposed surfaces, including groundsills, in concealed spaces or inaccessible spaces in accommodation spaces, service spaces and control stations are to have low flame-spread characteristics. Materials for exposed surfaces of ceilings in accommodation spaces, service spaces and control stations are to have low flame-spread characteristics.

2. Paints, varnishes and other finishes used on exposed interior surfaces are not to be capable of producing an execessive quantity of smoke or toxic products, this being determined in accordance with the Guidances relating to the Rules given by the Society.

3. Materials for primary deck coverings in accommodation spaces, service spaces and control stations are to be of approved material which will not readily ignite, or give rise to toxic or explosive hazards at elevated temperature, this being determined in accordance with the Guidances relating to the Rules given by the Society.

309. Details of construction

1. Method ⅠC - Linings, draught stops, ceilings and ground sills thereto in accommodation spaces, service spaces and control stations are to be of non-combustible materials.

2. Method ⅡC and Method ⅢC - Linings of corridors and stairways enclosures, draught stops, ceilings and groundsills thereto in accommodation spaces, service spaces and control stations are to be of non-combustible materials.

3. Method ⅠC, Method ⅡC and Method ⅢC

(1) Insulating materials, except those for cargo spaces or refrigerated compartments in service spaces, are to be non-combustible. Vapour barriers and adhesives used in conjunction with insulating materials for cooling systems as well as insulating materials for piping systems of cooling systems need not be non-combustible, but they are to be kept to the minimum quantity practicable and their exposed surfaces are to have low flame-spread characteristics.

(2) Where non-combustible bulkheads, linings and ceilings are fitted in accommodation and service spaces they may have a combustible veneer with a calorific value not exceeding 45 MJ/m^2 of the area for the thickness used.

(3) The total volume of combustible facings, mouldings, decorations and veneers in any accommodation and service space bounded by non-combustible bulkheads, ceilings and linings is not to exceed a volume equivalent to a 2.5 mm veneer on the combined area of the walls and ceilings.

(4) Air spaces behind ceilings, panellings and linings are to be divided by tight-fitted draught stops spaced not more than 14 m apart. In the vertical direction, such air spaces, including those behind linings of stairways, trunks, etc., are to be divided at each deck.

310. Arrangements for gaseous fuel for domestic purposes

Where gaseous fuel is used for domestic purposes, the arrangements for the storage, distribution and utilization of the fuel are to be such that having regard to the hazards of fire and explosion which may be provoked by the use of such fuel, the safety of the ship and the persons on board is preserved.

311. Fire protection arrangements in cargo spaces

1. Ro-ro spaces

(1) Enclosed ro-ro spaces are to be provided with an effective mechanical ventilation system sufficient to provided at least six times air changes per hour basing upon an empty hold. The system is to be perfectly independent from other ventilation systems. Ventilation ducts serving ro-ro spaces capable of being effectively closed are to be separate for each cargo space. The system is to be capable of being controlled from a position outside the relevant cargo space.

(2) The ventilation is to be so arranged as to prevent air stratification and stagnation.

(3) Means to indicate loss of the required ventilating capacity are to be provided in the navigation bridge.

(4) The ventilation system is to be capable of being rapidly cut off and effectively closed in case of fire, taking into account the weather and sea conditions.

(5) Ventilation ducts, including dampers, are to be made of steel and their arrangements are to be in accordance with the Guidances given by the Society.

(6) Enclosed ro-ro spaces carrying motor vehicles with fuel in their tanks for their own propulsion are to comply with the requirements in the following (a) to (e).

(a) Electric equipment and wiring, except for those specified in below (b) are to be of a type suitable for use in explosive gas atmospheres.

(b) Above a height of 450 mm from the deck and from each platform for vehicles, if fitted, except platforms with openings of sufficient size permitting penetration of petrol gases downwards, electrical equipment of a type so enclosed and protected as to prevent the escape of sparks may be permitted as an alternative of the electrical equipment specified in (a) above. In this case, the ventilation system is to be capable of continuously ventilating the cargo spaces at the rate of at least 10 air changes per hour whenever vehicles are on board.

(c) Any facility which may become a source of ignition of flammable vapours is not to be provided, except where approved by the Society.

(d) Electrical equipment and wiring in an exhaust ventilation duct are to be of a type approved for use in explosive petrol and air mixtures and the outlet from any exhaust duct is to be situated at a safe place apart from equipment and installations which may become a source of ignition.

(e) Scupper pipes are not to be led in machinery spaces or other spaces where sources of ignition may exist.

(7) Permanent openings in the side plating, the ends or deckhead of open and closed ro-ro space are to be so situated that a fire in the cargo space does not endanger stowage areas and embarkation stations for survival craft and accommodation spaces, service spaces and control stations in superstructures and deckhouses above the cargo spaces.

2. Cargo spaces, other than ro-ro spaces, intended for the carriage of motor vehicles with fuel in their tanks for their own propulsion are to comply with the requirements in **Par 1.**

Table 8.1.3 Application of the Requirements to Different Modes of Carriage of Dangerous Goods in Ships and Cargo Spaces

Kind of cargo spaces / Special requirements specified in **312. 2**	Not specially designed cargo spaces	Container cargo spaces	Closed ro-ro spaces	Open ro-ro spaces	Weather deck cargo spaces	Shipborne barge spaces
1. Exclusion of sources of ignition	○	○	○	○(2)		○
2. Installation of mechanical ventilation system	○	○(1)	○			○
3. Installation of explosion-proof mechanical ventilation system	○	○(1)	○			○
4. Prevention of ingress of bilge into engine room	○	○	○			
5. Heat-insulation of boundaries between cargo spaces and machinery spaces of category A	○	○(3)	○	○	○	

NOTES:
1. The kinds of cargo spaces are as follows:
   (a) Not specially designed cargo spaces: cargo spaces not specified in following (b) to (f).
   (b) Container cargo spaces: cargo spaces intended for the carriage of dangerous goods in freight containers and portable tanks.
   (c) Closed ro-ro spaces: ro-ro spaces defined in **104.** (12).
   (d) Open ro-ro spaces: ro-ro spaces defined in **104.** (11).
   (e) Weather deck cargo spaces: cargo spaces on decks completely exposed to the weather from above and from at least two sides in ships having cargo spaces specified in (a) to (d) and (f).
   (f) Shipborne barge spaces: cargo spaces intended for carriage of dangerous goods other than liquids and gases in bulk in shipborne barges.
2. Wherever "○" appears it means that special requirements are applicable to relevant cargo spaces. However, dangerous goods applicable to special requirements are given in **Table 8.1.4.**
3. The meanings of superscripts are as follows;
   (1) Not applicable to closed freight containers containing inflammable substances and oxidizing substances. When carried in closed freight containers containing high pressure gases, inflammable liquids, poisonous substances and corrosives, the ventilation rate may be reduced to not less than two air changes. A portable tank is a closed freight container.
   (2) Not applicable to cargo spaces intended for the carriage of motor vehicles with fuel in their tanks for their own propulsjon, without passenger spaces.
   (3) Applicable to decks only.
4. In special case where the barges are capable of containing flammable vapours or alternatively if they are capable of discharging flammable vapours to safe space outside the barge carrier compartment by means of ventilation ducts connected to the barges, these requirements may be reduced or waived to the satisfaction of the Society.

Table 8.1.4 Application of the Requirements to Different Classes of Dangerous Goods except Solid Dangerous Goods in Bulk

Class of dangerous goods / Special requirements specified in **312.2**	Explosives	High pressure gases			Flammable liquids		Flammable solids	Substances liable to spontaneous combustion	Substances emitting flammable gases in contact with water	Oxidizing substances	Toxic substances				Corrosives		Miscellaneous dangerous substances and articles
		2.1	2.2	2.3	3.1, 3.2	3.3					Liquids	Liquids (≤ 23°C)	Liquids (>23°C, ≤ 61°C)	Solids	Liquids (≤ 23°C)	Liquids (>23°C, ≤ 61°C)	
1. Exclusion of sources of ignition	○	○			○							○			○		
2. Installation of mechanical ventilation system		○		○	○		○(1)	○(1)	○	○(1)		○	○	○(1)	○	○	○(1)
3. Installation of explosion-proof mechanical ventilation system		○			○							○	○		○	○	
4. Prevention of ingress of bilge into engine room.					○						○	○	○		○		
5. Heat-insulation of boundaries between cargo spaces and machinery spaces of category A	○(2)	○	○	○	○	○	○	○	○	○(3)		○	○		○	○	

NOTES:
1. Wherever "○" appears it means that special requirements are applicable to the dangerous goods.
2. The meanings of superscripts are as follows:
   (1) When "mechanically-ventilated spaces" are required by the Intenational Maritime Dangerous Goods (IMDG) Code, as amended.
   (2) Goods of explosives are to be stowed 3 m horizontally away from the machinery space boundaries in all cases.
   (3) Refer to IMDG Code.
3. Not applicable to explosives of compatibility group S of division 1.4 classed in IMDG Code.
4. The class numbers for high pressure gases and flammable liquids are as follows:
   2.1 Flammable gases, 2.2 Non-flammable and non-toxic gases, 2.3 Toxic gases
   3.1 and 3.2 Liquids having a flashpoint below 23°C, closed cup test, 3.3 Liquids having a flashpiont of 23°C up to, and including, 61°C, closed cup test.

Table 8.1.5 Application of the Requirements to Different Classes of Dangerous Goods for Ships and Cargo Spaces Carrying Solid Dangerous Goods

Classes of dangerous goods / Special requirements specified in **312. 2**	Flammables solids	Substances liable to spontaneous combustion	Substances emitting flammable gases in contact with water(1)	Oxidizing substances	Toxic substances	Corrosives	Miscellaneous dangerous substances and articles
1. Exclusion of sources of ignition	○	○(2)	○	○(3)			○(3)
2. Installation of mechanical ventilation system		○(2)	○				
3. Installation of explosion-proof mechanical ventilation system	○(4)	○(2)	○	○(2),(4)			○(2),(4)
4. Natural ventilation	○	○	○	○	○	○	○
5. Heat-insulation of boundaries between cargo spaces and machinery spaces of category A	○	○	○	○(2)			○(5)

NOTE:
1. Wherever "○" appears it means that special requirements are applicable to the dangerous goods.
2. The meanings of superscripts are as follows :
   (1) The hazards of substances in this class which may be carried in bulk are such that special consideration must be given to the construction and equipment of the ship involved in addition to meeting the requirements enumerated in this Table.
   (2) Only applicable to seedcake containing solvent extractions, to ammonium nitate and to ammonium nitate fertilizers.
   (3) Only applicable to ammonium nitrate and to ammonium nitrate fertilizers. However, a degree of protection in accordance with standards contained in the IEC 60079 (Electrical Apparatus for Explosive Gas Atmospheres) is sufficient.
   (4) Only suitable wire mesh guards are required.
   (5) The requirements of the Code of Safe Practice for Solid Bulk Cargoes adopted by IMO Res. A.434(11), as amended, are sufficient.

312. Special requirements for ships carrying dangerous goods

1. General

(1) Cargo ships carrying dangerous goods are to comply with the requirements in this Article, in addition to those in **311.**

(2) The application of the special requirements in **Par 2** is to be in accordance with the **Tables 8.1.3** to **8.1.5** taking account of the type of ships, cargo spaces, kinds of dangerous goods and modes of carriage of dangerous goods. However, where considered safe from the quantity of dangerous goods, and danger, etc., the requirements are to be as deemed appropriate by the Society.

(3) In ships having ro-ro spaces, a separation is to be provided between a closed ro-ro space and an adijacent open ro-ro space, The separation is to be such as to minimize the passage of dangerous vapours and liquids between such spaces. Alternatively, such separation need not be provided if the ro-ro space is considered to be a closed cargo space over the entire length and is to fully comply with the relevant special requirements of the Rules.

(4) In ships having ro-ro spaces, a separation is to be provided between a closed ro-ro space and an adjacent weather deck. The separation is to be such as to minimize the passage of dangerous vapours and liquids between such spaces. Alternatively, such separation need not be provided if the arrangements of the closed ro-ro spaces are in accordance with those required for the dangerous goods carried on the adjacent weather deck.

2. Special requirements

(1) Exclusion of sources of ignition

(a) Electrical equipment and cables, except those essential for operational purposes, are not to be provided in enclosed cargo spaces or vehicle spaces.

(b) Where electrical equipment is inevitably provided in the spaces specified in (a), the equipment is to be of safety type which is approved for use in dangerous environment of the palce where it is set, except where a switch which can be completely cut off all circuits to the electrical equipment provided in the relevant space is placed outside the relevant space and where the switch is arranged to be able to be locked at the position of "off".

(c) The penetrating part of cable through the bulkheads or the deck of the spaces specified in (a) is to be of gastight construction. The cables in the spaces and the penetrating cables are to be protected against damage from impact.

(d) Any facilities which may become a source of ignition are not to be provided in the spaces specified in (a).

(2) Installation of mechanical ventilation systems
In enclosed cargo spaces, effective mechanical ventilation systems having a sufficient capacity to provide at least six times air changes per hour basing upon an empty hold and being capable of discharging vapour from top or bottom of the cargo spaces, are to be provided.

(3) Installation of explosion-proof mechanical ventilation systems
Ventilating fans are to be shch as to avoid the possibility of ignition of flammable air-gas mixtures (to be of non-sparking type). Air inlets and outlets for ventilation are to be fitted with suitable wire mesh guards for preventing foreign objects from entering into the fan casing.

(4) Natural ventilation
Natural ventilation is to be provided in enclosed cargo spaces intended for the carriage of solid dangerous goods in bulk, where there is no requirement for mechanical ventilation.

(5) Prevention of ingress of bilge into engine room
Where flammable liquids and poisonous liquids are loaded in enclosed cargo spaces and carried, bilge discharge systems are to be so designed as to ensure that these liquids are not imprudently sucked in, through piping systems or pumps in machinery spaces. Where these liquids are carried in large quantities, the Society may required additional measures for drainage of the relevant cargo spaces.

(6) Heat-insulation of boundaries between cargo spaces and machinery spaces of category A
Bulkheads constituting boundaries between cargo spaces and machinery spaces of category A are to be heat-insulated to "A-60" class, except where dangerous goods are housed 3 m or over horizontally apart from the bulkheads. Other boundaries in these spaces are to be heat-insulated by "A-60" class divisions.

SECTION 4
Requirements for Oil Tankers

401. Application

1. In regard to the construction and arrangement for tankers intended to carry crude oil and petroleum products having flashpoint not exceeding 60°C and having Reid vapour pressure below atmospheric pressure, or other liquid cargoes having similar fire hazards, the requirements in this Section, as well as those in **Secs 1, 2** and **3,** are to apply. With regard to the construction and arrangement for tankers intended to carry liquid cargoes having flashpoint exceeding 60°C, the requirements in this Section need not apply.

2. As for tankers in which fire hazards are deemed to increase due to carriage of liquid cargoes other than the cargoes specified in **Par 1** of liquefied gases, the Society may require additional safety measures in addition to the requirements in this Section.

3. Regarding tankers intended to carry chemicals and liquefied gases, the requirements in this Section are to apply, except where alternative and supplementary arrangements are provided to the satisfaction of the Society.

402. Arrangement and separation of spaces

1. Arrangement and separation of machinery spaces

Machinery spaces are to be positioned aft of cargo tanks and slop tanks; they are also to be situated aft of cargo pump rooms and cofferdams, but not necessarily aft of the oil fuel bunker tanks. Any machinery space is to be isolated from cargo tanks and slop tanks by cofferdams, cargo pump rooms, oil fuel bunker tanks or ballast tanks. Pump rooms containing pumps and their accessories for ballasting those spaces situated adjacent to cargo tanks and slop tanks and pumps for oil fuel transfer are to be considered as equivalent to a cargo pump room within the context of this Section, provided that such pump rooms have the same safety standard as that required for cargo pump rooms. However, the lower portion of the pump room may be recessed into machinery spaces of category A to accommodate pumps, provided that the deck head of the recess is in general not more than one third of the moulded depth above the keel, except that in the case of ships of not more than 25,000 tons deadweight, where it can be demonstrated that for reasons of access and satisfactory piping arrangements this is impracticable, the Society may permit a recess in excess of such height, but not exceeding one half of the moulded depth above the keel.

2. Arrangement and separation of accommodation spaces, main cargo control stations, control stations and service spaces

(1) Accommodation spaces, main cargo control stations, control stations and service spaces (excluding isolated cargo handling gear lockers) are to be positioned aft of all cargo tanks, slop tanks, and spaces which isolate cargo or slop tanks from machinery spaces but not necessarily aft of the oil fuel bunker tanks and ballast tanks, but are to be arranged in such a way that a single failure of a deck or bulkhead is not to permit the entry of gas or fumes from the cargo tanks into an accommodation space, main cargo control stations, control station, or service spaces. A recess provided in accordance with **Par 1** need not be taken into account when the position of these spaces is being determined.

(2) However, where deemed necessary, the Society may permit accommodation spaces, main cargo control stations, control stations, and service spaces forward of the cargo tanks, slop tanks and spaces which isolate cargo and slop tanks from machinery spaces, but not necessarily forward of oil fuel bunker tanks or ballast tanks. Machinery spaces, other than those of category A, may be permitted forward of the cargo tanks and slop tanks provided they are isolated from the cargo tanks and slop tanks by cofferdams, cargo pump rooms, oil fuel bunker tanks or ballast tanks. All of the above spaces are to be subject to an equivalent standard of safety and appropriate availability of fire extinguishing arrangements being provided to the satisfaction of the Society. Accommodation spaces, main cargo control stations, control stations and service spaces are to be arranged in such a way that a single failure of a deck or bulkhead is not to permit the entry of gas or fumes from the cargo tanks into such spaces. In addition, where deemed necessary for the safety or navigation of the ship, the Society may permit machinery spaces containing internal combustion machinery not being main propulsion machinery having an output greater than 375 kW to be located forward of the cargo area provided the arrangements are in accordance with the requirements of **402.**

(3) In case where it is necessary to arrange a maneuvering station above the cargo oil tanks, it is to be used only for maneuvering purpose and it is to be separated from the top plating of cargo oil tank by means of an open space with a height of at least 2 m. The fire protection of this maneuvering station is to be in compliance with the requirements for the fire protection of control stations in **403.** as well as in this Section.

(4) A permanent continuous coaming of a suitable height extending from side to side is to be provided in order to prevent spills on the deck from flowing into accommodation spaces and service spaces. Special consideration is to be given to the arrangements associated with stern loading.

3. Arrangement and separation of spaces in combination carriers

(1) The slop tanks are to be surrounded by cofferdams except where the boundaries of the slop tanks where slop may be carried on dry cargo voyages are the hull, main cargo deck, cargo pump room bulkhead or oil fuel bunker tank. These cofferdams are not to be open to a double bottom, pipe tunnel, pump room or other enclosed space. Means are to be provided for filling the cofferdams with water and for draining them. Where the boundary

of a slop tank is the cargo pump room bulkhead, the pump room is not to be open to the double bottom, pipe tunnel or other enclosed space; however, openings provided with gastight bolted covers may be permitted.

(2) Hatches and tank cleaning openings to slop tanks are only to be permitted on the open deck and are to be fitted with closing arrangements. Except where they consist of bolted plates with bolts at watertight spacing, these closing arrangements are to be provided with locking arrangements which are to be under the control of the responsible ship's officer.

4. Superstructures and deckhouses facing cargo spaces

(1) Exterior boundaries of superstructures and deckhouses enclosing accommodation and including any overhanging decks which support such accommodation, are to be constructed of steel and insulated to "A-60" class for the whole of the portions which face the cargo area and on the outward sides for a distance of 3 m from the end boundary facing the cargo area. In the case of the sides of those superstructures and deckhouses, such insulation is to be carried as high as is deemed necessary by the Society.

(2) Except as permitted in (3) below, access doors, air inlets and openings to accommodation spaces, service spaces, control stations and machinery spaces are not to face the cargo area. They are to be located on the transverse bulkhead not facing the cargo area or on the outboard side of the superstructure or deckhouse at a distance of at least 4% of the length of the ship but not less than 3 m from the end of the superstructure or deckhouse facing the cargo area. This distance need not exceed 5 m.

(3) The Society may permit access doors in boundary bulkheads facing the cargo area or within the 5 m limits specified in (2), to main cargo control stations and to such service spaces as provision rooms, store rooms and lockers, provided they do not give access directly or indirectly to any other space containing or provided for accommodations, control stations or service spaces such as galleys, pantries or workshops, or similar spaces containing sources of vapour ignition, The boundary of such a space is to be insulated to "A-60" class, with the exception of the boundary facing the cargo area. Bolted plates for the removal of machinery may be fitted within the limits specified in (2). Wheelhouse doors and wheelhouse windows may be located within the limits specified in (2) so long as they are designed to ensure that the wheelhouse can be made rapidly and efficiently gas and vapour tight.

(4) Windows and side scuttles facing the cargo area and those on the sides of superstructures or deckhouses within the limits specified in (2) aboce are to be of fixed (non-opening)

Table 8.1.6 Fire Integrity of Bulkheads Separating Adjacent Spaces

Spaces	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Control stations (1)	A-0[3]	A-0	A-60	A-0	A-15	A-60	A-15	A-60	A-60	*
Corridors, lobbies (2)		C	B-0	A-0[1] B-0	B-0	A-60	A-0	A-60	A-0	*
Accommodation spaces (3)			C	A-0[1] B-0	B-0	A-60	A-0	A-60	A-0	*
Stairways (4)				A-0[1] B-0	A-0[1] B-0	A-60	A-0	A-60	A-0	*
Service spaces (low risk)(5)					C	A-60	A-0	A-60	A-0	*
Machinery spaces of category A(6)						*	A-0	A-0[4]	A-60	*
Other machinery spaces (7)							A-0[2]	A-0	A-0	*
Cargo pump rooms (8)								*	A-60	*
Service spaces (high risk) (9)									A-0[2]	*
Spaces on open decks (10)										–

NOTES:
The superscripts to the notations for fire integrity and asterisks are as specified below:
1 : For clarification of application, refer to **303.** and **305.** in this Chapter.
2 : In case where the adjacent spaces are of the same category, a bulkhead of the rating given in the **Table** is required only when the adjacent spaces are for a different purpose. For example, in the case of category (9), a galley next to a galley does not require a bulkhead, but a galley next to a paint room requires an "A-0" class bulkhead.
3 : Bulkheads separating the wheelhouse, chart room and radio room from each other may be of "B-0" class.
4 : Bulkheads separating cargo pump room from machinery spaces of category A may be penetrated by cargo pump shaft glands or similar glanded penetration, provided that gastight seals with efficient lubrication or other means ensuring permanent gastightness are provided.
* : Where an asterisk appears in the **Table,** the division is required to be of steel or other equivalent materials, but is not required to be of "A-0" class.

type. Such windows and side scuttles, except wheelhouse windows, are to be constructed to "A-60" class. Such windows and side scuttles of superstructures or deckhouses in the first tier of the main deck are to be provided with deadlights of steel or other equivalent materials.

5. Bulkheads within accommodation spaces and service spaces and deatils of construction

(1) In applying the requirements in **302., 303.** and **309.** to tankers, only the method ⅠC as defined in **302. 5** (1) is to be used.

(2) Skylights to cargo pump rooms are to be of steel, but not to be fitted with glass. The skylights are to be capable of being closed from outside the pump room.

403. Fire integrity of bulkheads and decks

1. The application of **Tables 8.1.6** and **8.1.7** specified for the fire integrity of bulkheads and decks which separate adjacent spaces is to be in accordance with the following requirements. In application of the standard of the fire integrity, the respective spaces are classified into the following categories (1) to (10) in accordance with their risk of fire. The title of each category is intended to be typical rather than restrictive.

2. Permanent approved gastight lighting enclosures for illumination of cargo pump rooms may be provided on bulkheads and decks separating cargo pump rooms and other spaces, so far as they are of sufficient strength and the fire integrity and gastightness of the bulkhead or deck is maintained.

404. Protection of cargo oil tanks

1. In the case where the government of the ship's registry has not legislated any law or regulation deemed equivalent to the requirements of **402. 2** to **5** for the protection of cargo oil tanks, such protection of the ship is to comply with these requirements of **402. 2** to **5.**

2. Cargo oil tanks in tankers of not less than 20,000 *tons* deadweight are to be protected by means of inert gas systems in compliance with the requirements in **Pt 7, Ch 1, Sec 11.** Where, however, other combinations of fixed system are deemed by the Society to afford protection equivalent to the fixed inert gas system, the use of such combinations may be accepted in consideration of the arrangement and equipment of the ship.

3. In order that a system proposed in lieu of the fixed inert gas system may be considered equivalent, it is to be in compliance with both of the conditions given in the following (1) and (2):

Category	Description
(1) Control stations	· Spaces containing emergency sources of power and lighting · Wheelhouse and chart room · Radio room · Spaces containing fire indicating equipment, fire alarming equipment and fire control equipment · Control station for propulsion machinery provided outside the machinery space
(2) Corridors and lobbies	–
(3) Accommodation spaces	· Excluding corridors and lobbies
(4) Stairways	· Interior stairways, lifts and escalators (excluding those wholly contained within the machinery spaces) and enclosures thereto
(5) Service spaces (low risk)	· Lockers and store rooms not having provisions for the storage of flammable liquids and having areas less than 4 m^2 and drying rooms and laundries
(6) Machinery spaces of category A	· Spaces as defined in **104.**
(7) Other machinery spaces	· Machinery spaces excluding the machinery spaces of category A
(8) Cargo pump rooms	· Spaces containing cargo pumps and entrances and trunks to such spaces
(9) Service spaces (high risk)	· Galleys, pantries containing cooking appliances, paint and lamp rooms, lockers and store rooms having areas of 4m^2 or more, spaces for the storage of flammable liquids, and workshops other than those forming part of the machinery spaces
(10) Spaces on open decks	· Spaces on open decks, enclosed promenades without risk of fire and spaces outside superstructures and deckhouses

Table 8.1.7 Fire Integrity of Decks Separating Adjacent Spaces

Spaces above deck / Spaces below deck	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Control stations (1)	A-0	A-0	A-0	A-0	A-0	A-60	A-0	–	A-0	*
Corridors, lobbies (2)	A-0	*	*	A-0	*	A-60	A-0	–	A-0	*
Accommodation spaces (3)	A-60	A-0	*	A-0	*	A-60	A-0	–	A-0	*
Stairways (4)	A-0	A-0	A-0	*	A-0	A-60	A-0	–	A-0	*
Service spaces (low risk)(5)	A-15	A-0	A-0	A-0	*	A-60	A-0	–	A-0	*
Machinery spaces of category A (6)	A-60	A-60	A-60	A-60	A-60	*	A-60[5]	A-0	A-60	*
Other machinery spaces (7)	A-15	A-0	A-0	A-0	A-0	A-0	*	A-0	A-0	*
Cargo pump rooms (8)	–	–	–	–	–	A-0[4]	A-0	*	–	*
Service spaces (high risk) (9)	A-60	A-0	A-0	A-0	A-0	A-60	A-0	–	A-0[2]	*
Spaces on open decks (10)	*	*	*	*	*	*	*	*	*	–

NOTES:
The superscripts to the notation for fire integrity and asterisks are as specified below:
2, 4 : In the Notes to **Table 8.1.6,** "bulkhead" is to be read as "deck".
5 : As for the machinery spaces of category (7), in case where the Society deems there is little risk of fire, insulation need not be fitted.
* : As specified in the Notes to **Table 8.1.6.**

(1) To be capable of preventing dangerous accumulation of explosive mixtures in cargo oil tanks during normal service throughout the ballast voyage and necessary operations in tanks; and
(2) To be so designed as to minimize the risk of ignition due to generation of static electricity by the system itself.

4. Tankers making use of a cargo tank cleaning procedure by means of crude oil washing are to be provided with a fixed inert gas system complying with the requirements in **Pt 7, Ch 1, Sec 11** and with fixed tank washing machines.

5. Tankers equipped with a fixed inert gas system are to be provided with a closed-type ullage system.

SECTION 5
Means of Escape

501. Means of escape

1. Stairways and ladders in compliance with the conditions given in the followings are to be provided as ready means of escape from accommodation spaces and from spaces where the crew is normally employed, excluding machinery spaces, to the open deck and then to the lifeboats and liferafts:

(1) At all levels of accommodation spaces, at least two sets of means of escape widely separated from each enclosed space or each group of such spaces are to be provided.
(2) (a) Below the lowest open deck, the main means of escape is to be a stairway. Other means of escape may be trunks or stairways.
(b) The means of escape above the lowest open deck are to be stairways or doors to the open deck or combination thereof.
(3) Where deemed inevitable by the Society, one of the means of escape may be dispensed with in consideration of the nature and location of the space and the number of persons who might normally be quartered or employed there.
(4) No dead-end corridors exceeding 7 m in length are to be accepted. In this case, the dead-end corridor is a corridor or a part of a corridor which has only one escape route therefrom.
(5) The width and continuity of the means of escape are to be to the satisfaction of the Society.
(6) Where the radio room has no direct exit to the open deck, two sets of means of escape from the radio room are to be provided for emergency escape. In this case, one of them may be a side scuttle or a window of sufficient size or other means which is deemed appropriate by the Society.

2. In ro-ro spaces where the crew is normally employed, the number and location of escape routes to the open deck are to be to the satisfaction of the Society, but in no case is the number to be less than two and the routes are to be widely separated each other.

3. Two means of escape from the machinery space of category A to the open deck are to be provided, and they are to be in compliance with either one of the conditions given in the followings:

(1) The means of escape are to be two sets of steel ladders separated each other as widely as possible, leading to two doors similarly separated in the upper part of the space and from these doors passages to the open deck are to be provided. One of these sets of ladders is, in principle, to be protected by means of continuous fire shelter from the lower part of the space to a safe position outside the space. Where, however, a safe escape route from the lower part of the space is provided by means of the special arrangement of dimensions of the machinery space, the shelter may be dispensed with. This shelter is to be of steel, where necessary, to be insulated as deemed appropriate by the Society and to be provided with a self-closing door at the lower end; or

(2) The means of escape is to be one set of steel ladders leading to a door in the upper part of the space and a passage is to be provided from the door to the open deck. And further, in the lower part of the space and in a position well separated from the afore-mentioned ladder, a steel door capable of being operated from either side and leading to a safe escape route form the lower part of the space to the open deck is to be provided.

4. Notwithstanding the requirements in **Par 3,** in a ship of less than 1,000 tons gross tonnage, the Society may dispense with one set of means of escape paying due regard to the dimensions and arrangement of the upper part of the space.

5. The escape routes from machinery spaces other than those of category A are to be to the satisfaction of the Society having regard to the nature and position of the space and whether persons are normally employed in that space.

6. Lifts are not to be regarded as the means of escape required in this Section. ⚓

CHAPTER 2
FIRE DETECTION AND EXTINCTION

SECTION 1
General

101. Application

1. The requirements of this Chapter for fire detection and extinction apply to the ships which are engaged in international voyages and to which the Ships Safety Law or the Fishing Vessels Law of Korea do not apply. However, the fire detection and extinction for ships which come under one of the following (1) to (3) will be specially considered:

(1) Cargo ships of less than 500 tons gross tonnage;
(2) Ships not propelled by mechanical means;
(3) Fishing vessels.

2. The requirements of the fire detection and extinction specified in **Par 1** are to comply with the International Convention and the special requirements given by the Society.

3. The ships to which the Ships Safety Law or the Fishing Vessels Law of Korea apply are to be in accordance with the concerned requirements specified in these Laws.

102. Plans and documents

The following plans and documents are to be submitted the Society for the approval before the work is commenced.

(1) Plans of fire detection and extinction (arrangements, types, capacities, quantities and numbers of fire extinguishing appliances, fire extinguishers, fire pumps, hydrants, fire hoses, fireman's outfits, etc., are to be stated, and arrangement of fire detection and fire alarm systems are also to be stated).
(2) Other plans and documents deemed necessary by the Society. ⚓

PART L

MATERIALS AND WELDINGS

CHAPTER 1
MATERIALS

SECTION 1
General

101. Application

1. The requirements in this Chapter apply to the materials intended to be used for the components specified in each Part of hull construction, equipment and machinery.
2. The materials other than those prescribed in this Chapter may be used where specially approved in connection with the design. In such cases, the detailed data relating to the chemical compositions and mechanical properties, etc. of the materials are to be submitted for approval.

102. Process of manufacture

1. The materials prescribed in this Chapter are to be manufactured at approved works, except otherwise specially provided and made by open-hearth, electric furnace, basic oxygen processes, or other processes specially approved by this Society.
2. The manufacturer is to obtain approval by the Society in advance concerning the process of manufacture (melting process, ingot casting, rolling, casting, forging and heat treating).
3. The requirements specified in **Pars 1** and **2** may be applied to the non-ferrous material.

103. Chemical composition

1. The chemical composition of samples taken from each ladle of each cast is to be determined by the manufacturer in an adequately equipped and competently staffed laboratory and is to comply with the appropriate requirements for chemical composition provided in this Chapter.
2. A check analysis for the manufacture may be required by the Society where deemed necessary.

104. Testing and inspection

1. The materials are to be tested and inspected in the presence of the Society's Surveyor except otherwise specially provided, and are to comply with the requirements in this Chapter.
2. The materials other than those prescribed in this Chapter are to be tested and inspected according to the approved specification for the testing.
3. The Society may accept to omit the tests for materials having the appropriate certificates.
4. Where the materials are manufactured by the approval of quality assurance scheme specially specified by the Society, a part or all of test and inspection in the presence of the Society's Surveyor may be omitted.

105. Execution of testing and inspection

1. The manufacturers shall afford the Surveyor all necessary facilities and access to all relevant parts of the works to enable him to verify that the approved process is adhered to.
2. All tests and inspections are to be carried out at the place of manufacture prior to delivery, but in the event of any material proving unsatisfactory in the process of being worked, it is to be rejected, notwithstanding any previous certificate of satisfactory testing and inspection where the Surveyor considers necessary.
3. The testing machines used for the tests relative to this Chapter are to be authorized in inspection acceptable to the Society and to have its certificate.
4. In the case of special order, the manufacturer is

to show the order specifications, special requirements, etc. of the materials to the Surveyor prior to the material test.

106. Identification of materials

The manufacturer is to take a suitable measure for the identification of ingots, slabs, castings, forgings, and finished pieces, etc. which will enable the material to be traced to its original heat, roll, etc.

107. Test certificates

1. The Certificate for Materials Inspection is to be issued to the materials that have been satisfactorily tested and inspected in accordance with the requirements in this Chapter.

2. The Certificate for Materials Inspection is to contain in addition to the dimensions and weight of steels at least the following particulars;

(1) Purchaser's name and name or number of the ship for which the steel is intended. (if know)
(2) Identification of the cast and rolled piece.
(3) Manufacturer's name.
(4) Material grade mark
(5) Chemical composition (ladle analysis values of elements controlled by the requirements) and carbon equivalent calculated by following a formula. (if required)

$$\mathrm{Ceq} = \mathrm{C} + \frac{\mathrm{Mn}}{6} + \frac{\mathrm{Cr} + \mathrm{Mo} + \mathrm{V}}{5} + \frac{\mathrm{Ni} + \mathrm{Cu}}{15} (\%)$$

(6) Mechanical properties.
(7) Condition of heat treatment (e.g. normalized or controlled roll except for as rolled)
(8) Deoxidization procedure is to be stated. (rimmed steel only)

3. Notwithstanding the previous provisions, the accepted material may be omitted the issue of the Certificate for Materials Inspection where the manufacturer supplies the Mill Sheets stated the requirement of the previous **Pars 2.** for each accepted steel grade to the Surveyor for his signature. In this case, the manufacturer is to enter the following statement on the certificate to show that the steel material has been made by an approval process and that it has withstand satisfactory the required tests. The following form of declaration will be accepted if stamped or printed on each test certificate with the name of the steel works in English or Korean, and is to be signed by the personnel of the manufacturing shop in charge of product quality assurance or inspector.

"We hereby certify that the material has been made by an approval process and has been satisfactorily tested in accordance with the Rules of Korean Register of Shipping."

4. Where steel is not produced at the works at which it is melted, a certificate is to be supplied to the Surveyor at the rolling mill stating the process by which it was manufactured, the name of the manufacturer who supplied it, the number of the cast from which it was made and the ladle analysis. In this case, the manufacturing process of ingot, slab or billet should have been approved by this Society.

108. Quality and repair of defects

All materials are to be free from harmful defects. Welding or other means for the purpose of repairing defects is not permitted, unless the extent and method of repair (including welding procedure and heat treatment) are approved by the Surveyor. The repair of defects is to be carried out in the presence of the Surveyor, unless otherwise agreed.

109. Retest procedures

1. Where a part of the results of any test except impact test does not comply with the requirements, but the remainders are satisfactory, additional test specimens twice in number may be taken from the same material and retests for the failed test may be carried out. In such a case, all of the test specimens are to comply with the requirements.

2. Where the result of impact test fails to meet the requirements, additional tests are to be carried out according to the requirements in each Section.

3. If a heat treated material fails to meet the requirements in any test, retest and heat treatment may be allowed two times(three times including the first test). In this case, however, the material is not to be considered as having complied with the requirements, unless all tests fully comply with the test requirements.

4. If the percentage of elongation of any tension test specimen is less than that specified and any part of fracture is outside the one-fourth of the gauge length from the centre of gauge length, the test is to be considered as invalid, and a retest for the material from which the first test specimen has been taken may be allowed.

110. Marking

1. Every material complying with the requirements is to be clearly stamped with the Society's brand KR and material grade mark, and marked with the following particulars at least in one position by the maker:

(1) Name or mark to identify the steel works.
(2) Number or mark to identify the material.
(3) Name or mark to identify the purchaser. (if required by the purchaser)

2. Materials which are unsuitable for stamping may be marked with brands, seals or by other suitable means.

3. Materials which can not be stamped and marked in accordance with the requirements in **Pars 1** and **2** due to small size may be properly marked in the lump.

4. Materials which have been specially approved by the Society in accordance with the requirements in **101.2.** are to have the letter “S” after the material grade mark.

SECTION 2
Test Specimens and Testing Procedures

201. General

1. Application

(1) Test specimens and mechanical testing procedures for materials are to comply with the requirements of this Section, unless otherwise specially provided in each Section.

(2) Where test specimens and testing procedures differing from those prescribed in this Section are used, they are to be approved by this Society.

2. Selection of test specimens

(1) The test specimens are to be selected according to each requirement in this Chapter.

(2) Except where otherwise specified or agreed with the Surveyor, test samples are not to be detached from the material until being stamped by the Surveyor.

(3) If test samples are cut from material by flame cutting or shearing, a reasonable margin is required to enable sufficient material to be removed from the cut edges during final machining.

(4) The preparation of test specimens is to be done in such a manner that test specimens are not subjected to any significant cold working or heating.

(5) If any test specimen shows defective machining or defects having relation to the substantial nature, it may be discarded and substituted by another test specimen.

202. Form and dimension of test specimen

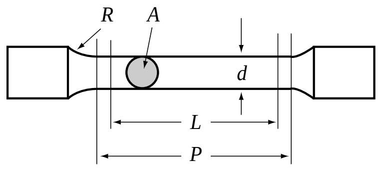
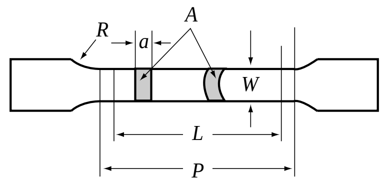
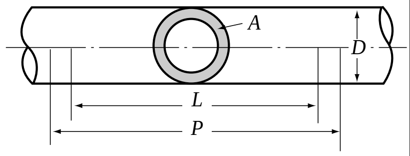
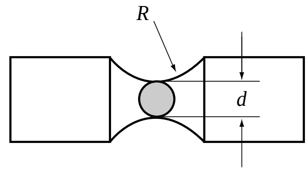
1. Tensile test specimen

Standard tensile test specimens are to be of the forms and sizes given in the following requirements and the both ends of the test specimens may be machined to such shapes as to fit the holder of the testing machine.

(1) Types and forms of test specimens are classified as shown in **Fig. 2.1.1.**

(a) *Forgings, castings and bars*

$R14A$ test specimen with the following dimensions is to be used. Type I test specimen is to be used but, where the use of Type I specimen is unreasonable according to the size of materials, type II test specimen may be considered. Also, these test specimens can be used in spheroidal iron castings and materials with a minimum elongation less than 10%. In this case R of test specimens is to be 20 mm for Type I and 1.5 d for Type II.

Type	Size of specimens	Materials to be applied
R 14 A		All materials except grey iron castings
R 14 B		Plates and tubes
R 14 C		Tubes
R 8		Grey iron castings

NOTES:
The notations used are difined as follows.

d : Diameter	A : Cross section
a : Thickness	R : Transition radius
W : Width	D : External tube diameter
L : Gauge length	t : Plate thickness
P : Parallel test length	

Fig. 2.1.1 Tensile Test Specimens (Unit: *mm*)

I	II
d = 14 mm L = 70 mm $P \cong$ 85 mm R = 10 mm	L = 5 d $P \cong L + d$ R = 10 mm

(b) *Plates 3 mm thick or more*

$R14A$ or $R14B$ test specimens with the following dimensions are to be used. If the capacity of the available testing machine does not allow flat specimen of full thickness $a = t$, the thickness may be reduced by the machining of one side only.

III	IV	V
$a = t$ $W = 25$ $L = 5.65\sqrt{A}$ $P \cong L + 2\sqrt{A}$ $R = 25$	$a = t$ $W = 25$ $L = 200$ $P \cong 225$ $R = 25$	$R14A$-I test specimen located with its centre $t/4$ from plate surface or as close to this position as possible

(c) *Sheet and strips with thickness less than 3 mm*
$R14B$ test specimen with the following dimensions is to be used.

a = t
W = 12.5
L = 50
P ≅ 75
R = 25

(d) *Tubes*
$R14B$ or $R14C$ test specimen with the following dimensions is to be used.

$R14B$	$R14C$
$a = t$ $W \geq 12\ mm$ $L = 5.65\sqrt{A}$ $P \cong L + 2W$ $R = 25$	$L = 5.65\sqrt{A}$ $P \cong L + D$ is the distance between the grips.

(e) *Grey iron castings*
$R8$ test specimen with the following dimensions is to be used.

d = 20
R = 25

Usually test specimens are machined from separately cast standard test samples with 30 mm diameter.

(2) When $L = 5d = 5.65\sqrt{A}$, the test specimen is called a proportional test specimen. The gauge length may be rounded off the nearest 5 mm, provided that the difference between this length and L is less than 10% of L.

(3) The manufacturers may use the test specimens approved by the Society, besides those specified in (1). In this case, the elongation measured at the tensile tests is to be corrected by the following formula:

$$E = \frac{n}{a}\left(\frac{L}{\sqrt{A}}\right)^{b}$$

where:
E = equivalent elongation for the proportional test specimens specified in (1) (%).
n = actual measured elongation of test specimen (%).
A = actual cross-sectional area of test specimen (mm^2).
L = actual gauge length of test specimen (mm).
a, b = constants given in **Table 2.1.1** in accordance with the kind of materials.

Table 2.1.1 Value of *a* and *b*

Constant / Material	a	b
Material 1	2.0	0.40
Material 2	2.6	0.55

NOTES:
1. Material 1 : For carbon and low alloy steels with a tensile strength not exceeding 590 N/mm^2 in the hot rolled, annealed, normalized or normalized and tempered conditions.
2. Material 2 : For carbon and low alloy steels in the quenched and tempered condition.
3. The values of a and b for other kinds of materials than Material 1 and Material 2 are to be as deemed appropriate by the Society.

Table 2.1.2 Permissible Variation

Diameter of test specimens where they are machined to a circular section, or thickness and width where they are machined to a rectangular section (mm)	Permissible variation (mm)	
	In case of circular section	In case of rectangular section
Over 3 up to 6	Max. 0.03	Max. 0.06
Over 6 up to 16	Max. 0.04	Max. 0.08
Over 16	Max. 0.05	Max. 0.10

(4) The permissible variation (difference between the maximum and minimum values) at the machine-finished parallel part of test specimens is to be as specified in **Table 2.1.2.**

2. Bend test specimen

Bend test specimens are to be of size and dimensions given in **Fig. 2.1.2** according to the kind of materials.

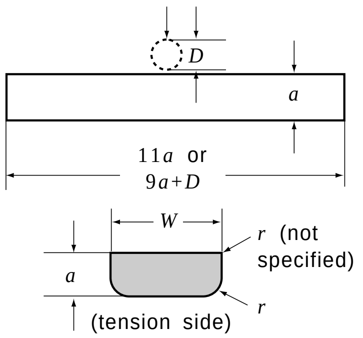
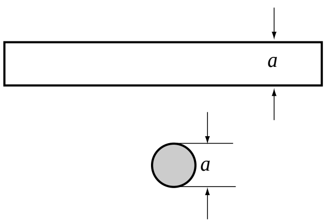
3. Impact test specimen

(1) The impact test specimens are to be machine finished to the forms and dimensions given in **Fig. 2.1.3** and **Table 2.1.3.**
The notch is to be cut in a face of the test specimen which was originally perpendicular to the rolled surface, casting surface and forging surface according to the kind of materials.

(2) Impact test specimens are to be provided in a set of three specimens, and the test speci-

Table 2.1.3 Dimensions of Impact Test Specimens

Dimensions \ Kinds		$R4$	$R5$
		Charpy 2mm V-notch test specimen	Charpy 5mm U-notch test specimen
Length (mm)	L	55 ± 0.6	55 ± 0.6
Width (mm)	W	10 ± 0.11	10 ± 0.11
Thickness (mm)	T	10 ± 0.06	10 ± 0.11
Angle of notch (deg)	θ	45 ± 2	–
Width of notch (mm)	w	–	2 ± 0.14
Depth below notch (mm)	D	8 ± 0.06	5 ± 0.09
Root radius of notch (mm)	R	0.25 ± 0.025	1 ± 0.07
Distance of notch from end of test specimen (mm)	S	27.5 ± 0.42	27.5 ± 0.42
Angle between plane of symmetry of notch and longitudinal axis of test specimen (deg)	–	90 ± 2	90 ± 2
Materials to be applied	–	All materials	Low alloy steel forgings specified in **601.**

Kinds	Size of specimens	Dimensions	Materials to be applied
$R1$		a = 20 W = 25 r = 1~2	Headers(**Ch 4, 405**)
		a = t W = 30 r = 1~2 Where the thickness of materials exceeds 25 mm, the thickness of test specimen may be reduced to 25 mm with its surface machined on compression side only.	Rolled steels(Steel plate) (**Ch 3**)
$R2$		a = d Where the diameter or the width across flat of materials exceeds 35 mm, they may be machined finished to a circular section of diameter not less than 35 mm.	Rolled steels (Rolled steel bars for boiler) (**Ch 3, 307.**)

NOTES:
The following designations are used:
a : Thickness, diameter or width
r : Edge radius
D : Diameter of mandrel
d : Diameter or width
W : Width
t : Thickness of material

Fig. 2.1.2 Size and Dimensions of Bend Test Specimens (Unit: mm)

mens are generally not to include the material nearer than 3 mm to the rolled surface. The position of the notch is not to be nearer than 25 mm to a flame cut or sheared edge.

(3) Where the $R4$ impact test specimens, having the size specified in (1) above for rolled steels, tubes and pipes cannot be taken, the width W may be the sub-size values given in **Table 2.1.4.** In this case, the average absorbed energy of rolled steels, tubes and pipes is not

Table 2.1.4 Multiplier to Absorbed Energy

Thickness of test specimen t (mm)	Thickness and width of sub-size specimen $t \times W(mm)$	Multiplier for absorbed energy	
		Average absorbed energy of 3 test specimens	Minimum absorbed energy of individual test specimen
$6 \leq t < 8.5$	$10 \times 5 \pm 0.06$	2/3	4/9
$8.5 \leq t < 10$	$10 \times 7.5 \pm 0.11$	5/6	5/9

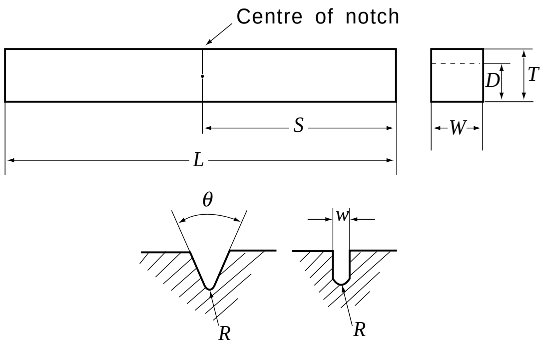


Fig. 2.1.3 Impact Test Specimen

to be less than the value(by counting fractions of 0.05 and over as 0.1 and disregarding the rest) multiplying the absorbed energy by values given in **Table 2.1.4** in accordance with the width of the test specimens.

(4) Where the thickness of a test specimen is less than 6 mm, and where impact test specimen having the sub-size specified in **Table 2.1.4** cannot be taken in welded parts of tubes and pipes, the impact test may be omitted.

4. Confirmation for test specimen

The size and dimensions of test specimens are to be carefully inspected and verified by suitable means before testing.

203. Testing procedure

1. Tensile test

(1) When well-defined yield phenomena exists, the value of yield strength(yield stress) is to be measured at the first peak obtained during yielding.

(2) When no well-defined yield phenomena exists, either the 0.2% yield strength(proof stress) or the 0.5% total elongation yield strength(proof stress) is to be determined according to the applicable specification.

(3) Where the value of yield point or yield stress is measured at tensile test, the test is to be carried out with an elastic stress-rate not exceeding 30 $N/mm^2/sec$ for steel 10 $N/mm^2/sec$ for non-ferrous metal.

(4) For ductile material, the machine speed during the tensile test is not to exceed that corresponding to a strain-rate at maximum load of 40% of the gauge length per minute. For brittle materials such as cast iron, the elastic stress-rate is not to exceed 10 $N/mm^2/sec$.

2. Impact test

The impact test is to be conducted on a Charpy impact testing machine having a capacity not less than 150 J and a striking velocity between 4.5 and 6 m/sec, with the test specimens at temperature controlled within +2 °C of the specified temperature.

SECTION 3
Rolled Steels

301. Rolled steels for hull

1. Application

(1) The requirements are to apply to hull structural rolled steels (hereinafter referred to as "steels") not exceeding 100 mm in thickness.
(2) Any requirement regarding steels over the thickness specified in **Table 2.1.5** is to be left to the discretion of this Society.
(3) Where improved through thickness properties are specified for plates and wide flats with thickness of 15 mm and over, the tensile test of through thickness property specified in **310.** is to be carried out in addition to the requirements of **301.**
(4) Steels other than those specified in **301.** are to be in accordance with the requirements of **101.2.**

2. Kinds

Steels are classified as specified in **Table 2.1.5.**

3. Deoxidation practice and chemical composition

The deoxidation practice and chemical composition of each grade are to comply with the requirements given in **Table 2.1.6.** When thermo-mechanical controlled processing (hereinafter referred to as "TMCP") is used as heat treatment, the requirement on the chemical composition of steel may be modified subject to the approval by this Society.

4. Heat treatment

The heat treatment of each grade is to comply with the requirements given in **Table 2.1.8** and **Table 2.1.9.**

Table 2.1.5 Grades of Rolled Steels for hull

Kinds		Grade	Thickness, t (mm)
Normal strength steel(1)	Plates(3)	RA RB RD RE	$t \leq 100$
	Sections and bars		$t \leq 50$
Higher strength steels(2)	Plates(3)	RA 32 RD 32 RE 32 RA 36 RD 36 RE 36	$t \leq 100$
		RF 32 RF 36 RF 40 RA 40 RD 40 RE 40	$t \leq 50$
	Sections and bars	RA 32 RD 32 RE 32 RF 32 RA 36 RD 36 RE 36 RF 36 RA 40 RD 40 RE 40 RF 40	$t \leq 50$

NOTE:
(1) Provision is made for four grades of normal strength steels based on the impact test requirements.
(2) For higher strength steels, provision is made for three strength levels(315, 355 and 390 N/mm^2) each subdivided into four grades(ex. : RA32, RD32, RE32, RF32) based on the impact test temperature.
(3) Steel plates include flat bars not less than 600 mm in width.

5. Mechanical properties

The mechanical properties of steels are to comply with the requirements given in **Table 2.1.7.**

6. Selection of test samples

(1) The samples of steel are to be treated together with and in the same way as the steel presented.
(2) For the samples of steel from which tensile test specimens are cut, except where specially approved by the Society, steels not greater than 50 $tonnes$ in mass (where the amount of scatter is to be less than 10 mm in thickness or diameter even when they belong to the same cast in the same manufacturing process) are to be treated as one lot, and the largest one in thickness or diameter is to be selected from each lot.
(3) For the samples of steel from which impact test specimens are cut, unless otherwise specially provided or except where specially approved by the Society, the thickest test sample is to be selected from each lot specified in **Table 2.1.8** and **Table 2.1.9,** according to the substance of deoxidation practices, type of products and kind of heat treatments
(4) The test samples are to be taken from the following portions according to the requirements (a) to (c) below and **Fig. 2.1.4,** unless otherwise specified:
 (a) *Plates and flat bars wider than 600 mm* :
 One end at a portion approximately 1/4 of the width from the flange end of the plates or flat bars.
 (b) *Sections and flat bars not exceeding 600 mm in width*:
 One end at a portion approximately 1/3 of the width from the flange end. In case of channels, bulb plates and H-section, the test samples may be taken from the portion approximately 1/4 of the depth from the centre line of the web.
 (c) *Bars*:
 The test samples are to be taken so that the axis of each test specimen may lie as near as possible to the portion specified in (i) and (ii) below. This rule, however, does not apply when, because dimensions of cross section are insufficient for standard test specimens, a piece cut in a proper length from the product having the largest diameter of a certain lot is used as it is for a tensile test.
 (i) For non-circular sections, at approximately 1/6 of the largest distance from the outside.
 (ii) For circular section, at approximately 1/6 of the diameter from the outside.

Table 2.1.6 Deoxidation Practice and Chemical Composition

Kinds	Grade	Thickness, $t(mm)$	Deoxidation Practice	Chemical Composition(%) (5)													
				C	Si	Mn	P	S	Cu	Cr	Ni	Mo	Al(8)	Nb	V	Ti	N
Normal strength steels	RA	$t \leq 50$	Killed and Semi-killed(1)	0.21 max. (3)(4)	0.50 max.	$2.5 \times C$ min. (4)	0.035 max.	0.035 max.	—	—	—	—	—	—	—	—	—
		$t > 50$	Killed														
	RB	$t \leq 50$	Killed and Semi-killed	0.21 max. (4)	0.35 max.	0.8 min. (4)(6)											
		$t > 50$	Killed														
	RD	$t \leq 25$	Killed	0.21 max. (4)	0.35 max.	0.6 min. (4)							0.015 min. (2)(9)				
		$t > 25$	Fine grain treated(2)														
	RE	$t \leq 100$	Killed and Fine grain treated	0.18 max. (4)	0.35 max.	0.7 min. (4)							0.015 min. (9)				
(13)Higher strength steels	$RA32$	$t \leq 100$	Killed and Fine grain treated	0.18 max.	0.50 max.	0.90~ 1.60(7)	0.035 max.	0.035 max.	0.35 max.	0.20 max.	0.40 max.	0.08 max.	0.015 min. (10)	0.02~ 0.05 (10)(11)	0.05~ 0.10 (10)(11)	0.02 max. (11)	—
	$RD32$																
	$RE32$																
	$RA36$																
	$RD36$																
	$RE36$																
	$RA40$	$t \leq 50$															
	$RD40$																
	$RE40$																
	$RF32$			0.16 max.		0.90~ 1.60	0.025 max.	0.025 max.			0.80 max.						0.009 max. (12)
	$RF36$																
	$RF40$																

NOTES:
(1) For sections up to 12.5 mm in thickness inclusive, subject to a special approval by the Society, rimmed steel may be accepted.
(2) For steels above 25 mm in thickness, aluminium treatment is to be used as a fully killed, fine grain practice. However, killed steel up to 50 mm in thickness may be accepted at the discretion of the Society.
(3) For steel sections, maximum carbon content may be increased to 0.23%.
(4) The value of C + Mn/6 is not to exceed 0.40%.
(5) Where additions of any other element have been made as part of the steelmaking paractice, the content is to be indicated on the test certificate.
(6) When an impact test as killed steels is conducted, the minimum manganese content may be reduced to 0.60%.
(7) For steels up to 12.5 mm in thickness inclusive, the minimum manganese content may be reduced to 0.70%.
(8) Aluminium content is to be represented by the acid soluble aluminium content, but may be determined by the total aluminium content. In such a case, the total aluminium content is not to be less than 0.020%.
(9) Upon the approval by the Society, grain refining elements other than aluminium may be used.
(10) The steel is to contain aluminium, niobium, vanadium or other suitable grain refining elements, either singly or in any combination. When used singly, the steel is to contain the specified minimum content of the grain refining element. When used in combination, the specified minimum content of each element is not applicable.
(11) The total niobium, vanadium and titanium content is to be less than 0.12%.
(12) If Aluminium is present, the maximum content of nitrogen may be increased to 0.012%.
(13) For TMCP steels, carbon equivalent values of each steel is to be left to the discretion of this Society.

7. Selection of test specimens

(1) Test specimens are not to be heat treated separately from the product.

(2) Tensile test specimens are to be taken according to (a) to (c) below.

(a) One test specimen is to be taken from one test sample.

(b) The test specimens are to be taken with their longitudinal axis normal to the final direction of rolling. For sections, bars and flat bars not exceeding 600 mm in width or when specially approved by the Society, however, they are to be taken with their longitudinal axis parallel to the final direction of rolling.

Table 2.1.7 Mechanical Properties

Grade	Tensile test			Impact test						
	Yield strength (N/mm^2)	Tensile strength (N/mm^2)	Elongation(6) ($L = 5.65\sqrt{A}$) (%)	test temp. (˚C)	Average absorbed energy(1) (J)					
					Thickness, t (mm)					
					$t \leq 50$		$50 < t \leq 70$		$70 < t \leq 100$	
					L(2)	T(2)	L(2)	T(2)	L(2)	T(2)
RA	235 min.	400~520(3)	22 min.	+20	-	-	(4)	(4)	(4)	(4)
RB				0(5)	27 min.	20 min.	34 min.	24 min.	41 min.	27 min.
RD				− 20						
RE				− 40						
RA 32	315 min.	440~590	22 min.	0	31 min.	22min.	38 min.	26 min.	46 min.	31 min.
RD 32				− 20						
RE 32				− 40						
RF 32				− 60						
RA 36	355 min.	490~620	21 min.	0	34 min.	24 min.	41 min.	27 min.	50 min.	34 min.
RD 36				− 20						
RE 36				− 40						
RF 36				− 60						
RA 40	390 min.	510~650	20 min.	0	41 min.	27 min.				
RD 40				− 20						
RE 40				− 40						
RF 40				− 60						

NOTE:
(1) When the absorbed energy of two or more test specimens among a set of test specimens is less in value than the specified average absorbed energy or when the absorbed energy of a single test specimen is less in value than 70% of the specified average absorbed energy, the test is considered to be failed.
(2) L (or T) denotes that the longitudinal axis of the test specimen is arranged parallel (or transverse) to the final direction of rolling.
(3) For all thickness of Grade RA section, the upper limit of the specified tensile strength, may be exceeded.
(4) For steels of ARS or CRS heat treatment, impact test may be required in case where deemed necessary by the Society. In this case, the average absorbed energy is to comply with the requirements of RB steel.
(5) For steels up to 25mm in thickness, generally no impact testing is required.
(6) The minimum elongation for R14BIV test specimen is to be in compliance with the requirement given in the Table below.

Grade \ Thickness, t (mm)	$3 \leq t \leq 5$	$5 < t \leq 10$	$10 < t \leq 15$	$15 < t \leq 20$	$20 < t \leq 25$	$25 < t \leq 30$	$30 < t \leq 40$	$40 < t \leq 50$
RA, RB, RD, RE RA32, RD32, RE32, RF32	14	16	17	18	19	20	21	22
RA36, RD36, RE36, RF36	13	15	16	17	18	19	20	21
RA40, RD40, RE40, RF40	12	14	15	16	17	18	19	20

(c) Flat test specimens of full product thickness are, generally, to be used. Round test specimen may be used when the plates and shapes(except bars) thickness exceeds 40mm or for bars. When tensile test specimens of bar type are taken from plates and shapes except bars, they are to be taken at a portion approximately 1/4 of the thickness from the surface.

(3) Impact test specimens are to be taken according to (a) to (c) below.

(a) A set of test specimens is to be taken from one test sample.

(b) The test specimens are to be taken with their longitudinal axis parallel (L direction) to the final direction of rolling. When deemed necessary by the Society, however, they are to be taken with their longitudinal axis normal (T direction) to the final direction of rolling.

(c) When the product thickness does not exceed 40 mm, the test specimens are to be cut with their edge within 2 mm from the “as rolled” surface. When the product thickness

Table 2.1.8 Heat Treatment and Size of lot for Impact Test specimen for Normal Strength Steels

<table>
<tr><th rowspan="3">Grade</th><th rowspan="3">Deoxidation practice</th><th rowspan="3">Products(5)</th><th colspan="5">Heat treatment and Size of Lot for Impact Test Specimen(1)(2)(3)(4)</th></tr>
<tr><th colspan="5">Thickness (mm)</th></tr>
<tr><th>0 – 12.5</th><th>12.5 – 25</th><th>25 – 35</th><th>35 – 50</th><th>50 – 100</th></tr>
<tr><td rowspan="4">RA</td><td>Rimmed(6)</td><td>Sections</td><td>AR ⟨—⟩</td><td colspan="4"></td></tr>
<tr><td>Semi-killed</td><td>All</td><td colspan="4">AR ⟨—⟩</td><td></td></tr>
<tr><td rowspan="2">Killed</td><td>Plates</td><td colspan="4">AR ⟨—⟩</td><td>N⟨-⟩ TMCP⟨-⟩ CRS⟨50⟩(7) ARS⟨50⟩(7)</td></tr>
<tr><td>Sections and bars</td><td colspan="4">AR ⟨—⟩</td><td></td></tr>
<tr><td rowspan="3">RB</td><td>Semi-killed</td><td>All</td><td colspan="2" rowspan="3">AR ⟨—⟩</td><td colspan="2" rowspan="3">AR ⟨50⟩</td><td></td></tr>
<tr><td rowspan="2">Killed</td><td>Plates</td><td>N ⟨50⟩ TMCP ⟨50⟩ CRS ⟨25⟩ ARS⟨25⟩</td></tr>
<tr><td>Sections and bars</td><td></td></tr>
<tr><td rowspan="3">RD</td><td>Killed</td><td>All</td><td colspan="2">AR ⟨50⟩</td><td colspan="2">TMCP ⟨50⟩ N ⟨50⟩ CR ⟨50⟩</td><td></td></tr>
<tr><td rowspan="2">Fine grain treated</td><td>Plates</td><td colspan="3" rowspan="2">AR ⟨50⟩</td><td>TMCP ⟨50⟩ N ⟨50⟩ CR ⟨50⟩</td><td>TMCP ⟨50⟩ N ⟨50⟩ CRS ⟨25⟩</td></tr>
<tr><td>Sections and bars</td><td>TMCP ⟨50⟩ N ⟨50⟩ CR ⟨50⟩ ARS ⟨25⟩</td><td></td></tr>
<tr><td rowspan="2">RE</td><td rowspan="2">Killed and Fine grain treated</td><td>Plates</td><td colspan="5">TMCP ⟨P⟩ N ⟨P⟩</td></tr>
<tr><td>Sections and bars</td><td colspan="4">TMCP ⟨25⟩ N ⟨25⟩ CRS ⟨15⟩ ARS ⟨15⟩</td><td></td></tr>
</table>

NOTES:

(1) Indication symbols used in heat treatment are as follows(the same holds henceforth in this Section):
AR : As Rolled *CR* : Controlled Rolling Condition *N* : Normalized Condition
TMCP : Thermo-Mechanical Controlled Processing *ARS* : As Rolled Condition subject to special approval of the Society
CRS : Controlled Rolled Condition subject to special approval of the Society.

(2) In the Table, "marks" put at the end of each symbol for heat treatment stand for the volume of each lot. For examples, <50>, <25> and <15> each indicate that steels not greater than 50, 25 and 15tonnes in weight (belonging to the same charge in the same manufacturing process) are to be taken as one lot; <P>, Piece, indicates that steel material rolled directly from one slab, billet or steel ingot is to be taken as one lot; and <-> indicates that no impact test is required.

(3) The following definitions are applicable to (2) above.
- Lot : A number of similar product manufactured from the same cast, heat treatment and condition of supply.
- Piece : The rolled product from a single slab, billet or ingot if this is rolled directly into plates, strip, sections or bars.

(4) *TMCP*, *N* or *CR* may be applied to instead of being left in a state of *AR*. In this case, steels are to be treated equivalent to those left in a state of *AR* with regard to the fundamental unit of lot.

(5) Steel plates include flat bars not less than 600*mm* in width.

(6) For sections up to 12.5*mm* in thickness, subject to a special approval by the Society, rimmed steel may be accepted.

(7) See Note(4) of **Table 2.1.7**

exceeds 40 *mm*, the test specimen is to be taken at a portion where the axis of the test specimen corresponds to approximately 1/4 of the thickness (1/6 of the diameter of bars) from the surface.

8. Surface inspection and verification of dimensions

(1) Surface inspection and verification of dimensions are the responsibility of the steel manufacturer and the maximum permissible under thickness tolerance for plates and wide flats is –0.3 *mm*. But the permissible under thickness tolerances for plates with thickness less than 5 *mm* may be specially agreed by this Society.

(2) Tolerances for rolled steel other than plates may be specially agreed.

(3) Tolerances for length, width, flatness and over thickness may be taken from *KS* or proprietary specification which give reasonable equivalence.

(4) The thickness is to be measured at random locations whose distance from longitudinal edge is to be at least 10 *mm*.

9. Quality and repair of defects

(1) The steel is to be reasonably free from segregations and non-metallic inclusions. The finished steel is to be free from internal or surface defects prejudicial to the use of steel for the intended application.

(2) The surface defects may be removed by local grinding, provided that the thickness is in no place reduced to less than 93% of the nominal thickness, but in no case by more than 3 *mm*. Such local grindings are to be carried out in the presence of the Surveyor unless otherwise approved by this Society.

(3) Surface defects which cannot be dealt with as above may be repaired by chipping or grind-

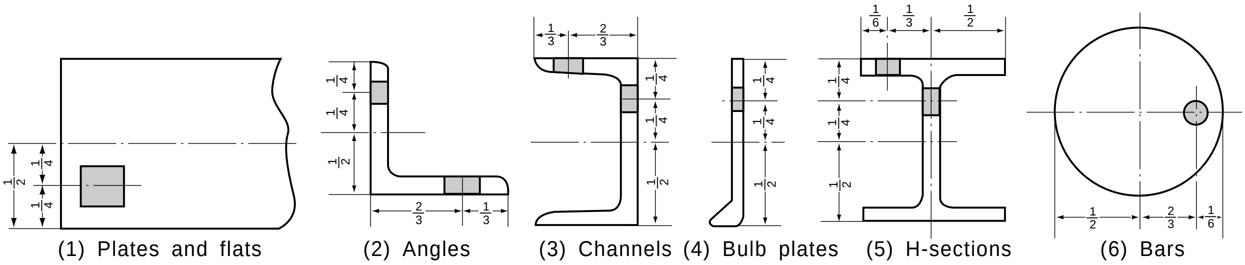


Fig. 2.1.4 Selection of Test Samples

ing followed by welding, subject to the approval by the Society, in the presence of the Surveyor unless otherwise approved by the Society, provided:

(a) That after removal of the defect, and before welding, the thickness of the piece is in no place reduced by more than 20% of the nominal thickness.

(b) That the welding is to be carried out by an approved procedure, by the welder qualified by the Society, with approved electrodes, and that the welding is ground smooth to the correct nominal thickness;

(c) That subsequent to the finish grinding, the piece may be required to be normalized or otherwise heat treated at the Surveyor's discretion.

10. Retest Procedures

(1) Where the tensile test fails to meet the requirements, two further tensile tests may be made from the same piece. If both of these additional tests meet all of the requirements, the piece and the remaining pieces from the same lot may be accepted.

(2) If one or both of the additional tests referred to above are unsatisfactory, the piece from which the above-mentioned test pieces have been taken is to be rejected. However, the remaining material from the same lot may be accepted, provided that two of the remaining pieces in the lot, selected in the same way, are tested with satisfactory results.

(3) (a) Where the result of the impact test is unsatisfactory, additional tests may be carried out, with the exception of the cases specified in (i) and (ii) below, by taking a set of test specimens out of the same piece from which the above-mentioned test specimens have been taken.

(i) The absorbed energy of all test specimens is under the required average absorbed energy.

(ii) The absorbed energy of two of the test specimens is under 70% the required average absorbed energy.

(b) In case of the previous (a), all pieces of the same lot from which the test specimens have been taken, may be accepted, provided that the average absorbed energy of the six test specimens, including those which have been rejected as unsatisfactory, is not less than the required average absorbed energy, and that not more than two individual results are lower than the required average absorbed energy and of these, not more than one result is below 70% of the required average absorbed energy.

(4) When the initial piece, representing a lot, gives unsatisfactory results from the additional Charpy V-notch impact tests referred to the preceding (3), this piece is to be rejected but the remaining material in the lot may be accepted provided that two of the remaining pieces in the lot are tested with satisfactory results. If unsatisfactory results are obtained from either of these two pieces, then the lot of material is to be rejected. The pieces selected for these additional tests are to be the thickest remaining in the batch.

(5) Where the test pieces fail in the retests specified above, the piece from which the test pieces have been taken is to be rejected, However, at the consultation of the manufacturer and the orderer, the remaining pieces in the lot may be resubmitted individually for test and those pieces which give satisfactory results may be accepted.

(6) At the consultation of the manufacturer and the order, the rejected piece may be resubmitted after heat treatment of re-heat treatment, or may be resubmitted as any other grade of steel and then, may be accepted, provided that the required tests are satisfactory.

11. Marking

Steels which have satisfactorily complied with the required tests are to be marked with the identification mark in accordance with the requirements in **110.** and material supplied in the thermo-mechanical controlled processing condition is to have the letters TM added after the material grade mark. (e.g. *RE40TM*)

302. Rolled steel plates for boiler

1. Application

(1) These requirements are to apply to the steel plates (hereinafter referred to as "steel plates")

Table 2.1.9 Hest Treatment and Size of Lot for Impact Test Specimen for Higher Strength Steels

<table>
<tr><th rowspan="3">Grade</th><th rowspan="3" colspan="2">Deoxidation practice</th><th rowspan="3">Products(5)</th><th colspan="6">Heat treatment and Size of Lot for Impact Test Specimen(1)(2)(3)(4)</th></tr>
<tr><th colspan="6">Thickness (mm)</th></tr>
<tr><th>0</th><th>12.5</th><th>20</th><th>25</th><th>35</th><th>50 — 100</th></tr>
<tr><td rowspan="5">RA32
RA36</td><td rowspan="5">Killed and Fine grain treated</td><td rowspan="2">Nb and/or V(6)</td><td>Plates</td><td rowspan="2">AR ⟨50⟩</td><td colspan="4">TMCP ⟨50⟩ N ⟨50⟩ CR ⟨50⟩</td><td>TMCP ⟨50⟩ N ⟨50⟩ CR ⟨25⟩</td></tr>
<tr><td>Sections and bars</td><td colspan="4">TMCP ⟨50⟩ N ⟨50⟩ CR ⟨50⟩ ARS ⟨25⟩</td><td></td></tr>
<tr><td rowspan="3">Al alone or with Ti</td><td rowspan="2">Plates</td><td rowspan="3" colspan="2">AR ⟨50⟩</td><td colspan="2">ARS ⟨50⟩</td><td colspan="2"></td></tr>
<tr><td colspan="3">TMCP ⟨50⟩ N ⟨50⟩ CR ⟨50⟩</td><td>TMCP ⟨50⟩ N ⟨50⟩ CR ⟨25⟩</td></tr>
<tr><td>Sections and bars</td><td colspan="3">TMCP ⟨50⟩ N ⟨50⟩ CR ⟨50⟩ ARS ⟨25⟩</td><td></td></tr>
<tr><td rowspan="5">RD32
RD36</td><td rowspan="5">Killed and Fine grain treated</td><td rowspan="2">Nb and/or V(6)</td><td>Plates</td><td rowspan="2">AR ⟨50⟩</td><td colspan="4">TMCP ⟨50⟩ N ⟨50⟩ CR ⟨50⟩</td><td>TMCP ⟨50⟩ N ⟨50⟩ CR ⟨25⟩</td></tr>
<tr><td>Sections and bars</td><td colspan="4">TMCP ⟨50⟩ N ⟨50⟩ CR ⟨50⟩ ARS ⟨25⟩</td><td></td></tr>
<tr><td rowspan="3">Al alone or with Ti</td><td rowspan="2">Plates</td><td rowspan="3" colspan="2">AR ⟨50⟩</td><td>ARS ⟨25⟩</td><td colspan="3"></td></tr>
<tr><td colspan="3">TMCP ⟨50⟩ N ⟨50⟩ CR ⟨50⟩</td><td>TMCP ⟨50⟩ N ⟨50⟩ CR ⟨25⟩</td></tr>
<tr><td>Sections and bars</td><td colspan="3">TMCP ⟨50⟩ N ⟨50⟩ CR ⟨50⟩ ARS ⟨25⟩</td><td></td></tr>
<tr><td>RE32</td><td rowspan="10">Killed and Fine grain treated</td><td rowspan="10">Any grain refining treated elements</td><td>Plates</td><td colspan="6">TMCP ⟨P⟩ N ⟨P⟩</td></tr>
<tr><td>RE36</td><td>Sections and bars</td><td colspan="5">TMCP ⟨25⟩ N ⟨25⟩ CRS ⟨15⟩ ARS ⟨15⟩</td><td></td></tr>
<tr><td>RF32</td><td>Plates</td><td colspan="5">TMCP ⟨P⟩ N ⟨P⟩ QT ⟨P⟩</td><td></td></tr>
<tr><td>RF36</td><td>Sections and bars</td><td colspan="5">TMCP ⟨25⟩ N ⟨25⟩ QT ⟨25⟩ CRS ⟨15⟩</td><td></td></tr>
<tr><td>RA40</td><td>All</td><td>AR ⟨50⟩</td><td colspan="4">TMCP ⟨50⟩ N ⟨50⟩ CR ⟨50⟩</td><td></td></tr>
<tr><td>RD40</td><td>All</td><td colspan="5">TMCP ⟨50⟩ N ⟨50⟩ CR ⟨50⟩</td><td></td></tr>
<tr><td rowspan="2">RE40</td><td>Plates</td><td colspan="5">TMCP ⟨P⟩ N ⟨P⟩ QT ⟨P⟩</td><td></td></tr>
<tr><td>Sections and bars</td><td colspan="5">TMCP ⟨25⟩ N ⟨25⟩ QT ⟨25⟩</td><td></td></tr>
<tr><td rowspan="2">RF40</td><td>Plates</td><td colspan="5">TMCP ⟨P⟩ N ⟨P⟩ QT ⟨P⟩</td><td></td></tr>
<tr><td>Sections and bars</td><td colspan="5">TMCP ⟨25⟩ N ⟨25⟩ QT ⟨25⟩</td><td></td></tr>
</table>

NOTES:

(1) Indication symbols used in heat treatment are as follows (the same holds henceforth in this Section);
AR : As rolled *CR* : Controlled Rolling Condition *N* : Normalized Condition *TMCP* : Thermo-Mechanical Controlled Processing *QT* : Quenched and Tempered Condition *ARS* : As Rolled Condition subject to special approval of the Society *CRS* : Controlled Rolled Condition subject to special approval of the Society.

(2) In the Table, "makrs" put at the end of each symbol for heat treatment stand for the volume of each lot. For examples, <50>, <25> and <15> each indicate that steels not greater than 50, 25 and 15tonnes in weight (belonging to the same charge in the same manufacturing process) are to be taken as one lot; <P>, Piece, indicates that steel material rolled directly from one slab, billet or steel ingot is to be taken as one lot; and <-> indicates that no impact test is required.

(3) The following definitions are applicable to (2) above.

- Lot ; A number of similar product manufactured from the same cast, heat treatment and condition of supply.
- Piece : The rolled product from a single slab, billet or ingot if this is rolled directly into plates, sirip, sections or bars.

(4) *TMCP*, *N* or *CR* may be applied to instead of being left in a state of *AR*. In this case, steels are to be treated equivalent to those left in a state of *AR* with regard to the fundamental unit of lot.

(5) Steel plates include flat bars not less than 600*mm* in width.

(6) Nioblum treatment stands for the addition of Nb either singly or in any combination, regardless of the *Nb* content, for grain refining. (Refer to Note (10) of **Table 2.1.6**)

for boilers and pressure vessels to be used at high temperatures.

(2) Steel plates other than those specified in **302.** are to comply with the requirements in **101.2**.

2. Kinds

The steel plates are classified as specified in **Table 2.1.10.**

Table 2.1.10 Grades of Steel Plates

Grade	Max. thickness (*mm*)
RSP 42	200
RSP 46	
RSP 49	
RSP 46 *A*	150
RSP 49 *A*	

3. Heat treatment

(1) For steel plates of the "*RSP*42, *RSP*46 and *RSP*49" grade with 50 *mm* or less and of the

"*RSP*46*A* and *RSP*49*A*" grade with 38 *mm* or less in thickness, they are to be as rolled. They, however, may be heat treated as deemed necessary by the manufacturer.

(2) For steel plates of the "*RSP*42, *RSP*46 and *RSP*49'' grade more than 50 *mm* and of the "*RSP*46*A* and *RSP*49*A*" grade more than 38 *mm* in thickness, they are to be either normalized to obtain the normal grain size or heated uniformly to such a temperature at the time of hot forming that an effect equivalent to normalizing can be achieved. In case of normalizing, it is, in principle, to be performed by the manufacturer.

(3) For steel plates to which stress relieving is required after welding or stress relieving is applied by the purchaser one or several times repeatedly during their working process, instruction of that effect is to be given at the time when they are placed for an order. In case where the procedure of stress relieving is not specified by the purchaser, a heat treatment is to be applied for the test samples by heating them slowly and uniformly to the temperature of 600°C to 650°C, holding at that temperature for a period of over one hour per 25 *mm* of thickness, and then, to be cooled to 300°C in the furnace before exposure in a still atmosphere.

4. Chemical composition

The chemical composition of steel plates is to comply with the requirements given in **Table 2.1.11.**

5. Mechanical properties

The mechanical properties of steel plates are to comply with the requirements given in **Table 2.1.12.**

6. Selection of test samples

(1) For the steel plates which are not to be heat treated, one test sample is to be taken from each plate as rolled directly from one slab or ingot

(2) For the steel plates which are to be heat treated, one test sample is to be taken from every similarly heat treated plate as rolled directly from one slab or ingot.

(3) Where the plates specified in (1) and (2) are stress-relieved as specified in **Par 3** (3), the test samples are to be heat treated in accordance with the intended stress-relieving.

(4) The test samples are to be taken from the portion approximately 1/4 of the width from the side end of the plates.

7. Selection of test specimens

Tensile test specimens are to be taken according to (1) to (3) below.

(1) One test specimen is to be taken from one test sample.

(2) The test specimens are to be taken with their longitudinal axis normal to the final direction of rolling.

Table 2.1.11 Chemical Composition

Grade	Chemical composiition (%)						
	Thickness t (mm)	C	Si	Mn	P	S	Mo
RSP 42	$t \le 25$	0.24 max.	0.15 ~ 0.30	0.90 max.	0.035 max.	0.040 max.	—
	$25 < t \le 50$	0.27 max.					
	$50 < t \le 200$	0.30 max.					
RSP 46	$t \le 25$	0.28 max.					
	$25 < t \le 50$	0.31 max.					
	$50 < t \le 200$	0.33 max.					
RSP 49	$t \le 25$	0.31 max.					
	$25 < t \le 50$	0.33 max.					
	$50 < t \le 200$	0.35 max.					
RSP 46 *A*	$t \le 25$	0.18 max.					0.45 ~ 0.60
	$25 < t \le 50$	0.21 max.					
	$50 < t \le 100$	0.23 max.					
	$100 < t \le 150$	0.25 max.					
RSP 49 *A*	$t \le 25$	0.20 max.					
	$25 < t \le 50$	0.23 max.					
	$50 < t \le 100$	0.25 max.					
	$100 < t \le 150$	0.27 max.					

NOTES:
1. For *RSP* 46 with 25 *mm* and over in thickness, carbon and manganese content may be 0.30% or less and 1.00% or less, respectively.
2. For *RSP* 49, carbon and managanese content may be 0.30% or less and 1.15% or less, respectively.

Table 2.1.12 Mechanical Properties

Grade	Yield strength (N/mm^2)	Tensile strength (N/mm^2)	Elongation (%) ($L = 5.65\sqrt{A}$)
$RSP\,42$	225 min.	410~550	24 min.
$RSP\,46$	245 min.	450~590	22 min.
$RSP\,49$	265 min.	480~620	20 min.
$RSP\,46A$	255 min.	450~590	23 min.
$RSP\,49A$	275 min.	480~620	21 min.

NOTE:
For the plates over 90 mm in thickness, the elongation may be reduced from that mentioned in the above Table by 0.5% for each increment of 12.5 mm or fraction thereof exceeding 90 mm in thickness. Such reduction, however, is limited to 3%.

(3) The test specimens of bar type are to be taken from the portion approximately 1/4 of the thickness from the surface.

8. Tolerance for thickness

The minus tolerance for the nominal thickness of plates is to be 0.25 mm.

9. Retest procedure

Where the tensile tests from the first test specimens selected fail to meet the requirements, additional tests may be conducted according to the requirements given in **109.**

10. Marking

(1) Steel plates which have satisfactorily complied with the required tests are to be marked with the identification mark relating to heat treatment in addition to the requirements in **110.**
(2) The marks relating to heat treatment in (1) are to be as specified in the following:
Where the plates are normalized -------------N
Where the test specimens are heat treated corresponding to the stress relieving to be applied. --SR

303. Rolled steel plates for pressure vessel

1. Application

(1) These requirements are mainly to apply to the steel plates for pressure vessels to be used at atmospheric temperature (hereinafter referred to as "steel plates")
(2) The steel plates having characteristics differing from those specified in **303.** are to comply with the requirements in **101.2.**

Table 2.1.13 Grades of Steel Plates

Grade	Max. thickness to be applied (mm)
$RPV\,24$	200
$RPV\,32$	100
$RPV\,36$	75
$RPV\,46$	
$RPV\,50$	

2. Kinds

The steel plates are classified as specified in **Table 2.1.13.**

3. Heat treatment

(1) $RPV24$, $RPV32$ and $RPV36$ plates are to be as rolled. The plates, however, may be heat treated as deemed necessary by this Society.
(2) $RPV46$ and $RPV50$ plates are to be quenched and tempered, But, they may be normalized, controlled-rolled, TMCP or as rolled under the approval by this Society.
(3) The steel plates to be stress-relieved after welding or the steel plates to be stress-relieved by the purchaser during their working process, are to be as required in **302.3** (3).

4. Chemical composition

The chemical composition of steel plates is to comply with the requirements given in **Table 2.1.14.**

Table 2.1.14 Chemical Composition

Grade	Chemical composition (%)						Carbon equivalent (%)	
	C		Si	Mn	P	S	$t \le 50$ (mm)	$50 < t \le 75$ (mm)
$RPV24$	$t \le 100\,mm$	0.18 max.	0.15~0.35	1.40 max	0.030 max.	0.030 max.	—	—
	$t > 100\,mm$	0.20 max.						
$RPV32$	0.18 max.		0.15~0.55	1.50 max.			—	—
$RPV36$	0.20 max.		0.15~0.55	1.60 max.			—	—
$RPV46$	0.18 max.		0.15~0.75	1.60 max.			0.43 max.	0.45 max.
$RPV50$	0.18 max.		0.15~0.75	1.60 max.			0.44 max.	0.46 max.

Table 2.1.15 Mechanical Properties

Grade	Tensile test					Impact test		
	Yield strength (N/mm^2) Thickness of plate t (mm)			Tensile strength (N/mm^2)	Elongation (%) ($L = 5.65\sqrt{A}$)	Test temp. (°C)	Average absorbed energy(J)	Absorbed energy of individual test specimen(J)
	$t \le 50$	$50 < t \le 100$	$100 < t \le 200$					
$RPV24$	235 min.	215 min.	195 min.	400~510	23 min.	0	47 min.	27 min.
$RPV32$	315 min.	295 min.	—	490~610	22 min.			
$RPV36$	355 min.	335 min.		520~640	20 min.			
$RPV46$	450 min.	430 min.		570~700	17 min.	－10		
$RPV50$	490 min.	470 min.		610~740	16 min.			

Where deemed necessary, other elements than speeified in **Table 2.1.14** may be added. In that case, such elements are to be stated in the test sheets.

5. Mechanical properties

The mechanical properties of steel plates are to comply with the requirements given in **Table 2.1.15.**

6. Selection of test samples

(1) For the steel plates which are not to be heat treated, one test sample is to be taken from each plate as rolled directly from one slab or ingot.
(2) For the steel plates which are to be heat treated, one test sample is to be taken from every similary heat treated plate as rolled directly from one slab or ingot.
(3) Where the plates specified in (1) and (2) are stress-relieved as specified in **Par 3** (3), test samples are to be heat treated in accordance with the intended stress-relieving.
(4) The test samples are to be taken from the portion approximately 1/4 of the width from the side end of the plate.

7. Selection of test specimen

(1) Tensile test specimens are to be taken according to (a) to (c) below.
  (a) One test specimen is to be taken from one test sample.
  (b) The test specimens are to be taken with thier longitudinal axis normal to the final direction of rolling .
  (c) The test specimens of bar type are to be taken from the portion approximately 1/4 of the thickness from the surface.
(2) Impact test specimens is to be taken according to (a) to (c) below.
  (a) A set of test specimens are to be taken from one test sample.
  (b) The test specimens are to be taken with their longitudinal axis parallel (L direction) to the final direction of rolling. Where deemed necessary by the Society, however, they are to be taken with their longitudinal axis normal (T direction) to the final direction of rolling.
  (c) The test specimens are to be taken at a portion where the axis of the test specimen corresponds to approximately 1/4 of the thickness from the surface.

8. Tolerance for thickness

The minus tolerance for thenominal thickness of plates is to be 0.25 mm.

9. Retest procedures

(1) Where the tensile test from the first test specimen selected fails to meet the requirements, additional tests may be conducted according to the requirements given in **109.**
(2) In case where the mean value of absorbed energies in impact tests of three test specimens shows 85% or more of the specified value and each value of two or more test specimens meets the required value, although the mean value fails to meet the requirements, three additional test specimens may be put to retest taking such specimens from the position in the vicinity where the former test specimens were taken. In this case, if the mean value of six test specimens and each value of three test specimens in the retest meet the requirements, they may be accepted.

10. Marking

(1) Steel plates which have satisfactorily complied with the required tests are to be marked with the identification mark relating to heat treatment in addition to the requirements in **110.**
(2) The marks relating to heat treatment in (1) are to be as specified in the following:
Where the plates are controlled-rolled-----CR
Where the plates are normalized-------------N
Where the plates are quenched and tempered ---QT
Where the plates are heat treated in TMCP condition ---TM
Where the test specimens are heat treated corresponding to the stress-relieving to be applied--SR

11. Steel plates equivalent to standard

(1) The mild steel plates of grade *RD* and *RE*, the high tensile steels of rolled steels for hull specified in **301.** are taken as equivalent to the plates specified in **303.,** in case where the test specimens are taken as required in **Pars 6** and **7** and test results comply with the requirements in **301.** In this case, "*PV*" is to be suffixed to the markings to indicate the kind of plates specified in **301.**

(2) Any requirements regarding heat treatment of steel plates specified in (1) is left to the discretion of this Society.

304. Rolled steels for low temperature service

1. Application

(1) The requirements are to apply to the rolled steels not exceeding 40 *mm* in thickness intended for tanks and ship's hull structures adjacent to tanks of liquefied gas carriers, and other parts such a hull structures of refrigerated cargo carrier which are exposed to low temperature (hereinafter referred to as "steels").

(2) Any requirement regarding the steels over 40 *mm* in thickness is left to the discretion of this Society.

(3) The requirements other than those specified in **304.** are applicable to the requirements in **301.**

(4) The steels other than those specified in **304.** are to comply with the requirements in **101.2.**

2. Kinds

Steels are classified as specified in **Table 2.1.16.**

3. Heat treatment

The heat treament of steels is to comply with the requirements given in **Table 2.2.17.**

4. Deoxidation practice and chemical composition

(1) The deoxidation practice and chemical composition of each grade are to comply with the requirements given in **Table 2.1.16.** When deemed necessary, chemical elements other than those given in the table may be added.

(2) Notwithstanding the requirements given in (1), when heat treatment has been conducted according to TMCP, the chemical composition of steels specified in **Table 2.1.16** may be modified subject to the approval by this Society.

5. Mechanical properties

The mechanical properties of steels are to comply with the requirements given in **Table 2.1.17.** Where deemed necessary by this Society. other tests on notch toughness may be required additionally.

6. Selection of test sample

(1) For steel plates, one test sample is to be taken from each plate as rolled directly from one slab or ingot.

(2) For test samples used in other steels than steel plates, steels not greater than 10 *tonnes* in mass (having the same cross-sectional dimensions and being from the same cast manufactured by the same process) are to be treated as one lot, and one test sample is to be taken from each lot.

(3) The requirements specified in **301.6** (4) are to be applied to the selection of the test samples.

7. Selection of test specimens

(1) Tensile test specimens are to be taken according to the requirements specified in **301.7** (2).

(2) Impact test specimens are to be taken according to the following (a) and (b):

(a) The requirements specified in **301.7** (3) are to apply.

(b) For steel plates, the test specimens are to be taken with their longitudinal axis normal (*T* direction) to the final direction of rolling; for other steels than steel plates, they are to be taken with their longitudinal axis parallel (*L* direction) to the final direction of rolling.

Table 2.1.16 Grades and Chemical Composition

Grade	Deoxidation	Chemical composition (%)						Carbon equivalent
		C	Si	Mn	P	S	Ni	
RL24A	Fully killed Aluminium treated fine grain	0.16 max.	0.10~0.50	0.70~1.60	0.030 max.	0.025 max.	—	0.41 max.
RL24B		0.14 max.						
RL27		0.14 max.						
RL33		0.14 max.						
RL37		0.14 max.						
RL2N30		0.14 max.	0.15~0.30	0.70 max.	0.025 max.	0.025 max.	2.10~2.50	—
RL3N32		0.14 max.					3.25~3.75	
RL5N43		0.12 max.		0.90 max.			4.50~5.50	
RL9N53		0.10 max.					8.50~9.50	
RL9N60								

Table 2.1.17 Heat Treatment and Mechanical Properties

Grade	Heat treatment	Tensile test			Impact test [3][4]		
		Yield strength (N/mm^2)	Tensile strength (N/mm^2)	Elongation (%)[2] ($L=5.65\sqrt{A}$)	Test temp.[5] (°C)	Average absorbed energy (J)	
						L	T
$RL24A$	Normalized or $TMCP$	235 min.	400~510	20 min.	− 40	41 min.	27 min.
$RL24B$					− 50		
$RL27$		265 min.	420~540		− 60		
$RL33$	Quenched and tempered or $TMCP$	325 min.	440~560				
$RL37$		360 min.	490~610	19 min.			
$RL2N30$	Normalized or normalized and tempered[1]	295 min.	420~570		− 70		
$RL3N32$		315 min.	440~590		− 95		
$RL5N43$		420 min.	540~690		− 110		
$RL9N53$	Double normalized and tempered[1]	520 min.	690~840	18 min.	− 196		
$RL9N60$	Quenched and tempered[1]	590 min.	690~840				

NOTES:
(1) Heat treatment may be conducted according to $TMCP$, subject to the special approval by the Society.
(2) The minium elongation for $R14B$ IV test specimen is to be in compliance with the requiements given in the Table below.

Minimum Elongation (%)

Grade \ Thickness t (mm)	$t \le 5$	$5 \langle t \le 10$	$10 \langle t \le 15$	$15 \langle t \le 20$	$20 \langle t \le 25$	$25 \langle t \le 30$	$30 \langle t \le 35$	$35 \langle t \le 40$
RL 24A, RL 24B, RL 27	13	14	15	16	17	18	18	19
RL 33	12	13	14	15	16	17	18	19
RL 37	11	12	13	14	15	16	17	18
RL 2N 30, RL 3N 32, RL 5N 43	12	13	14	15	16	17	17	18
RL 9N 53, RL 9N 60	10	11	12	13	14	15	16	17

(3) L (or T) indicates that the longitudinal axis of the test specimen is arranged parallel (or transverse) to the final direction of rolling.
(4) When the absorbed energy of two or more test specimens among a set of test specimens is less in value than the specified average absorbed energy or when the absorbed energy of a single test specimen is less in value than 70% of the specified average absorbed energy, the test is considered to have failed.
(5) Impact test temperature for steels specified in **Pt 7, Ch 5** is to comply with the requirements given in **Table 2.1.18.**

8. Surface inspection and verification of dimensions

Surface inspection and verification of dimensions are the responsibility of the steel manufacturer and the minus tolerance in the nominal thickness of plates is to be 0.25 mm. For steels except steel plates, any requirement regarding the minus tolerance is left to the discretion of the Society.

9. Retest procedures

(1) Where the tensile test from the first test specimen selected fails to meet the requirements, additional test may be conducted according to the requirements given in **109.**
(2) Regarding the impact test, additional tests may be conducted according to the requirements given in **301.10** (3).

10. Marking

Steels which have satisfactorily complied with the required tests are to be marked with the identification mark in accordance with the requirements in **110.** For steels to which the requirements given in Notes (1) and (5) of **Table 2.1.17** have been applied, "TM'' and impact test temperature "T" are to be suffixed to the markings. (e.g. $RL33TM$-50T)

305. Rolled stainless steels

1. Application

(1) These requirements are to apply to the rolled stainless steels (hereinafter referred to as "steels") for tanks in low temperature service or corrosion-resisting service.

Table 2.1.18 Impact Test Temperature of Steels Specifed in Pt 7, Ch 5.

<table>
<tr><th>Grade</th><th>Thickness t (mm)</th><th>Test temp. (°C)(1)</th></tr>
<tr><td rowspan="4">RL24A
RL24B
RL27
RL33
RL37</td><td>$t \le 25$</td><td>− 20 or (Td − 5) (2)</td></tr>
<tr><td>25 〈 $t \le 30$</td><td>− 20 or (Td − 10) (2)</td></tr>
<tr><td>30 〈 $t \le 35$</td><td>− 20 or (Td − 15) (2)</td></tr>
<tr><td>35 〈 $t \le 40$</td><td>(Td − 20)</td></tr>
<tr><td rowspan="4">RL2N30</td><td>$t \le 25$</td><td>− 70</td></tr>
<tr><td>25 〈 $t \le 30$</td><td>− 70 or (Td − 10) (2)</td></tr>
<tr><td>30 〈 $t \le 35$</td><td>− 70 or (Td − 15) (2)</td></tr>
<tr><td>35 〈 $t \le 40$</td><td>− 70 or (Td − 20) (2)</td></tr>
<tr><td rowspan="4">RL3N32</td><td>$t \le 25$</td><td>− 95</td></tr>
<tr><td>25 〈 $t \le 30$</td><td>− 95 or (Td − 10) (2)</td></tr>
<tr><td>30 〈 $t \le 35$</td><td>− 95 or (Td − 15) (2)</td></tr>
<tr><td>35 〈 $t \le 40$</td><td>− 95 or (Td − 20) (2)</td></tr>
<tr><td rowspan="4">RL5N43</td><td>$t \le 25$</td><td>− 110</td></tr>
<tr><td>25 〈 $t \le 30$</td><td>− 110 or (Td − 10) (2)</td></tr>
<tr><td>30 〈 $t \le 35$</td><td>− 110 or (Td − 15) (2)</td></tr>
<tr><td>35 〈 $t \le 40$</td><td>− 110 or (Td − 20) (2)</td></tr>
<tr><td>RL9N53</td><td rowspan="2">$t \le 40$</td><td rowspan="2">− 196</td></tr>
<tr><td>RL9N60</td></tr>
<tr><td colspan="3">NOTES:
(1) Td is the design temperature (°C).
(2) The test temperature is to be the lower of those specified above.</td></tr>
</table>

(2) The requirements other than those specified in **305.** are applicable to the requirements in **301.**

(3) Steels other than those specified in **305.** are to comply with the requirements in **101.2.**

2. Kinds

Steels are classified as specified in **Table 2.1.19.**

3. Heat treatment

The steels are generally to receive a solid solution treatment.

4. Chemical composition

The chemical composition of steels is to comply with the requirements given in **Table 2.1.19.**

5. Mechanical properties

(1) The mechanical properties of steels are to comply with the requirements given in **Table 2.1.20.**

(2) The results of hardness test, according to the test method, are to comply with the requirements given in **Table 2.1.20.**

(3) Other tests on notch toughness or corrosion-resistance may be required, where deemed necessary by the Society.

6. Selection of test samples

(1) One test sample is to be taken from each steel as rolled directly from one slab, billet or ingot.

(2) The requirements provided in **301.6** (4) are to be applied to the selection of the test samples.

7. Selection of test specimens

Table 2.1.19 Grades and Chemical Composition of Stainless Steels

<table>
<tr><th rowspan="2">Grade</th><th colspan="10">Chemical composition (%)</th></tr>
<tr><th>C</th><th>Si</th><th>Mn</th><th>P</th><th>S</th><th>Ni</th><th>Cr</th><th>Mo</th><th>N</th><th>Others</th></tr>
<tr><td>RSUS304</td><td>0.08 max.</td><td rowspan="6">1.00 max.</td><td rowspan="2">2.00 max</td><td rowspan="16">0.040 max</td><td rowspan="16">0.030 max</td><td>8.00~10.50</td><td rowspan="4">18.00~20.00</td><td rowspan="7">—</td><td rowspan="2">—</td><td rowspan="3">—</td></tr>
<tr><td>RSUS304L</td><td>0.030 max.</td><td>9.00~13.00</td></tr>
<tr><td>RSUS304N1</td><td rowspan="2">0.08 max.</td><td rowspan="2">2.50 max</td><td>7.00~10.50</td><td>0.10~0.25</td></tr>
<tr><td>RSUS304N2</td><td>7.50~10.50</td><td>0.15~0.30</td><td>Nb ≤ 0.15</td></tr>
<tr><td>RSUS304LN</td><td>0.030 max.</td><td rowspan="12">2.00 max</td><td>8.50~11.50</td><td>17.00~19.00</td><td>0.12~0.22</td><td rowspan="10">—</td></tr>
<tr><td>RSUS309S</td><td rowspan="3">0.08 max.</td><td>12.00~15.00</td><td>22.00~24.00</td><td rowspan="4">—</td></tr>
<tr><td>RSUS310S</td><td>1.50 max</td><td>19.00~22.00</td><td>24.00~26.00</td></tr>
<tr><td>RSUS316</td><td rowspan="9">1.00 max</td><td>10.00~14.00</td><td rowspan="3">16.00~18.00</td><td rowspan="4">2.00~3.00</td></tr>
<tr><td>RSUS316L</td><td>0.030 max.</td><td>12.00~15.00</td></tr>
<tr><td>RSUS316N</td><td>0.08 max.</td><td>10.00~14.00</td><td>0.10~0.22</td></tr>
<tr><td>RSUS316LN</td><td>0.030 max.</td><td>10.50~14.50</td><td>16.50~18.50</td><td>0.12~0.22</td></tr>
<tr><td>RSUS317</td><td>0.08 max.</td><td rowspan="3">11.00~15.00</td><td rowspan="3">18.00~20.00</td><td rowspan="3">3.00~4.00</td><td rowspan="2">—</td></tr>
<tr><td>RSUS317L</td><td rowspan="2">0.030 max.</td></tr>
<tr><td>RSUS317LN</td><td>0.10~0.20</td></tr>
<tr><td>RSUS321</td><td rowspan="2">0.08 max.</td><td rowspan="2">9.00~13.00</td><td rowspan="2">17.00~19.00</td><td rowspan="2">—</td><td rowspan="2">—</td><td>Ti ≥ 5 × C</td></tr>
<tr><td>RSUS347</td><td>Nb ≥ 10 × C</td></tr>
</table>

Table 2.1.20 Mechanical Properties of Stainless Steels

<table>
<tr><th rowspan="2">Grade</th><th colspan="3">Tensile</th><th colspan="3">Hardness test</th></tr>
<tr><th>Yield strength (N/mm^2)</th><th>Tensile strength (N/mm^2)</th><th>Elongation(%) ($L=5.65\sqrt{A}$)</th><th>Brinell H_B</th><th>Rock well H_{RB}</th><th>Vickers H_V</th></tr>
<tr><td>$RSUS304$</td><td>205 min.</td><td>520 min.</td><td rowspan="2">40 min.</td><td rowspan="2">187 max.</td><td rowspan="2">90 max.</td><td rowspan="2">200 max.</td></tr>
<tr><td>$RSUS304L$</td><td>175 min.</td><td>480 min.</td></tr>
<tr><td>$RSUS304N1$</td><td>275 min.</td><td>550 min.</td><td rowspan="2">35 min.</td><td>217 max.</td><td>95 max.</td><td>220 max.</td></tr>
<tr><td>$RSUS304N2$</td><td>345 min.</td><td>690 min.</td><td>250 max.</td><td>100 max.</td><td>260 max.</td></tr>
<tr><td>$RSUS304LN$</td><td>245 min.</td><td>550 min.</td><td rowspan="5">40 min.</td><td>217 max.</td><td>95 max.</td><td>220 max.</td></tr>
<tr><td>$RSUS309S$</td><td rowspan="3">205 min.</td><td rowspan="3">520 min.</td><td rowspan="4">187 max.</td><td rowspan="4">90 max.</td><td rowspan="4">200 max.</td></tr>
<tr><td>$RSUS310S$</td></tr>
<tr><td>$RSUS316$</td></tr>
<tr><td>$RSUS316L$</td><td>175 min.</td><td>480 min.</td></tr>
<tr><td>$RSUS316N$</td><td>275 min.</td><td rowspan="2">550 min.</td><td>35 min.</td><td rowspan="2">217 max.</td><td rowspan="2">95 max.</td><td rowspan="2">220 max.</td></tr>
<tr><td>$RSUS316LN$</td><td>245 min.</td><td rowspan="6">40 min.</td></tr>
<tr><td>$RSUS317$</td><td>205 min.</td><td>520 min.</td><td rowspan="2">187 max.</td><td rowspan="2">90 max.</td><td rowspan="2">200 max.</td></tr>
<tr><td>$RSUS317L$</td><td>175 min.</td><td>480 min.</td></tr>
<tr><td>$RSUS317LN$</td><td>245 min.</td><td>550 min.</td><td>217 max.</td><td>95 max.</td><td>220 max.</td></tr>
<tr><td>$RSUS321$</td><td rowspan="2">205 min.</td><td rowspan="2">520 min.</td><td rowspan="2">187 max.</td><td rowspan="2">90 max.</td><td rowspan="2">200 max.</td></tr>
<tr><td>$RSUS347$</td></tr>
</table>

(1) Tensile test specimens are to be taken according to the requirements specified in **301.7** (2).
(2) The hardness test specimen may be a portion of tensile test specimen.

8. Tolerance for thickness

Surface inspection and verification of dimensions are the responsibility of the steel manufacturer and the minus tolerance in the nominal thickness is to be 0.25 mm. For steels except steel plates, any requirement regarding the minus tolerance is left to the discretion of the Society.

9. Marking

Steels which have satisfactorily complied with the required tests are to be marked with identification mark in accordance with the requirements in **110.**

306. Round bars for chain

1. Application

(1) These requirements are to apply to the rolled round bars (hereinafter referred to as "chain bars") for chain specified in **Pt 4, Ch 8, Sec 4.**
(2) The requirements other than those specified in **306.** are applicable to the requirements in **301.**
(3) Chain bars having characteristics differing from those specified in **306.** are to comply with the requirements in **101.2.**

2. Kinds

The chain bars are classified as specified in **Table 2.1.21.**

Table 2.1.21 Grades of Chain Bars

Grade		Application
Grade 1 chain bar	$RSBC$ 31	Unstudded chain Grade 1 chain
Grade 2 chain bar	$RSBC$ 50	Grade 2 chain
Grade 3 chain bar	$RSBC$ 70	Grade 3 chain
Grade $R3$ chain bar	$RSBCR$ 3	Grade $R3$ chain
Grade $R3S$ chain bar	$RSBCR$ 3 S	Grade $R3S$ chain
Grade $R4$ chain bar	$RSBCR$ 4	Grade $R4$ chain

3. Deoxidation practice and chemical composition

The deoxidation practice and chemical composition of each grade are to comply with the requirements given in **Table 2.1.22.** Elements other than specified in **Table 2.1.22** may be added subject to a special approval by the Society.

4. Mechanical properties

The mechanical properties of chain bars are to comply with the requirements given in **Table 2.1.23.**

5. Selection of test sample

(1) Chain bars not greater than 50 $tonnes$ in weight (from the same cast manufactured by the same process) are to be treated as one lot, and one test sample largest in diameter is to be taken from each lot.

Table 2.1.22 Deoxidation Practice and Chemical Composition (%)

Grade	Deoxidation	C	Si	Mn	P	S	Al(1)
*RSBC*31	Killed	0.20 max.	0.15~0.35	0.40 min.	0.040 max.	0.040 max.	–
*RSBC*50	Fine-grained killed	0.24 max.	0.15~0.55	1.60 max.	0.035 max.	0.035 max.	0.020 min.
*RSBC*70		0.36 max.	0.15~0.55	1.00~1.90	0.035 max.	0.035 max.	0.020 min.
*RSBCR*3	Fine-grained killed	(2)(3)					
*RSBCR*3*S*							
*RSBCR*4							

NOTE:
(1) *Al* content is to be represented by the total *Al* content and may be replaced partly by other fine graining elements.
(2) Detailed chemical composition is to be approved by the Society.
(3) For Grade RSBCR4, the steel should contain a minimum of 0.2% molybdenum.

Table 2.1.23 Mechanicsl Properties

Grade	Tensile test				Impact test(1)(2)	
	Yield strength (N/mm^2)(3)	Tensile strength (N/mm^2)(3)	Elongation(%) ($L=5d$)	Reduction of area(%)	Test temp. (°C)	Average absorbed energy (J)
RSBC 31	–	370~490	25 min.	–	–	–
RSBC 50	295 min.	490~690	22 min.	–	0	27 min.
RSBC 70	410 min.	690 min.	17 min.	40 min.	0	60 min.
RSBCR 3	410 min.	690 min.	17 min.	50 min.	– 20(4)	40 min.(4)
RSBCR 3*S*	490 min.	770 min.	15 min.	50 min.	– 20(4)	45 min.(4)
RSBCR 4	580 min.	860 min.	12 min.	50 min.	– 20	50 min.

NOTES:
(1) When the absorbed energy of two or more test specimens among a set of test specimens is less in value than the specified average absorbed energy or when the absorbed energy of a single test specimen is less in value than 70% of the specified average absorbed energy, the test is considered to have failed.
(2) For *RSBC* 50 intended for Grade 2 chain which will be heat treated according to **Pt 4, Ch 8, 405.,** no impact testing is required.
(3) The yield ratio (the aim value of yield to tensile ratio) for grade *RSBCR*3, *RSBCR*3*S*, or *RSBCR*4 is to be maximum 0.92.
(4) Impact test of grade *RSBCR*3 and *RSBCR*3*S* may be carried out at the temperature of 0°C where approved by the Society. In this case, minimum mean absorbed energy is to be not less than 60J for grade *RSBCR*3 and 65J for grade *RSBCR*3*S*.

Table 2.1.24 Heat Treatment of Test Sample

Grade	Heat treatment
RSBC 31	As rolled
RSBC 50	As rolled or Normalized(1)
RSBC 70	Normalized, Normalized and tempered, or Quenched and tempered
RSBCR 3	
RSBCR 3 *S*	
RSBCR 4	

NOTE:
(1) The round bars for chain which will not be heat treated according to **Pt 4, Ch 8, 405.,** are to be treated as rolled.

(2) The heat treatment of the test sample is to comply with the requirements given in **Table 2.1.24** for each grade. In this case, the same heat treatment applied to chain bars after welding is to be carried out on the test sample.

6. Selection of test specimens

(1) For Grade 1 chain bars, one tensile test specimen is to be taken from the test sample; for Grade 2 chain bars, one tensile test specimen and one set (3 pieces) of impact test specimens (except when Note (2) of **Table 2.2.23** is applied); for Grade 3 chain bars, one tensile test specimen and one set (3 pieces) of impact test specimens are to be taken from the test sample.

(2) For grades RSBCR3S and RSBCR4 in addition to the test specimen required by (1), two tensile test specimens having a diameter of 20mm in principle, are to be taken for the hydrogen embrittlement test. In this case, test specimen is to be taken from the central region of bar materials heat-treated in the same manner as (a) or (b).

(a) In case of continuous casting, test sam-

ples representing both the beginning and the end of the charge(except the mixed zone of the charge) shall be taken.
   (b) In case of ingot casting test samples representing two different ingots shall be taken.
(3) The test specimens are to be taken with their longitudinal axis parallel to the final direction of rolling.
(4) The tensile and impact test specimens are to be taken from the test sample in the longitudinal direction at a depth of 1/6 diameter from the surface or as close as possible to this position. (See **Fig. 2.1.5**)
(5) The longitudinal axis of the notch is to correspond approximately to the radial direction of each test specimen.

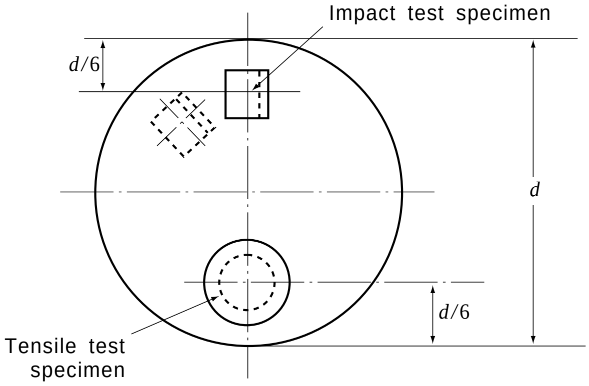


Fig. 2.1.5 Selection of Test Specimens

7. Hydrogen embrittlement test

(1) Hydrogen embrittlement test is to be carried out in accordance with the following procedure:
   (a) One tensile test specimen is to be tested within max. 3 hours after machining. Alternatively, tensile test specimen may be cooled to –60°C immediately after machining and kept at that temperature for a period of max. 5 days.
   (b) The other specimen is to be tested after baking at 250°C for 4 hours.
   (c) A slow strain rate as far as practicable is used during the entire test, and tensile strength, elongation and reduction of area are to be measured.
(2) The test result is to comply with the following formula.

$$Z(1) \ / \ Z(2) \ \geq \ 0.85$$

Z(1) is the reduction of area measured by the test specified in (1) (a)
Z(2) is the reduction of area measured by the test specified in (1) (b)

8. Surface inspection, non-destructive inspection and verification of dimensions

(1) Surface inspection for all grades is to be carried out and it is to be confimed that there are no harmful defects.
(2) For grades *RSBCR*3, *RSBCR*3*S* and *RSBCR*4, all round bar for chains are subjected to ultrasonic examination at an appropriate stage of the manufacture and it is to be confirmed that there are no harmful defects.
(3) For grades *RSBCR*3, *RSBCR*3*S* and *RSBCR*4, one hundred percent of round bars for chains is to be examined by magnetic particle or eddy current methods and it is to be confimed by magnetic particle or eddy current methods and it is to be confirmed that there are no harmful defects.
(4) Notwithstanding the requirements of (2) and (3), the frequency of non-destructive inspection may be reduced where the quality control conditions of the manufacturer are satisfactorily met. However, non-destructive inspection of samples required in 5. are to be carried out in every case.
(5) The diameter and roundness of all grades of round bars for chains are to be within the tolerances specified in **Table 2.1.25.**

Table 2.1.25 Dimensional tolerance

Nominal Diameter (mm) (1)	Tolerance on diameter (mm)	Tolerance on roundness ($d_{max} - d_{min}$) (mm) (2)
less than 25	− 0+1.0	0.6 max
25~35	− 0+1.2	0.8 max
36~50	− 0+1.6	1.1 max
51~80	− 0+2.0	1.50 max
81~100	− 0+2.6	1.95 max
101~120	− 0+3.0	2.25 max
121~160	− 0+4.0	3.00 max

NOTES:
(1) For nominal diameter of bar materials which have more than 161, dimensional tolerances are to be as deemed appropriate by the Society.
(2) d_{max} and d_{min} mean the maximum and minimum diameter of a round bar.

9. Retest procedures

(1) Where the tensile test or impact test on the selected first test specimens have failed to meet the requirements, additional tests may be carried out according to the requirements given in **301.10** (1) and (3)
(2) Where the test of heat treated samples specified in (1) has failed, additional tests may be carried out according to the requirements given in **109.3.**

10. Marking

Chain bars which have satisfactorily complied with the required tests are to be marked with identification marks in accordance with the requirements in **110.**

307. Rolled steel bars for boiler

1. Application

(1) These requirements are to apply to hot rolled steel bars intended to be used for the stay bolts for boilers (hereinafter referred to as "steel bars'').

(2) The steel bars having characteristics differing from those specified in **307.** are to comply with the requirements of **101.2.**

2. Kinds

The steel bars are classified as specified in **Table 2.1.26.**

Table 2.1.26 Grades and Chemical Composition

Grade	Chemical composition (%)		
	C	S	P
RSB 42	0.30 max.	0.04 max.	0.05 max.
RSB 46	0.33 max.		

3. Heat treatment

The heat treatment of steel bars is to be as deemed appropriate by the Society.

4. Chemical composition

The chemical composition of steel bars is to comply with the requirements given in **Table 2.1.26.**

5. Mechanical properties

The mechanical properties of steel bars are to comply with the following requirements.

(1) The tensile test of steel bars is to comply with the requirements given in **Table 2.1.27.**

Table 2.1.27 Mechanical Properties

Grade	Yield strength (N/mm^2)	Tensile strength (N/mm^2)	Elongation(%) ($L=5.65\sqrt{A}$)
RSB 42	225 min.	410~490	24 min.
RSB 46	245 min.	450~540	22 min.

NOTE:
The required value of yield strength for the steel bars exceeding 100 *mm* in diameter may be taken as 205 N/mm^2 for *RSB* 42 and 225 N/mm^2 for *RSB* 46, regardless of the above requirements.

(2) The bend test specimen is to stand being bent cold through 180 *degrees* without cracking on the outside of the bent portion to an inside redius given in **Table 2.1.28.**

Table 2.1.28 Bend Test

Dia.of bar (*mm*)	Ratio of inside radius of bend to diameter of test specimen	
	RSB 42	*RSB* 46
$d \le 25$	$\frac{3}{4}$	1
$25 < d \le 50$	1	$1\frac{1}{4}$
$50 < d \le 75$	$1\frac{1}{4}$	
$75 < d$		$1\frac{1}{2}$

Table 2.1.29 Number of Test Samples

Weight of group (*ton*)	Number of test samples
25 and under	1 each
Over 25 up to 30	2 each
Over 30	2 each plus 1 each for each 10 *tons* of excess or fraction thereof

Table 2.1.30 Tolerance for Diameter

Diameter of bar (*mm*)	Tolerance
$d < 16$	± 0.4 *mm*
$16 \le d < 28$	± 0.5 *mm*
$28 \le d$	± 1.8%

6. Selection of test samples

For the test samples of steel bars, steel bars which belong to the same cast manufactured by the same process and where the amount of scatter is to be less than 10 *mm* in diameter, are to be treated as one lot, and test samples are to be taken from each lot accord ing to the mass of the lot and to the requirements provided in **Table 2.1.29.**

7. Selection of test specimens

(1) Each one piece of tensile and bend test specimen is to be taken from one test sample.

(2) Test specimens are to be taken with their longitudinal axis parallel to the final direction of rolling.

(3) Tensile test specimens are to be taken from the sample in the longitudinal direction at a depth of 1/6 diameter from the surface or as close as possible to this position. (See **Fig. 2.1.5**)

8. Tolerance for diameter

The tolerance for diameter of the steel bars is to comply with the requirements in **Table 2.1.30.**

9. Marking

Steel bars which have satisfactorily complied with the required tests are to be marked with the identification mark in accordance with the requirements in **110.**

308. Extra high strength rolled steels for structures.

1. Application

(1) The requirements given in **308.** are to apply to extra high strength rolled steels for structures not exceeding 70 *mm* in thickness intended for mobile offshore units, tanks of liquefied gas carriers and process pressure vessels (hereinafter referred to as "steels").
(2) Any requirements regarding the steels over 70 *mm* in thickness are left to the discretion of the Society.
(3) The requirements other than those specified in **308.** are applicable to the requirements in **301.**
(4) Steels having characteristics differing from those specified in **308.** are to comply with the requirements in **101.2.**

Table 2.1.31 Grade of Steels

Kind	Grade
Extra high strength rolled steels for structures	*RA* 43, *RD* 43, *RE* 43, *RF* 43
	RA 47, *RD* 47, *RE* 47, *RF* 47
	RA 51, *RD* 51, *RE* 51, *RF* 51
	RA 56, *RD* 56, *RE* 56, *RF* 56
	RA 63, *RD* 63, *RE* 63, *RF* 63
	RA 70, *RD* 70, *RE* 70, *RF* 70

2. Kinds

Steels are classified as specified in **Table 2.1.31.**

3. Heat treatment

The heat treatment of each grade is to comply with the requirements given in **Table 2.1.33.**

4. Deoxidation practice and chemical composition

(1) The deoxidation practice and chemical composition of steels are to comply with the requirements given in **Table 2.1.32.** Where deemed

Table 2.1.32 Deoxidation Practice and Chemical Composition (%)

<table>
<tr><th>Grade</th><th>Deoxidation practice</th><th>C</th><th>Si</th><th>Mn</th><th>P</th><th>S</th><th>Cu</th><th>Cr</th><th>Mo</th><th>V</th><th>B</th><th>N</th></tr>
<tr><td>RA 43</td><td rowspan="24">Fully killed fine grain</td><td>0.21max.</td><td rowspan="24">0.55 max.</td><td>1.70max.</td><td>0.035max.</td><td>0.035max.</td><td rowspan="16"></td><td rowspan="16"></td><td rowspan="16"></td><td rowspan="16"></td><td rowspan="16"></td><td rowspan="24">0.020 max.</td></tr>
<tr><td>RD 43</td><td>0.20max.</td><td>1.70max.</td><td>0.035max.</td><td>0.035max.</td></tr>
<tr><td>RE 43</td><td>0.20max.</td><td>1.70max.</td><td>0.035max.</td><td>0.035max.</td></tr>
<tr><td>RF 43</td><td>0.18max.</td><td>1.60max.</td><td>0.025max.</td><td>0.025max.</td></tr>
<tr><td>RA 47</td><td>0.21max.</td><td>1.70max.</td><td>0.035max.</td><td>0.035max.</td></tr>
<tr><td>RD 47</td><td>0.20max.</td><td>1.70max.</td><td>0.035max.</td><td>0.035max.</td></tr>
<tr><td>RE 47</td><td>0.20max.</td><td>1.70max.</td><td>0.035max.</td><td>0.035max.</td></tr>
<tr><td>RF 47</td><td>0.18max.</td><td>1.60max.</td><td>0.025max.</td><td>0.025max.</td></tr>
<tr><td>RA 51</td><td>0.21max.</td><td>1.70max.</td><td>0.035max.</td><td>0.035max.</td></tr>
<tr><td>RD 51</td><td>0.20max.</td><td>1.70max.</td><td>0.035max.</td><td>0.035max.</td></tr>
<tr><td>RE 51</td><td>0.20max.</td><td>1.70max.</td><td>0.035max.</td><td>0.035max.</td></tr>
<tr><td>RF 51</td><td>0.18max.</td><td>1.60max.</td><td>0.025max.</td><td>0.025max.</td></tr>
<tr><td>RA 56</td><td>0.21max.</td><td>1.70max.</td><td>0.035max.</td><td>0.035max.</td></tr>
<tr><td>RD 56</td><td>0.20max.</td><td>1.70max.</td><td>0.035max.</td><td>0.035max.</td></tr>
<tr><td>RE 56</td><td>0.20max.</td><td>1.70max.</td><td>0.035max.</td><td>0.035max.</td></tr>
<tr><td>RF 56</td><td>0.18max.</td><td>1.60max.</td><td>0.025max.</td><td>0.025max.</td></tr>
<tr><td>RA 63</td><td>0.21max.</td><td>1.70max.</td><td>0.035max.</td><td>0.035max.</td><td rowspan="8">0.50 max.</td><td rowspan="3">1.00max.</td><td rowspan="8">0.60 max.</td><td rowspan="8">0.10 max.</td><td rowspan="8">0.006 max.</td></tr>
<tr><td>RD 63</td><td>0.20max.</td><td>1.70max.</td><td>0.035max.</td><td>0.035max.</td></tr>
<tr><td>RE 63</td><td>0.20max.</td><td>1.70max.</td><td>0.035max.</td><td>0.035max.</td></tr>
<tr><td>RF 63</td><td>0.18max.</td><td>1.60max.</td><td>0.025max.</td><td>0.025max.</td><td rowspan="5">1.20max.</td></tr>
<tr><td>RA 70</td><td>0.21max.</td><td>1.70max.</td><td>0.035max.</td><td>0.035max.</td></tr>
<tr><td>RD 70</td><td>0.20max.</td><td>1.70max.</td><td>0.035max.</td><td>0.035max.</td></tr>
<tr><td>RE 70</td><td>0.20max.</td><td>1.70max.</td><td>0.035max.</td><td>0.035max.</td></tr>
<tr><td>RF 70</td><td>0.18max.</td><td>1.60max.</td><td>0.025max.</td><td>0.025max.</td></tr>
</table>

Table 2.1.33 Heat Treatment and Mechanical Properties

Grade	Heat treatment	Tensile test			Impact test[2][3]		
		Yield strength (N/mm^2)	Tensile strength (N/mm^2)	Elongation (%)[5] ($L=5.65\sqrt{A}$)	Test temp.[4] (°C)	Average absorbed energy(J)	
						L	T
RA 43	Quenched and tempered[1]	420 min.	530~680	18 min.	0	42min.	28min.
RD 43					− 20		
RE 43					− 40		
RF 43					− 60		
RA 47		460 min.	570~720	17 min.	0	46min.	31min.
RD 47					− 20		
RE 47					− 40		
RF 47					− 60		
RA 51		500 min.	610~770	16 min.	0	50min.	33min.
RD 51					− 20		
RE 51					− 40		
RF 51					− 60		
RA 56		550 min.	670~830	16 min.	0	55min.	37min.
RD 56					− 20		
RE 56					− 40		
RF 56					− 60		
RA 63		620 min.	720~890	15 min.	0	62min.	41min.
RD 63					− 20		
RE 63					− 40		
RF 63					− 60		
RD 70		690 min.	770~940	14 min.	0	69min.	46min.
RA 70					− 20		
RE 70					− 40		
RF 70					− 60		

NOTES:
(1) Heat treatment may be conducted according to $TMCP$, instead of quenching and tempering, subject to the special approval by the Society.
(2) L (or T) denotes that the longitudinal axis of each test specimen is parallel (or normal) to the final direction of rolling.
(3) When the absorbed energy of two or more test specimens among a set of test specimens is less in value than the specified average absorbed energy or when the absorbed energy of a single test specimen is less in value than 70% of the specified average absorbed energy, the test is considered to have failed.
(4) Impact test temperature for steels specified in **Pt 7, Ch 5** are given in **Table 2.1.34.**
(5) The minimum elongation for R14B IV test specimen is to be in compliance with the requirement given in the Table below.

Grade	Thickness (mm)						
	$t \le 10$	$10<t \le 15$	$15<t \le 20$	$20<t \le 25$	$25<t \le 40$	$40<t \le 50$	$50<t \le 70$
$RA43$, $RD43$, $RE43$, $RF43$	11	13	14	15	16	17	18
$RA47$, $RD47$, $RE47$, $RF47$	11	12	13	14	15	16	17
$RA51$, $RD51$, $RE51$, $RF51$	10	11	12	13	14	15	16
$RA56$, $RD56$, $RE56$, $RF56$	10	11	12	13	14	15	16
$RA63$, $RD63$, $RE63$, $RF63$	9	11	12	12	13	14	15
$RA70$, $RD70$, $RE70$, $RE70$	9	10	11	11	12	13	14

Table 2.1.34 Impact Test Temperature for Steels specified in Pt 7, Ch 5

Grade	Thickness (mm)	Test temp.(°C)
$RA43$, $RD43$	$t \le 20$	0
$RA47$, $RD47$	$20 < t \le 40$	− 20
$RA51$, $RD51$ $RA56$, $RD56$ $RA63$, $RD63$ $RA70$, $RD70$	$40 < t$	(1)

NOTE:
(1) Temperature is to be as deemed appropriate by the Society.

necessary, other elements than specified in **Table 2.1.32** may be added.

(2) Notwithstanding the requirements given in (1), where heat treatment has been conducted according to TMCP, the requirements given in **Table 2.1.32** may be modified subject to the special approval by the Society.

5. Mechanical properties

(1) The mechanical properties of steels are to comply with the requirements given in **Table 2.1.33.**

(2) Where deemed necessary by the Society, other test on notch-toughness and weldability may be required in addition to the tests specified in **Table 2.1.33.**

6. Selection of test samples

(1) One test sample is to be taken from each steels rolled directly from one slab, billet or ingot.

(2) The requirements specified in **301.6** (4) are to be applied to the selection of the test samples.

7. Selection of test specimens

(1) Tensile test specimens are to be taken according to the requirements specified in **301.7** (2).

(2) Impact test specimens are to be taken according to the requirements specified in **304.7** (2).

8. Surface inspection and verification of dimensions

Surface inspection and verification of dimensions are the responsibility of the steel manufacturer and the minus tolerance in the nominal thickness of plates is to be 0.25 mm. For steels except steel plates, any requirement regarding the minus tolerance is left to the discretion of the Society.

9. Retest procedures

(1) Where the tensile test from the first test specimen selected fails to meet the requirements, additional tests may be conducted according to the requirements given in **109.**

(2) Regarding the impact tests, additional tests are to be carried out according to the requirements given in **301.10.** (3).

10. Marking

Steels which have satisfactorily complied with the required tests are to be marked with the identification mark in accordance with the requirements in **110.** For steels to which the requirements given in Note (4) of **Table 2.1.33** have been applied, the "impact test temperature T" are to be suffixed to the marking. (e.g. RD63-25T)

309. Stainless clad steel plates

1. Application

(1) The requirements in **309.** are to apply to the stainless clad steels not exceeding 50 mm in thickness intended for tanks of ships carrying dangerous chemicals in bulk, tank circumference hull construction units and corrosion-resisting tanks (hereinafter referred to as “steel plates”).

(2) The requirements other than those specified in **309.** are to be in accordance with the requirements in **301.**

(3) Steel plates over 50 mm in thickness and having characteristics differing from those specified in **309.** are to comply with the requirements in **101.2.**

2. Process of manufacture

(1) Manufacture of steel plates is to comply with the processes shown in (a) to (e) below:
(a) Rolling
(b) Cast rolling
(c) Explosive pressing
(d) Explosive rolling
(e) Overlay rolling

(2) Application of any other process of manufacture than those specified in (1) is left to the discretion of the Society.

3. Structural metals

(1) Base and clad materials for steel plates are to be mild steel plates of rolled steels for hull specified in **301.** and steel plates of rolled stainless steels specified in **305.,** respectively.

(2) The material grade marks are to be signified by a combination of base metal and clad material.

4. Heat treatment

The steel plates are to comply with the requirements for heat treatment of the base metal.

5. Mechanical properties

(1) The mechanical properties of steel plates are to comply with the requirements given in **Table 2.1.35.**

(2) Where deemed necessary by the Society according to the use of steel plates, tests on corrosion resistance may be required.

6. Selection of test samples

(1) One test sample is to be taken from each steel

Table 2.1.35 Mechanical Properties

Grade	Tensile test(1)			Shearing strength test(3)	Impact test
	Yield strength (N/mm^2)	Tensile strength (N/mm^2)	Elongation (%)	Shearing strength (N/mm^2)	
RA RB RD RE	235 min.	σ_B min.(2)	To be complied with requirement for base metal	195 min.	To be complied with requirement for base metal

NOTES:
(1) The tensile test specimen is to be R14BIV test specimens.
(2) σ_B is to be obtained from the following formula:

$$\sigma_B = \frac{t_1 \sigma_1 + t_2 \sigma_2}{t_1 + t_2}$$

where:
σ_B = Tensile strength of steel plates (N/mm^2)
σ_1 = Specified minimum tesile strength of base metal (N/mm^2)
σ_2 = Specified minimum tensile strength of clad material (N/mm^2)
t_1 = Thickness of base metal (mm)
t_2 = Thickness of clad material (mm)
(3) Any requirement for the procedure of shear strength test is left to the discretion of the Society.

plate, being from the same manufacturing process, which belong to the plate as rolled from a slab or ingot of a certain base metal.

(2) The requirements specified in **301.6** (4) are to be applied to the selection of the test samples.

7. Selection of test specimens

(1) Tensile test specimens are to be taken according to the requirements specified in **301.7** (2).

(2) Impact test specimens are to be taken according to the requirements specified in **301.7** (3). In this case, the thickness of the test specimens is to agree with that of the base metal from which the clad material has been removed.

(3) Shearing strength test specimens are to be taken according to the requirements specified in the following (a) to (b):

(a) One test specimen is to be taken from one test sample.

(b) The size and dimensions of the test specimens, are to be determined according to **Fig. 2.1.6.**

8. Surface inspection and verification of dimensions

Surface inspection and verification of dimensions are the responsibility of the manufacturer Any requirement regarding minus tolerance of thickness is left to the discretion of the Society.

9 Quality and repair of defects

(1) Each steel plate is to be subjected to ultrasonic testing. Any requirement for the test procedure is left to the discretion of the Society.

(2) Any defects on the surface or joints of material found by the ultrasonic testing, etc. may be repaired by welding, subject to the special approval by the Society.

10. Marking

(1) The test certificates are to comply with the requirements given in **107.** and are to contain the particulars as to the process of manufacture of steel plates and the thickness of the clad material.

(2) Steel plates which have satisfactorily complied with the required tests are to be suffixed with the following marks relating to the process of manufacture of the steel plates, in addition to the marks showing the kinds of the base and clad materials. (e.g. RA + $RSUS$316 – R)

Rolling	:	[–R]
Cast rolling	:	[–ER]
Explosive pressing	:	[–B]
Explosive rolling	:	[–BR]
Overlay rolling	:	[–WR]

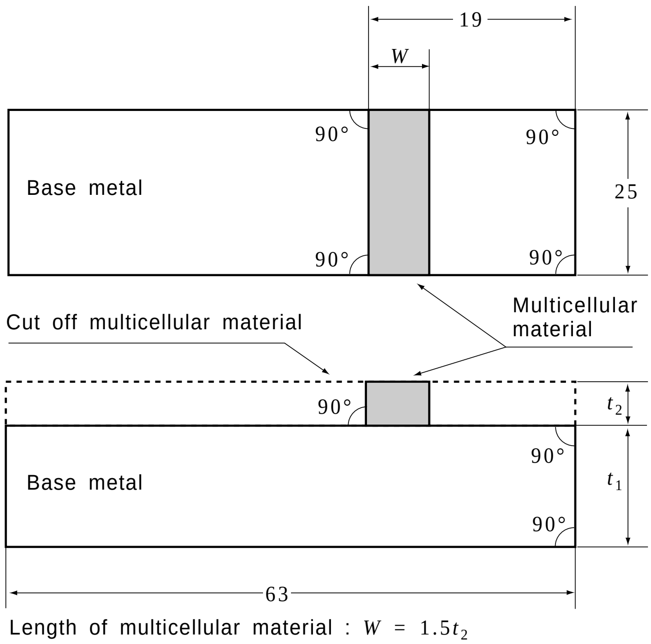


Fig. 2.1.6 Size and Dimensions of Shearing Test Specimens (unit: mm)

310. Additional requirements for through thickness properties

1. Application

(1) The requirements in **310.** are to apply to the steels which is required improved through thickness properties relating to the structural disign.
(2) The requirements are to apply to hull structural rolled steels and extra high strength rolled steels for plates and wide flats with thickness of 15 *mm* and over.
(3) The requirements are applicable to the other steels than the material specified in (2) above, where deemed appropriate by the Society.

2. Through thickness properties

(1) The through thickness properties of steels are to comply with the requirements given in **Table 2.1.36** as the result of tensile tests whose specimens are taken in the through thickness direction of the product.
(2) Where deemed necessary by the Society, ultrasonic tests may be required.

3. Selection of test samples

(1) For steel plates, one test sample is to be taken from each plate as rolled directly from one slab or ingot.
(2) For test samples of flat bars, flat bars which belong to the same cast manufactured by the same process and which are equivalent to each other and not less than 25 *mm* in thickness (or less than 25 *mm*), are to be treated as one lot for every 20 *tonnes* (or as one lot for every 10 *tonnes*). Thus, one test sample is to be taken from each lot.
(3) The test samples are to be taken from one end (top of ingot when applicable) of the portion corresponding to the middle of the plates or flat bars as shown in **Fig. 2.1.7.**

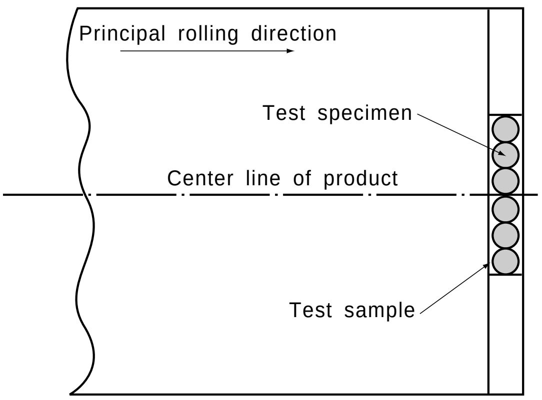


Fig. 2.1.7 Selection of Test Samples

Table 2.1.36 Through Thickness Properties

Grade	Reduction of area	
	Average value of three specimens (%)	Value of one individual specimens (%)
RA, *RB*, *RD*, *RE* *RA* 32, *RD* 32, *RE* 32, *RF* 32 *RA* 36, *RD* 36, *RE* 36, *RF* 36 *RA* 40, *RD* 40, *RE* 40, *RF* 40 *RA* 43, *RD* 43, *RE* 43, *RF* 43 *RA* 47, *RD* 47, *RE* 47, *RF* 47 *RA* 51, *RD* 51, *RE* 51, *RF* 51 *RA* 56, *RD* 56, *RE* 56, *RF* 56 *RA* 63, *RD* 63, *RE* 63, *RF* 63 *RA* 70, *RD* 70, *RE* 70, *RF* 70	25 min.	20 min.

Table 2.1.37 Dimensions of Specimen

Product thickness t (mm)	Diameter of test specimen d (mm)	Parallel length p (mm)
$15 \leq t \leq 25$	$d = 6$	$P \geq 2d$
$25 \langle t$	$d = 10$	$P \geq 2d$

4. Selection of test specimens

(1) Three tensile test specimens are to be taken from one test sample in the through thickness direction.
(2) The test specimens are to be taken according to the requirements for dimensions provided in **Table 2.1.37.**
(3) Where the product thickness does not allow to prepare specimens of sufficient length suitable for the gripping jaws of the testing machine, the ends of the specimens may be built up by suitable welding methods. The welding is not to impair the portion of the specimen within the parallel length.

5. Retest procedure

If the average of the three test results is less than the specified value or if one individual result is less than the specified value, three more tests are carried out on the remaining test specimens. In such case, the average of the results of the six tests is to be greater than the specified value and no individual result from the new series is to be less than the specified value.

6. Marking

Steels which have sastisfactorily complied with the requirements specified in **310.** are to have the letter “*Z*” after the material grade mark. (e.g. *RE*36*Z*)

SECTION 4
Steel Tubes and Pipes

401. Steel tubes for boilers and heat exchangers

1. Application

(1) The requirements are mainly to apply to steel tubes intended for heat transfer at inside or outside of the tubes; for example, smoke tubes, water tubes, stay tubes, superheater tubes of boilers, other tubes for high temperature heat exchangers, etc. (hereinafter referred to as "steel tubes").

(2) The steel tubes complying with *KS D* 3563 (*Carbon Steel Boiler and Heat Exchanger Tube Grade 1* (*STH* 30)) or equivalent thereto may be used as the tubes of heat exchangers, except for high temperature exchangers prescribed in (1).

(3) Steel tubes other than those specified in (1) are to comply with the requirements in **101.2.**

2. Kinds

The steel tubes are classified as specified in **Table 2.1.38.**

3. Heat treatment

The heat treatment of steel tubes is to comply with the requirements given in **Table 2.1.39.**

4. Chemical composition

The chemical composition of steel tubes is to comply with the requirements given in **Table 2.1.40.**

5. Mechanical properties

The mechanical properties of steel tubes are to comply with the following requirements.

(1) *Tensile test*: The tensile test of steel tubes is to comply with the requirements given in **Table 2.1.41.**

(2) *Flattening test*: A tubular section which is taken from the end of the steel tube is to stand being flattened cold between parallel plates, without cracking or showing flaw, until the distance between the plates becomes less than the value of H calculated by the following formula. In this case, the length L of steel tube is to be $1.5D$ or $10\,mm$ whichever is the greater, however, not more than $100\,mm$. For electric-resistance welded steel tubes, however, the welded line is to be placed at right angle to the direction of the applied force as shown in **Fig. 2.1.8.**

$$H = \frac{(1+e)t}{e+\dfrac{t}{D}}$$

where:

H = Distance between flattening plates (mm).
t = Thickness of steel tube (mm).
D = Outside diameter of steel tube (mm).

Table 2.1.38 Grades of Tubes

Grade	Description
RSTH 33	Low carbon seamless steel tubes and electric-resistance welded steel tubes
RSTH 35	Low carbon killed seamless steel tubes and electric-resistance welded steel tubes
RSTH 42	Medium carbon killed seamless steel tubes and electric-resistance welded steel tubes
RSTH 12	$\frac{1}{2}\mathrm{Mo}$ Alloy seamless steel tubes
RSTH 22	$1\mathrm{Cr}-\frac{1}{2}\mathrm{Mo}$ alloy seamless steel tubes
RSTH 23	$1\frac{1}{4}\mathrm{Cr}-\frac{1}{2}\mathrm{Mo}-\frac{3}{4}\mathrm{Si}$ alloy seamless steel tubes
RSTH 24	$2\frac{1}{4}\mathrm{Cr}-1\mathrm{Mo}$ alloy seamless steel tubes

Table 2.1.39 Heat Treatment

Grade	Seamless steel tube		Electric-resistance welded steel tube		
	Hot working	Cold working	As weld	Hot working	Cold working
RSTH 33 *RSTH* 35	As drawn	Annealed	Normalized	As drawn	Normalized(1)
RSTH 42			Normalized	Annealed	Normalized(1)
RSTH 12 *RSTH* 22	Annealed or normalized and tempered or full annealed		—		
RSTH 23 *RSTH* 24	Full annealed or normailzed and tempered at 650°C and over		—		

NOTE:
(1) Steel tubes which are normalized during the process of cold working after tubing, may be treated with annealing, instead of normalizing as required in this Table.

Table 2.1.40 Chemical Composition

Grade	Chemical composition (%)						
	C	Si	Mn	P	S	Cr	Mo
RSTH 33	0.18 max.	0.35 max.	0.25~0.60	0.035 max.	0.035 max.	—	—
RSTH 35		0.10~0.35	0.30~0.60				
RSTH 42	0.32 max.		0.30~0.80				
RSTH 12	0.10~0.20	0.10~0.50					0.45~0.65
RSTH 22	0.15 max.	0.50 max.	0.30~0.60			0.80~1.25	
RSTH 23		0.50~1.00		0.030 max.	0.030 max.	1.00~1.50	
RSTH 24		0.50 max.				1.90~2.60	0.87~1.13

NOTE:
In case where approved by the Society, *RSTH*35 and *RSTH*42 may be the killed steel of below 0.10% Si.

Table 2.1.41 Mechanical Properties

Grade	Yield strength (N/mm^2)	Tensile strength (N/mm^2)	Elongation (%) $(L=5.65\sqrt{A})$
RSTH 33	175 min.	325 min.	26(22) min.
RSTH 35		340 min.	
RSTH 42	255 min.	410 min.	21(17) min.
RSTH 12	205 min.	380 min.	
RSTH 22 *RSTH* 23 *RSTH* 24		410 min.	

NOTES:
1. The values of elongation in parenthesis are applicable to the test specimens taken transversely. In this case, the sampling material is to be heated 600°C to 650°C after flattened and annealed in order to make it free from strain.
2. In case where test specimen of non-tubular section is taken from an electric-resistance welded steel tube, the test specimen is to be taken from the parts that do not include the welded line.

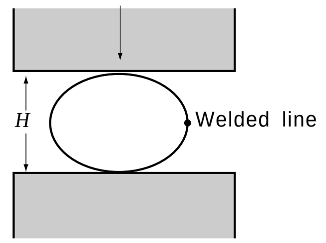


Fig. 2.1.8 Flattening Test

e = Constant given in **Table 2.1.42** which varies according to the grade of steel tubes.

(3) *Flanging test*: A section of steel tube which is taken from its end is to be turned over cold so as to have a flange, the outside diameter of which is not less than specified in **Table 2.1.43**, at right angle to the axis without cracking or showing flaw. In this case, the flanging test specimen is to be of length L such that after testing the remaining cylindrical portion is not less than $0.5D$. But, this test is to be made only for *RSTH* 33 tubes having wall thickness not more than 1/10 of its outside diameter and not more than 5 mm.

(4) *Flaring test*: A section of steel tube which is taken from its end is to stand being flared cold with a tool having an included angle of 60 degrees, until the steel tube at the mouth of the flare is expanded without cracking or showing flaw to the diameter shown in **Table 2.1.44.** In this case, the length of test specimen is to be $1.5D$, however, not less than 50 mm. For *RSTH* 33 tubes which require the flanging test, this test need not be carried out.

Table 2.1.42 Value of e

Grade	Value of e
RSTH 33, *RSTH* 35	0.09
others	0.08

Table 2.1.43 Outside Diameter of Flange after Flanging

Outside diameter of steel tube	Outside diameter of flange
Less than 63 mm	1.3 times the outside diameter of steel tube
63 mm and over	Outside diameter of steel tube +20 mm

Table 2.1.44 Outside Diameter of Steel Tube End after Flaring

Grade	Outside diameter of steel tube end
RSTH 33, *RSTH* 35, *RSTH* 42	1.2 times the outside diameter of steel tube
RSTH 12, *RSTH* 22, *RSTH* 23, *RSTH* 24	1.14 times the outside diameter of steel tube

(5) *Crushing test*: For *RSTH* 33 tubes, where

required by the Surveyor, a crushing test is to be made on a section of steel tube of 65 mm in length which is to stand crushing longitudinally without cracking or splitting to the height specified in **Table 2.1.45.**

Table 2.1.45 Height of Section after Crushing

Thickness of steel tube t (mm)	Height of section after crushing
$t \leq 3.4$	19 mm or until outside folds are in contact
$t > 3.4$	32 mm

(6) *Reverse flattening test*: A section of steel tube of 100 mm in length which is taken from the steel tube is to be slotted longitudinally on the opposite side of the welded line, opened and flattened without cracking or showing flaw on the inside of the welded line. There is also to be no misalignment, lack of penetration and overlap. But, this test is applied for electric-resistance welded steel tubes only.

(7) *Hydraulic test*:

(a) Steel tubes are to be hydraulically tested to a satisfactory result by 2 times and over the maximum working pressure at the mill. But the minimum test pressure is to be 7 MPa.

(b) The test pressure prescribed in (a) need not exceed the pressure calculated by the following formula:

$$P = \frac{2.0\,St}{D} \quad (MPa)$$

where:

t = Thickness of steel tube (mm).
D = Outside diameter of steel tube (mm)
S = 60% of the prescribed minimum yield strength (N/mm^2)

(c) Where each steel tube is hydraulically tested as a regular procedure during the process of manufacturing at the mill, which makes a number of steel tubes continually, and the results are forwarded to the Surveyor, the test in the presence of the Surveyor maV be dispensed with.

(d) A non-destructive inpection deemed appropriate by the Society may be substituted for the hydraulic test specified in (a).

6. Selection of test specimen

The test specimens are to be taken in accordance with the following requirements, from each grade and each size which has been heat treated at the same time in the same heating furnace for heat-treated tubes and from each grade and each size for non-heat-treated steel tubes respectively.

(1) *Seamless steel tubes*

(a) $RSTH$ 33

One sampling steel tube is to be selected from each lot of 100 tubes or fraction thereof, and one tension, one flattening and one flanging or flaring test specimens are to be taken from each of the sampling steel tubes.

(b) Other than $RSTH$ 33

One sampling steel tube is to be selected from each lot of 50 tubes or fraction thereof for 100 and less steel tubes, and each lot of 100 tubes or fraction thereof for 100 over steel tubes. Each one specimen for tensile test, flattening test and flaring test is to be taken from each sampling steel tube.

(2) *Electric-resistance welded steel tubes*

For electric-resistance welded steel tubes, in addition to the requirements in (1), one sampl ing steel tube is to be selected from each lot of 50 tubes or fraction thereof for 100 and less steel tubes, and each lot of 100 tubes or fraction thereof for 100 over steel tubes, and one reverse flattening test specimen is to be taken from each of the sampling steel tubes.

7. Tolerance for dimensions

The tolerances for the outside diameter and thickness are to comply with the requirements in **Table 2.1.46.**

8. Quality

The steel tubes are to be of uniform quality and free from harmful defects. For electric-resistance welded steel tubes, deposit metal projected on outside of tubes is to be removed and finished smooth and that projected on inside of tubes is to be removed to have a height not more than 0.25 mm.

9. Marking

(1) The name or brand of the manufacturer, grade of tubes, size and symbol of the method of the manufacture relating to (2) below are to be legibly stamped or stenciled before shipment on each length steel tube in case of 30 mm and above in outside diameter and on each bundle or container of steel tubes in case of less than 30 mm in outside diameter. The Society's brand indicating compliance with the requirements is to be stamped in the vicinity of the foregoing marks.

(2) The symbols indicating the method of manufacture are to be as specified in the following:
Hot finished seamless steel tube-------- -S-H
Cold drawn seamless steel tube-----------S-C
Electric-resistance welded steel tube of other than hot and cold working ---------------- -E-G
Electric-resistance welded steel tube of hot working--- -E-H
Electric-resistance welded steel tube of cold working--- -E-C

Table 2.1.46 Tolerance for Dimensions of steel Tubes

(a) Tolerance for Outside Diameter (mm)

Kind \ Outside diameter of steel tube D (mm)	$D < 102$	$102 \le D < 160$	$160 \le D < 200$	$200 \le D$
Hot finished seamless steel tube	+0.4 −0.8	+0.4 −1.2	+0.4 −1.6	+0.4 −1.8

Kind \ Outside diameter of steel tube D (mm)	$D < 25$	$25 \le D < 40$	$40 \le D < 50$	$50 \le D < 60$	$60 \le D < 80$	$80 \le D < 100$	$100 \le D < 120$	$120 \le D < 160$	$160 \le D < 200$	$200 \le D$
Cold drawn seamless steel tube and electric-resistance welded steel tube of cold working	±0.10	±0.15	±0.20	±0.25	±0.30	±0.40	+0.40 −0.60	+0.40 −0.80	+0.40 −1.20	+0.40 −1.60
Electric-resistance welded steel tube of other than cold working	±0.15	±0.20	±0.25	±0.30	±0.40	+0.40 −0.60	+0.40 −0.80	+0.40 −1.00		

(b) Tolerance for Thickness

Kind	Outside diameter D (mm) \ Thickness t (mm)	$t < 2$	$2 \le t < 2.4$	$2.4 \le t < 3.8$	$3.8 \le t < 4.6$	$4.6 \le t$
Hot finished seamless steel tube	$D < 102$	–	+40 % 0 %	+35 % 0 %	+33 % 0 %	+28 % 0 %
	$D \ge 102$		–			
Cold drawn seamless steel tube and electric-resistance welded steel tube of cold working	$D < 40$	+0.4 mm 0 mm	+22 % 0 %			
	$D \ge 40$	+22 % 0 %				
Electric-resistance welded steel tube of other than cold working	$D < 40$	+0.3 mm 0 mm	+18 % 0 %			
	$D \ge 40$	+18 % 0 %				

NOTE:
For hot finished seamless steel tubes. the tolerance for deviation in wall thickness is to be 22.8% and under of the thickness of the steel tube. But, for steel tubes of less than 5.6 mm in thickness, this note is not applied.

402. Steel pipes for pressure piping

1. Application

(1) These requirements are mainly to apply to seamless steel pipes and electric-resistance welded steel pipes intended for use in piping which is prescribed in **Pt 5, Ch 6** (hereinafter referred to as “steel pipes”).

(2) Steel pipes for general pupose specified in **102.2** (4) of **Pt 5, Ch 6** are to comply with the requirements of *KS D* 3507(*SPP*) or equivalent thereto. However, tests in the presence of the Surveyor are not required.

(3) The steel pipes having characteristics differing from those specified in **402.** are to comply with the requirements in **101.2.**

2. Kinds

The steel pipes are classified as specified in **Table 2.1.47.**

3. Heat treatment

The heat treatment of steel pipes is to comply with the requirements given in **Table 2.1.48.**

4. Chemical composition

The chemical composition of steel pipes is to comply with the requirements given in **Table 2.1.49.**

5. Mechanical properties

The mechanical properties of steel pipes are to comply with the following requirements.

(1) *Tensile test*: The tensile test of steel pipes are to comply with the requirements given in **Table 2.1.50.**

(2) *Bend test*: A test specimen of tubular section which is taken from the end of the steel pipe and has sufficient length is to stand being bent cold, up to the specified value in **Table 2.1.51,** withoul cracking or showing flaw on the wall. But, for Grade 4, this test need not be carried out.

(3) *Flattening test*: A tubular section of steel pipe which is taken from the end of the steel pipe, is to stand being flattened between parallel plates, without cracking or showing flaw, until

Table 2.1.47 Grades of Steel Pipes

Grade		Description	Schedule applied	Reference
Grade 1	$RST138$	Low carbon seamless steel pipe and electric-resistance welded steel pipe	Sch.10 ~ Sch. 80	KS D 3562 Carbon steel pipe for pressure service
	$RST142$	Medium carbon seamless steel pipe and electric-resistance welded steel pipe		
Grade 2	$RST238$	Low carbon killed seamless steel pipe	Sch.40 ~ Sch. 160	KS D 3564 Carbon steel pipe for high pressure service
	$RST242$ $RST249$	Medium carbon killed seamless steel pipe		
Grade 3	$RST338$	Low carbon coarse grain killed seamless steel pipe and electric-resistance welded steel pipe	Sch.10 ~ Sch. 160	KS D 3570 Carbon steel pipe for high temperature service
	$RST342$	Medium carbon coarse grain killed seamless steel pipe and electric-resistance welded steel pipe.		
	$RST349$	Medium carbon coarse grain killed seamless steel pipe		
Grade 4	$RST412$	$\frac{1}{2}\mathrm{Mo}$ alloy seamless steel pipe		KS D 3573 Alloy steel pipe
	$RST422$	$1\mathrm{Cr}-\frac{1}{2}\mathrm{Mo}$ alloy seamless steel pipe		
	$RST423$	$1\frac{1}{4}\mathrm{Cr}-\frac{1}{2}\mathrm{Mo}-\frac{3}{4}\mathrm{Si}$ alloy seamless steel pipe		
	$RST424$	$2\frac{1}{4}\mathrm{Cr}-1\mathrm{Mo}$ alloy seamless steel pipe		

Table 2.1.48 Heat Treatment

Grade		Seamless steel pipe		Electric-resistance welded steel pipe		
		Hot finished	Cold drawn	As weld	Hot finished	Cold finished
Grade1	$RST138$	As drawn	Annealed	As weld	As drawn	Annealed
	$RST142$					
Grade2	$RST238$		Annealed or normalized	—		
	$RST242$					
	$RST249$					
Grade3	$RST338$	As drawn	Annealed	Annealed or normalized	As drawn	Annealed or normalized
	$RST342$					
	$RST349$			—		
Grade4	$RST412$	Annealed				
	$RST422$					
	$RST423$	Full annealed or normalized and tempered at 650°C and over				
	$RST424$					

the distance between the plates becomes less than the value of H calculated by the following formula. In this case, the length of test specimen is to comply with the requirements in **401.5** (2). For steel pipes, however, of 100 mm and above in outside diameter and of 15% of outside diameter and above in thickness, C-type test specimen may be used, having a part of its circumference discarded as shown in **Fig. 2.1.10.**

(a) *Pipes other than Grade 1 of electric-resistance welded steel pipe*:

$$H = \frac{(1+e)t}{e+\frac{t}{D}}$$

where:

H = Distance between flattening plates (mm).
t = Thickness of steel pipe (mm).
D = Outside diameter of steel pipe (mm).
e = Constant given in **Table 2.1.52** which

Table 2.1.49 Chemical Composition

Grade		Chemical composition (%)						
		C	Si	Mn	P	S	Cr	Mo
Grade1	RST138	0.25 max.	0.35 max.	0.30~0.90	0.040 max.	0.040 max.	—	—
	RST142	0.30 max.		0.30~1.00				
Grade2	RST238	0.25 max.	0.10~0.35	0.30~1.10	0.035 max.	0.035 max.		
	RST242	0.30 max.		0.30~1.40				
	RST249	0.33 max.		0.30~1.50				
Grade3	RST338	0.25 max.		0.30~0.90				
	RST342	0.30 max.		0.30~1.00				
	RST349	0.33 max.						
Grade4	RST412	0.10~0.20	0.10~0.50	0.30~0.80				0.45~0.65
	RST422	0.15 max.	0.50 max.	0.30~0.60			0.80~1.25	
	RST423		0.50~1.00		0.030 max.	0.030 max.	1.00~1.50	
	RST424		0.50 max.				1.90~2.60	0.87~1.13

Table 2.1.50 Mechanical Properties

Grade		Yield strength (N/mm^2)	Tensile strength(N/mm^2)	Elongation(%) ($L=5.65\sqrt{A}$)
Grade1	RST138	215 min.	370 min.	24(20) min.
Grade2	RST238			
Grade3	RST338			
Grade1	RST142	245 min.	410 min.	21(17) min.
Grade2	RST242			
Grade3	RST342			
Grade2	RST249	275 min.	480 min.	19(15) min.
Grade3	RST349			
Grade4	RST412	205 min.	380 min.	21(17) min.
Grade4	RST422		410 min.	
	RST423			
	RST424			

NOTES:
1. The requirements for elongation given in parentheses in the Table are applied for the case where test specimens are taken transversely. In this case, the test sample is to be stress relieved at the temperature of 600°C to 650°C after flattened.
2. In case where test specimen of non-tubular section is taken from electric-resistance welded steel pipes, the test specimen is to be taken from the part that does not include a welded line.

varies according to the grade of steel tubes.

(b) *Electric-resistance welded steel pipes Grade 1*:

$$H=\frac{2}{3}D \quad \text{for welded line,}$$

$$H=\frac{1}{3}D \quad \text{for elsewhere.}$$

In case of electric-resistance welded steel pipes, the welded line is to be placed at right angle to the direction of the applied force, as in **Fig. 2.1.9.** Where C-type test

Table 2.1.51 Bend Test

Grade	Angle of bending	Inside bend radius
1,2 and 3	90°	6 times the outside diameter of steel pipe

NOTE:
Electric-resistance welded steel pipes are to be so bent as the welded line is placed widest.

Table 2.1.52 Value of e

Grade	RST 142, RST 242, RST 342, RST 249, RST 349	RST 138, RST 238, RST 338, RST 412, RST 422, RST 423, RST 424
e	0.07	0.08

specimen is used, it is to be placed as in **Fig. 2.1.10.**

(4) *Hydraulic test*

(a) Grade 1 steel pipes are to be hydraulically tested with the pressure specified in **Table 2.1.53.**

(b) In case where the test pressure higher than prescribed in (a) is specified by the purchaser for Grade 2 through 4 steel pipes, the test is to be carried out with the specified pressure. In this case, test pressure need not exceed the pressure calculated by the following formula:

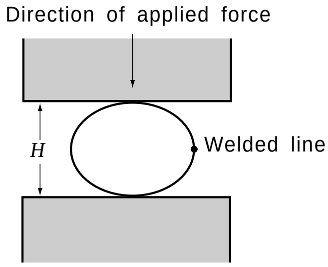


Fig. 2.1.9 Flattening Test for Ordinary Test Specimen

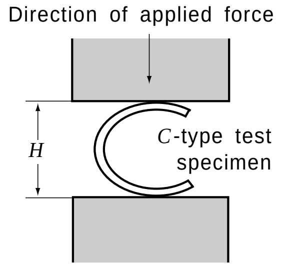


Fig. 2.1.10 Flattening Test for C-type Test Specimen

Table 2.1.53 Schedule and Hydraulic Test Pressure

Nominal diameter(A)	Outside diameter(mm)	Nominal thickness (mm)									
		Sch.10(10S)	Sch.20(20S)	Sch.30	Sch.40	Sch.60	Sch.80	Sch.100	Sch.120	Sch.140	Sch.160
6	10.5	(1.2)	(1.5)	–	1.7	2.2	2.4	–	–	–	–
8	13.8	(1.65)	(2.0)	–	2.2	2.4	3.0	–	–	–	–
10	17.3	(1.65)	(2.0)	–	2.3	2.8	3.2	–	–	–	–
15	21.7	(2.1)	(2.5)	–	2.8	3.2	3.7	–	–	–	4.7
20	27.2	(2.1)	(2.5)	–	2.9	3.4	3.9	–	–	–	5.5
25	34.0	(2.8)	(3.0)	–	3.4	3.9	4.5	–	–	–	6.4
32	42.7	(2.8)	(3.0)	–	3.6	4.5	4.9	–	–	–	6.4
40	48.6	(2.8)	(3.0)	–	3.7	4.5	5.1	–	–	–	7.1
50	60.5	(2.8)	3.2(3.5)	–	3.9	4.9	5.5	–	–	–	8.7
65	76.3	(3.0)	4.5(3.5)	–	5.2	6.0	7.0	–	–	–	9.5
80	89.1	(3.0)	4.5(4.0)	–	5.5	6.6	7.6	–	–	–	11.1
90	101.6	(3.0)	4.5(4.0)	–	5.7	7.0	8.1	–	–	–	12.7
100	114.3	(3.0)	4.9(4.0)	–	6.0	7.1	8.6	–	11.1	–	13.5
125	139.8	(3.4)	5.1(5.0)	–	6.6	8.1	9.5	–	12.7	–	15.9
150	165.2	(3.4)	5.5(5.0)	–	7.1	9.3	11.0	–	14.3	–	18.2
200	216.3	(4.0)	6.4(6.5)	7.0	8.2	10.3	12.7	15.1	18.2	20.6	23.0
250	267.5	(4.0)	6.4(6.5)	7.8	9.3	12.7	15.1	18.1	21.4	25.4	28.6
300	318.5	(4.5)	6.4(6.5)	8.4	10.3	14.3	17.4	21.4	25.4	28.6	33.3
350	355.6	6.4	7.9	9.5	11.1	15.1	19.0	23.8	27.8	31.8	35.7
400	406.4	6.4	7.9	9.5	12.7	16.7	21.4	26.2	30.9	36.5	40.5
450	457.2	6.4	7.9	11.1	14.3	19.0	23.8	29.4	34.9	39.7	45.2
500	508.0	6.4	9.5	12.7	15.1	20.6	26.2	32.5	38.1	44.4	50.0
550	558.8	6.4	9.5	12.7	15.9	22.2	28.6	34.9	41.3	47.6	54.0
600	609.4	6.4	9.5	14.3	17.5	24.6	31.0	38.9	46.0	52.4	59.5
650	660.4	7.9	12.7	–	18.9	26.4	34.0	41.6	49.1	56.6	64.2
Hydraulic test pressure (MPa)	Grade 1	2.0	3.5	5.0	6.0	9.0	12.0	-	-	-	
	Grade 2	-	-	-	6.0	9.0	12.0	15.0	18.0	20.0	20.0
	Grade 3 and Grade 4	2.0	3.5	5.0	6.0	9.0	12.0	15.0	18.0	20.0	20.0

NOTE:
The values of nominal thickness in parentheses are applicable to stainless steel pipes.

$$P = \frac{2.0\,St}{D} \quad (MPa)$$

where :

P = Hydraulic test pressure (MPa).
D = Outside diameter of steel pipe (mm).
t = Thickness of steel pipe (mm).
S = 60% of the prescribed minimum yield strength (N/mm^2).

(c) When each steel pipe is hydraulically tested as a regular procedure during the process of manufacturing at the mill which makes a number of steel tubes continually, and the results are forwarded to the Surveyor, the test in the presence of the Surveyor may be dispensed with.

(d) A non-destructive inspection deemed appropriate by the Society may be substituted for the hydraulic inspection specified in (a).

6. Selection of test specimen

The test specimens are to be taken in accordance with the following requirements, from each grade and each size which was heat treated at the same time for heat treated steel pipes, and from each grade and each size for non-heat-treated steel pipes, respectively.

(1) *Grade 1*

(a) *For steel pipes of 150 mm and under in out side diameter*:
One sampling steel pipe is to be selected from each lot of 200 pipes or fraction thereof, and each one specimen for tensile test and flattening test is to be taken from each sampling steel pipe. As for pipes of 50 mm and under, the specimen for flattening test may be substituted for that for bend test.

(b) *For steel pipes over 150 mm in outside diameter*:
One sampling steel pipe is to be selected from each lot of 100 pipes or fraction thereof, and each one specimen for tensile test and flattening test is to be taken from each sampling steel pipe.

(2) *Grade 2*
One sampling steel pipe is to be selected from each lot of 50 tubes or fraction thereof for 100 and less steel tubes, and each lot of 100 tubes or fraction thereof for 100 over steel tubes, and each one specimen for tensile test and flattening test is to be taken from each sampling steel pipe. As for steel pipes of 50 mm and under in outside diameter, the specimen for flattening test may be substituted for that for bend test.

(3) *Grade 3*
Selection of test specimen is to comply with the requirements in (2).

(4) *Grade 4*
One sampling steel pipe is to be selected from each lot of 50 tubes or fraction thereof for 100 and less steel tubes, and each lot of 100 tubes or fraction thereof for 100 over steel tubes, and each one specimen for tensile test and flattening test is to be taken from each sampling steel pipe.

7. Tolerance for dimensions

Tolerances for the outside diameter and the thickness are to comply with the requirements in **Table 2.1.54.**

8. Quality

The steel pipes are to be of uniform quality and free from harmful defects.

9. Marking

(1) The name or brand of the manufacturer, grade of steel tubes, size and symbol of the method of the manufacture relating to (2) below are to be legibly stamped or stenciled before shipment on each length steel tube in case of 60 mm and above in outside diameter and on each bundle or container of steel tubes in case of less than 60 mm in outside diameter. The Society's brand indicating compliance with the requirements is to be in the vicinity of the fore-

Table 2.1.54 Tolerance for Dimensions

Kind	Outside diameter of steel pipe D (mm)	Tolerance for outside diameter	Tolerance for wall thickness			
			Grade1		Grade2,3 and 4	
Hot finished seamless steel pipe	$D < 50$	± 0.5mm	Thickness of steel pipe: Less than 4 mm	+0.6mm −0.5mm	Thickness of steel pipe: Less than 4 mm	± 0.5mm
	$D \geq 50$	± 1%	Thickness of steel pipe: 4 mm and over	+15% −12.5%	Thickness of steel pipe: 4 mm and over	± 12.5%
Cold drawn seamless steel pipe and electric-resistance welded steel pipe	$D < 40$	± 0.3mm	Thickness of steel pipe: Less than 3 mm	± 0.3mm	Thickness of steel pipe: Less than 2 mm	± 0.2mm
	$D \geq 40$	± 0.80%	Thickness of steel pipe: 3 mm and over	± 10%	Thickness of steel pipe: 2 mm and over	± 10%

NOTE:
For hot finished seamless steel pipes Grades 2, 3 and 4, the tolerance for deviation in wall thickness is to be 20% and under of the thickness of the pipes. But, for steel pipes less than 5.6 mm in thickness, this note is not applied.

going marks.

(2) The symbols indicating the method of manufacture are to comply with the requirement in **401.9** (2).

403. Stainless steel pipes

1. Application

(1) The requirements are to apply to the stainless steel pipes for low temperature service or corrosion-resistance service (hereinafter referred to as “stainless steel pipes”).

(2) Stainless steel pipes having characteristics d iffering from those specified in **403.** are to comply with the requirements in **101.2.**

2. Kinds

The stainless steel pipes are classified as specified in **Table 2.1.55.**

3. Heat treatment

The stainless steel pipes are generally to receive a solid solution treatment.

4. Chemical composition

The chemical composition of stainless steel pipes is to comply with the requirements given in **Table 2.1.55.**

5. Mechanical properties

(1) The mechanical properties of stainless steel pipes are to comply with the following requirements.

(a) *Tensile test*

The tensile test of stainless steel pipes is to comply with the requirements given in **Table 2.1.56.**

(b) *Flattening test*:

Flattening tests are to be carried out in accordance with the requirements in **402.5** (3). However, where the requirements are applied, the value of e is to be taken as 0.09.

Table 2.1.56 Tensile Test

<table>
<tr><th rowspan="2">Grade</th><th rowspan="2">Yield strength (N/mm^2)</th><th rowspan="2">Tensile strength (N/mm^2)</th><th colspan="2">Elongation (%) ($L=5.65\sqrt{A}$)</th></tr>
<tr><th>L</th><th>T</th></tr>
<tr><td>RSUS304TP</td><td>205min.</td><td>520min.</td><td rowspan="10">26 min.</td><td rowspan="10">22 min.</td></tr>
<tr><td>RSUS304LTP</td><td>175min.</td><td>480min.</td></tr>
<tr><td>RSUS309STP</td><td rowspan="3">205min.</td><td rowspan="3">520min.</td></tr>
<tr><td>RSUS310STP</td></tr>
<tr><td>RSUS316TP</td></tr>
<tr><td>RSUS316LTP</td><td>175min.</td><td>480min.</td></tr>
<tr><td>RSUS317TP</td><td>205min.</td><td>520min.</td></tr>
<tr><td>RSUS317LTP</td><td>175min.</td><td>480min.</td></tr>
<tr><td>RSUS321TP</td><td rowspan="2">205min.</td><td rowspan="2">520min.</td></tr>
<tr><td>RSUS347TP</td></tr>
</table>

NOTES:
1. L (or T) denotes that the longitudinal axis of the test specimen is arranged parallel (or normal) to the final direction of rolling.
2. Where the nominal diameter of stainless steel pipes is 200 mm and over, tensile test specimens may be taken transversely.
3. Where test specimens of non-tubular section are taken from welded pipes, the test specimens are to be taken from the part that does not include the welded line.

(c) Hydraulic test:

(i) Stainless steel pipes are to be hydraulically tested with the pressure specified in **Table 2.1.57.**

(ii) In case where the test pressure higher than prescribed in (a) is specified by the purchaser, the test is to be carried out with the specified pressure. In this case, the test pressure need not exceed the pressure calculated by the following formula:

$$P = \frac{2.0\,St}{D} \quad (MPa)$$

Table 2.1.55 Grades and Chemical Composition

<table>
<tr><th rowspan="2">Grade</th><th colspan="9">Chemical Composition (%)</th></tr>
<tr><th>C</th><th>Si</th><th>Mn</th><th>P</th><th>S</th><th>Ni</th><th>Cr</th><th>Mo</th><th>Others</th></tr>
<tr><td>RSUS304TP</td><td>0.080 max.</td><td rowspan="3">1.00 max.</td><td rowspan="10">2.00 max.</td><td rowspan="10">0.040 max.</td><td rowspan="10">0.030 max.</td><td>8.00~11.00</td><td rowspan="2">18.00~20.00</td><td rowspan="4">—</td><td rowspan="8">—</td></tr>
<tr><td>RSUS304LTP</td><td>0.030 max.</td><td>9.00~13.00</td></tr>
<tr><td>RSUS309STP</td><td rowspan="3">0.080 max.</td><td>12.00~15.00</td><td>22.00~24.00</td></tr>
<tr><td>RSUS310STP</td><td>1.50 max.</td><td>19.00~22.00</td><td>24.00~26.00</td></tr>
<tr><td>RSUS316TP</td><td rowspan="6">1.00 max.</td><td>10.00~14.00</td><td rowspan="2">16.00~18.00</td><td rowspan="2">2.00~3.00</td></tr>
<tr><td>RSUS316LTP</td><td>0.030 max.</td><td>12.00~16.00</td></tr>
<tr><td>RSUS317TP</td><td>0.080 max.</td><td rowspan="2">11.00~15.00</td><td rowspan="2">18.00~20.00</td><td rowspan="2">3.00~4.00</td></tr>
<tr><td>RSUS317LTP</td><td>0.030 max.</td></tr>
<tr><td>RSUS321TP</td><td rowspan="2">0.080 max.</td><td rowspan="2">9.00~13.00</td><td rowspan="2">17.00~19.00</td><td rowspan="2">—</td><td>$Ti \geq 5 \times C$</td></tr>
<tr><td>RSUS347TP</td><td>$Nb \geq 10 \times C$</td></tr>
</table>

Table 2.1.57 Hydraulic Test Pressure

Schedule No.	Sch. 10S	Sch. 20S	Sch. 40S	Sch. 80S	Sch. 120S	Sch. 160S
Test pressure (MPa)	2.0	3.5	6.0	12.0	18.0	20.0

where:
P = Hydraulic test pressure (MPa).
t = Thickness of stainless steel pipe (mm).
D = Outside diameter of stainless steel pipe (mm).
S = 60% of the prescribed minimum yield strength (N/mm^2).

(iii) When each pipe is hydraulically tested as a regular during the process of manufacturing at the mill which makes a number of tubes continually, and the results are forwarded to the Surveyor, the test in the presence of the Surveyor may be dispensed with.

(iv) A non-destructive inspection deemed appropriate by the Society may be substituted for the hydraulic test specified in (a).

(2) The Society may require the impact test or corrosion resistance test according to purposes of stainless steel pipes.

6. Selection of test specimens

One sampling pipe is to be selected from each lot of 50 pipes or fraction thereof which are of the same charge, size and kind and are simultaneously heat treated, and each one specimen for tensile test and flattening test is to be taken from each sample pipe.

7. Tolerance for dimensions

Tolerances for the outside diameter and the thickness are to comply with the requirements in **Table 2.1.58.**

8. Quality

The stainless steel pipes are to be of uniform quality and free from harmful defects.

9. Marking

Stainless steel pipes which have satisfactorily complied with the required tests are to be marked with identification mark in accordance with the requirements in **402.9.**

404. Steel pipes for low temperature service

1. Application

(1) These requirements are to apply to the seamless steel pipes and electric resistance welded steel pipes not exceeding 25 mm in thickness, intended to be used at the design temperature lower than 0°C in liquefied gas carriers (hereinafter referred to as “steel pipes”).

(2) Any requirement regarding the steel pipes over 25 mm in thickness is left to the discretion of the Society.

(3) Steel pipes having characteristics differing from those specified in **404.** are to comply with the requirements in **101.2.**

Table 2.1.58 Tolerance for Dimensions

Kind	Outside diameter of stainless steel pipe (mm)	Tolerance for outside diameter	Tolerance for wall thickness	
Hot-finished seamless stainless steel pipe	Less than 50	± 0.5mm	Thickness of pipe: Less than 4 mm	± 0.5mm
	50 and over	± 1%	Thickness of pipe: 4 mm and over	± 12.5%
Cold drawn seamless stainless pipe, automatic arc welded stainless steel pipe and electric-resistance welded stainless steel pipe	Less than 30	± 0.3mm	Thickness of pipe: Less than 2 mm	± 0.2mm
	30mm and over	± 1%	Thickness of pipe: 2 mm and over	± 10%

NOTE:
For hot finished seamless stainless steel pipes, the tolerance for deviation in wall thickness is to be 20% and under of the thickness of the pipes. But, for stainless steel pipes less than 5.6 mm in thickness, this note is not applied.

Table 2.1.59 Grades and Chemical Composition (%)

Grade	Deoxidation	C	Si	Mn	P	S	Ni
RLPA	Fully killed fine grain	0.23 max.	0.35 max.	1.60 max.	0.035 max.	0.035 max.	−
RLPB		0.18 max.	0.35 max.	1.60 max.	0.035 max.	0.035 max.	−
RLPC		0.18 max.	0.35 max.	1.60 max.	0.035 max.	0.035 max.	−
RLP2		0.19 max.	0.10~0.35	0.90 max.	0.035 max.	0.035 max.	2.00~2.60
RLP3		0.16 max.	0.10~0.35	0.90 max.	0.030 max.	0.030 max.	3.20~3.80
RLP9		0.10 max.	0.10~0.35	0.90 max.	0.030 max.	0.030 max.	8.40~9.50

Table 2.1.60 Heat Treatment and Mechanical Properties

Grade	Heat treatment	Tensile test (1)(2)(3)				Bend test		Impact test	
		Yield strength (N/mm^2)	Tensile strength (N/mm^2)	Elongation (%) ($L=5.65\sqrt{A}$)		Inside radius of bend	Angle of bend (°)	Test temp. (°C)	Average absorbed energy (J)(4)
				L	T				
$RLPA$	Normalized, normalized and tempered or quenched and tempered	205 min.	380 min.	26 min.	19 min.	6 times the outside diameter of steel pipe	90°	− 40(5)	27 min.
$RLPB$								− 50(5)	
$RLPC$								− 60(5)	
$RLP2$		245 min.	450 min.	20 min.	14 min.			− 70	34 min.
$RLP3$								− 95	
$RLP9$	Double normalized and tempered or quenched and tempered	520 min.	680 min.	15 min.	11 min.			− 196	41 min.

NOTES:
(1) L (or T) denotes that the longitudinal axis of the test specimen is arranged parallel (or normal) to the final direction of rolling.
(2) Where the nominal diameter of steel pipes is 200 mm and over, the tensile test specimen may be taken transversely.
(3) Where test specimen of non-tubular section is taken from electric resistance welded pipes, the test specimen is to be taken from the portion that does not include the welded line.
(4) When the absorbed energy of two or more test specimens among a set of test specimens is less in value than the specified average absorbed energy or when the absorbed energy of a single test specimen is less in value than 70% of the specified average absorbed energy, the test is considered to have failed.
(5) Impact test temperature for steel pipes specified in **Pt 7, Ch 5** is to be 5°C below the design temperature or –20°C, whichever is the lower.

2. Kinds

The steel pipes are classified as given in **Table 2.1.59.**

3. Deoxidation practice and chemical composition

The deoxidation practice and chemical composition of each grade are to comply with the requirements given in **Table 2.1.59.**

4. Heat treatment

The heat treatment of steel pipes is to comply with the requirements given in **Table 2.1.60.**

5. Mechanical properties

(1) The mechanical properties of steel pipes are to comply with the following (a) to (e).
(a) *Tensile test*
The tensile test of steel pipes is to comply with the requirements given in **Table 2.1.60.**
(b) *Bend test*
(i) Test specimen of tubular section which is taken from the end of the steel pipe and has sufficient length is to stand being bent cold up to the specified value in **Table 2.1.60,** without flaw and cracking on the outside of bent portion.
(ii) Electric resistance welded steel pipes are to be bent at the place where the welded line is on the outside of bent portion.
(c) *Impact test*
The impact test of steel pipes is to comply with the requirements given in **Table 2.1.60.**
(d) *Flattening test*
Flattening test is to be carried out in accordance with the requirements given in **402.5** (3). Where this requirement is applied, the value of e is to be taken as 0.08.
(e) *Hydraulic test*
All steel pipes are to be subjected to hydraulic test in accordance with the requirements given in **402.5** (4).

(2) For steel pipes of 50 mm and under in outside diameter, tension, bend, impact and hydraulic tests are to be carried out.
(3) For steel pipes over 50 mm in outside diameter, tension, flattening, impact and hydraulic tests are to be carried out.
(4) Where deemed necessary by the Society, other tests may be required in addition to the tests specified in (1) to (3).

6. Selection of test specimens

(1) One sampling pipe is to be selected from each lot of 50 pipes or fraction thereof which are of the same charge, size and kind and are simultaneously heat treated. Each one specimen for tensile test and flattening test is to be taken from each sample pipe.
(2) One set of three specimens for impact test is to be taken from each sample pipe in accordance with **Fig. 2.1.11**. Moreover, for electric

resistance welded steel pipes, another set of three specimens is to be taken from the welded zone in accordance with **Fig. 2.1.12.**

7. Tolerance for dimensions

The tolerances for outside diameter and wall thickness of steel pipes are to be in accordance with the requirements given in **Table 2.1.61.**

8. Quality

The steel pipes are to be of uniform quality and free from harmful defects.

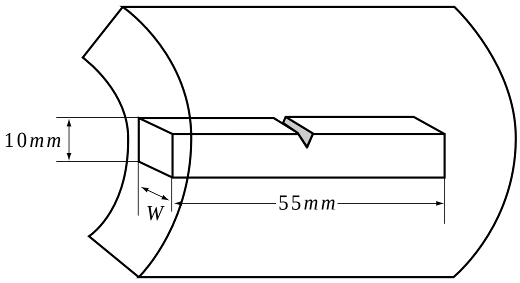


Fig. 2.1.11 The position of selection for impact test specimen taken from the seamless steel pipes and other portions than weld zone of electric-resistance welded steel pipes

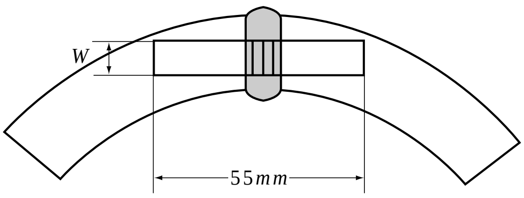


Fig. 2.1.12 The position of selection for impact test specimen taken from the weld zone of electric-resistance welded steel pipes

Table 2.1.61 Tolerance for Outside Diameter and Wall Thickness

Kind	Tolerance for outside diameter	Tolerance for wall thickness
Hot-finished seamless steel pipe	$D < 50$: $\pm 0.5 mm$ $50 \le D < 250$: $\pm 1\%$ (maximum value $2.0 mm$) $250 \le D$: $\pm 0.8\%$	$t < 4$: $\pm 0.5 mm$ $t \ge 4$: $\pm 12.5\%$
Cold-drawn seamless steel pipe and elec-tric-reslstance welded steel pipe	$\pm 0.8\%$ (max. value $0.3 mm$)	$t < 2$: $\pm 0.2 mm$ $t \ge 2$: $\pm 10\%$
NOTE: For hot-finished seamless steel pipes, the tolerance for deviation in wall thickness is to be 20% or less of wall thickness, but it shall not be applied to the pipes less than 5.6 mm in wall thickness.		

9. Retest procedures

(1) Where other mechanical tests than impact tests fail to meet the requirements, additional tests may be carried out according to the requirements given in **109.**

(2) Regarding the impact tests, additional tests are to be carried out according to the requirements given in **301.10** (3).

10. Marking

Marking for steel pipes is generally to comply with the requirements given in **402.9.** and in case the requirement in Note (5) of **Table 2.1.60** has been applied, "impact test temperature T" is to be suffixed to the marking. (e.g. $RLPA$-25T)

405. Header

1. Application

(1) These requirements are to apply to the headers to be used for boilers.

(2) The headers having characteristics differing from those specified in **405.** are to comply with the requirements in **101.2.**

2. Kinds

The headers are classified as specified in **Table 2.1.62.**

Table 2.1.62 Grades of Headers

Grade	Grade1	Grade2	Grade3	Grade4	Grade5	Grade6
	RBH 1	RBH 2	RBH 3	RBH 4	RBH 5	RBH 6

3. Heat treatment

Headers are to be heat treated by annealing or normalizing.

4. Chemical composition

The chemical composition of headers is to comply with the requirements given in **Table 2.1.63.**

5. Mechanical properties

(1) *Tensile test*: The tensile test of headers is to comply with the requirements given in **Table 2.1.64.**

(2) *Bend test*: The test specimen is to stand being bent cold through 180° without flaw and cracking on the outside of bent portion to an inside radius of 12 mm. Where the test specimen of 20 mm in thickness can not be taken, the test specimen may be as original in thickness, in which case, however, the width of test specimen is not to be less than 1.5 times the thickness and the inside radius of bend is to be equal to the thickness.

6. Selection of test specimens

(1) Tensile test specimens are to be taken length-

Table 2.1.63 Chemical Composition

Grade	Chemical composition (%)						
	C	Si	Mn	P	S	Cr	Mo
*RBH*1	0.25 max.	0.10~0.35	0.30~0.80	0.040 max.	0.040 max.	—	—
*RBH*2	0.30 max.						
*RBH*3	0.10~0.20	0.10~0.50		0.030 max.			0.45~0.65
*RBH*4			0.30~0.60		0.030 max.	0.80~1.20	0.20~0.45
*RBH*5	0.15 max.						0.45~0.65
*RBH*6						2.00~2.50	0.90~1.10

Table 2.1.64 Mechanical Properties

Grade	Yield strength (N/mm^2)	Tensile strength (N/mm^2)	Elongation (%) $L = 5.65\sqrt{A}$	Reduction of area (%)
*RBH*1	205 min.	410 min.	24 min.	38 min.
*RBH*2	225 min.	450 min.	23 min.	40 min.
*RBH*3	205 min.	380 min.	22 min.	
*RBH*4		410 min.	21 min.	
*RBH*5				
*RBH*6				

NOTE:
When test specimens are taken crosswise to the rolled direction, the values of yield strength and tensile strength are to be as given in this Table and the elongation is to take the value reduced by 5% from the percentage given in this Table. The value of reduction of area may be only remained on records for reference.

wise or crosswise to the rolled direction and bend test specimens to be taken crosswise to the rolled direction each from the open ends of headers.

(2) For the headers of the same size made from the same melt and subjected to the heat treatment simultaneously in the same furnace, tensile and bend test specimens are to be selected in accordance with the requirements given in **Table 2.1.65.**

(3) Where the both ends of header are closed by reforging, the test samples of proper size may be cut from the open ends before reforging.

(4) Where test samples cut from circular headers, etc. are necessary to be flattened, the test samples are to be taken from the body before being subjected to the heat treatment and after flattening the test samples are to be heat treated simultaneously with the body in the same furnace, or the test samples are to be cut from the structures after being subjected to the heat treatment and after flattened cold, they are to be heated to the temperature of 600°C to 650°C for the purpose of removing the distortion due to the flattening, and the required test specimens are to be cut from the test samples.

7. Tolerance for thickness

The tolerance for thickness is to be +12.5%. The tolerance, however, may not apply to the closed portions of circular or square headers, the side corners of square headers and the corrugated headers.

Table 2.1.65 Number of Test Specimens

Grade	Length of test specimens l (mm)	Number of test specimens
*RBH*1 *RBH*2	$3000 \leq l$	1 set for each one length
	$2000 \leq l < 3000$	1 set for each three lengths
	$2000 > l$	1 set for each five lengths
*RBH*3 *RBH*4 *RBH*5 *RBH*6	$3000 \leq l$	1 set from each end for each one length
	$3000 > l$	1 set for each one length

8. Quality

Headers are to be of uniform quality and free from harmful defects.

9. Marking

Headers which have satisfactorily complied with the required tests are to be marked with the identification mark in accordance with the requirements in **401.9.**

SECTION 5
Castings

501. Steel castings

1. Application

(1) The requirements in **501.** are to apply to the steel castings intended to be used for the components specified in the relevant Parts of hull construction equipments and machinery, except that defined in **502., 503.** and **504**.

(2) Steel castings having characteristics differing from those specified in **501.** are to comply with the requirements in **101.2.**

2. Kinds

The steel castings are classified as specified in **Table 2.1.66.**

3. Heat treatment

(1) Steel castings are to be annealed, normalized, normalized and tempered, or quenched and tempered. The tempering temperature is to be not less than 550°C.

(2) Steel castings which are locally heated or subjected to any cold work after heat treatment, are to be stress-relieved.

(3) Flame cutting or scarfing to remove risers and surplus metals is to be completed before final heat treatment of the steel castings.

(4) Castings for components such as crankshafts and engine bedplates, where dimensional stability and freedom from internal stresses are important, are to be given a stress relief heat treatment. This is to be carried out at a temperature of not less than 550°C followed by furnace cooling to 300°C or lower.

(5) Heat treatment is to be carried out in properly constructed furnaces which are efficiently maintained and have adequate means for control and recording of temperature. The furnace dimensions are to be such as to allow the whole casting to be uniformly heated to the necessary temperature In the case of very large castings alternative methods for heat treatment will be specially considered by the Society.

4. Chemical composition

(1) The chemical composition of steel castings is to comply with the requirements given in **Table 2.1.67**. Where carbon steel castings are intended for welded hull construction, the carbon content is generally not to exceed 0.23%, and Mn content not to exceed 0.8% in consideration of the weldability. For each reduction of 0.01% carbon below the maximum specified, and increase 0.04% manganese above the maximum specified for the carbon steel castings will be permitted to a maximum of 1.00% in total content.

(2) Unless otherwise required suitable grain refining elements such as aluminium may be used at the discretion of the manufacturer. The content of such elements is to be reported in the ladle analysis.

5. Mechanical properties

The mechanical properties of the steel castings are to comply with the requirements given in **Table 2.1.66.**

6. Selection of test specimens

(1) Unless otherwise agreed, test samples are to be either integrally cast or gated to the casting and are to have a thickness of not less than 30 mm.

(2) The test samples are to be heat treated togeth-

Table 2.1.66 Grades and Mechanical Properties

Kind	Grade	Tensile strength (N/mm^2)	Yield strength (N/mm^2)	Elongation (%) ($L=5.65\sqrt{A}$)	Reduction of area (%)
Carbon steel castings	RSC 42	410 min.	205 min.	24 min.	38 min.
	RSC 46	450 min.	225 min.	22 min.	29 min.
	RSC 49	480 min.	245 min.	20 min.	27 min.
	RSC 53	520 min.	265 min.	18 min.	25 min.
	RSC 57	560 min.	305 min.	15 min.	20 min.
	RSC 61	600 min.	325 min.	13 min.	20 min.
Low alloy steel castings	RSC 45 A	440 min.	245 min.	22 min.	40 min.
	RSC 49 A	480 min.	275 min.	17 min.	35 min.
	RSC 56 A	550 min.	345 min.	16 min.	35 min.

NOTES:
1. For intermediate values of the tensile strength, the minimum values for yield strength, elongation and reduction of area may be obtained by interpolation and the value at the first decimal place is to be subjected to the method of counting fractions over 1/2 as one and disregarding the rest.
2. The upper limit of the tensile strength is to be within 145 N/mm^2 from minimum tensile strength of each gread.

Table 2.1.67 Chemical Composition

Kind	Chemical composition (%)							Residual	
	C	Si	Mn	P	S	Cr	Mo		
Carbon steel castings	0.40 max.	0.60 max.	0.50~1.60	0.040 max.	0.040 max.	–	–	Cu : 0.30 max. Cr : 0.20 max. Ni : 0.50 max. Mo : 0.20 max.	(1)
Low alloy steel castings	0.25 max.	0.60 max.	0.50~0.80	0.030 max.	0.030 max.	1.50 max.	1.20 max.	Cu : 0.50 max. Ni : 0.50 max. W : 0.10 max.	(2)

NOTES:
(1) For each reduction of 0.01% carbon below the maximum specified, an increase of 0.04% chromium above the maximum specified will be permitted to a maximum of 0.40% in total content.
(2) The total content of the residual elements is not to exceed 1.00%.

Table 2.1.68 Numbar of Test Specimens

Condition of casting	Number of test specimens
Where the casting is of complex design or where the finished weight exceeds 10 *tons*	2 for each casting
Where the weight of one steel casting is between 1 *ton* and 10 *tons* inclusive	1 for each casting
Where a number of small castings with a weight of 1 *ton* or less which are to be of similar type and dimensions, made from one cast and heat-treated in the same furnace charge.	1 for each cast
Where large castings are made from two or more casts which are not mixed in a ladle prior to pouring.	Two or more corresponding to the number of casts involved

NOTES:
These test samples are to be integrally cast at locations as widely separated as possible.

er with the castings which they represent.

(3) Number of test specimens is to comply with the requirements of **Table 2.1.68.**

7. Surface and dimension inspections

(1) When heat treatment and machining are finished and, if necessary, at a proper time during machining, surface inspection is to be carried out.

(2) The dimension inspection of the steel castings is to be conducted under the responsibility of the manufacturer, unless otherwise specified.

8. Quality

Steel castings are to be of uniform quality and free from harmful defects.

9. Non-destructive inspection

(1) *Ultrasonic test*

(a) The steel castings intended for stern frame, rudder post and other important structural members or the steel castings specified in **Pt 5, Ch 2, 201. 1** are to be subjected to ultrasonic tests at an appropriate stage of the manufacturing process and the test reports are to be showed or submitted to the Surveyor.

(b) Performance of ultrasonic testing apparatus is to be of good efficiency for testing of large steel castings.

(c) Each operator intended to engage in the ultrasonic tests is to have a sufficient technique and experience for the testing of steel castings.

(2) *Magnetic particle test*

The important parts of the following steel castings are to be subjected to magnetic particle tests at an appropriate stage of the manufacturing process. But, machining surfaces may be subjected to liquid penetrant tests.

(a) Steel castings intended for stern frame, rudder post and other important structural members.

(b) Steel castings specified in **Pt 5, Ch 2, 201.1.**

(c) Propellers.

(d) Turbine castings.

(3) In place of the test methods specified in (1) and (2), the Society may accept the application of other non-destructive inspections considered adequate by the Society.

(4) The Society may require non-destructive inspections by radiographic test, ultrasonic test, magnetic particle test or penetrant test not only for the steel casting specified in (1) and (2) but also for the steel casting deemed necessary by the Society.

(5) The welding parts of steel castings used to welded construction are to be subjected to non-destructive inspections considered adequate by the Society.

10. Repair of defects

(1) In the event of finding defects in the steel casting, the defects may be removed by grinding, etc.
(2) After removing the defects, adequate non-destructive inspections are to be carried out to ensure that all defects have been completely removed.
(3) Where the steel castings from which defects were removed are used in that condition or after repaired by welding, the steel castings are to be approved by the Surveyor.
(4) All castings in alloy steels and all castings for crankshafts are to be suitably pre-heated prior to welding. Castings in carbon or carbon-manganese steel may also require to be preheated depending on their chemical composition and the dimensions and position of the weld repairs.
(5) After welding has been completed the castings are to be given either a suitable heat treatment in accordance with the requirements of **Par 3** (1) or a stress relieving heat treatment at a temperature of not less than 550°C. The type of heat treatment employed will be dependent on the chemical composition of the casting and the dimensions, positions and nature of the defects.
(6) The portions repaired by welding are to be confirmed that they are free from harmful defects by adequate non-destructive inspection.

11. Retest procedure

Where the tensile test fails to meet the requirements, additional test may be carried out in accordance with the requirements of **109.**

12. Marking

(1) The grade of material and the manufacturer's name or trade mark are to be cast or stamped on all steel castings. In addition, the cast number is to be stamped on all steel castings not less than 250 Kg in mass. The Society's brand indicating satisfactory compliance with the requirements is to be stamped in the vicinity of the foregoing marks.
(2) For steel castings to which the requirements given in note 1 of the **Table 2.1.66**, the material symbols are specified as RSC - (or RSC - A) and the required tensile strength is to be filled in symbol " - ". (e.g. For carbon steel castings which the required tensile strength is 420 N/mm^2, RSC 43)
(3) Where cabon steel castings are intended for welded hull construction specified in **Par 4** (1), "W" is to be suffixed to the marking. (e.g, RSC 42-W)

13. Additional requirements for crank throw

(1) In case where semi-built-up crank throw for diesel engines is made of steel casting, the manufacturing procedure is to be approved by the Society.
(2) Where special manufacturing methods are adopted to reduce the size of crank throw according to the requirements in **Pt 5, Ch 2, 208,** the preliminary test instructed by the Society are to be carried out.

14. Surface hardening treatment

Where the surface of steel castings is hardened by induction hardening, nitriding, cold rolling or other methods, these hardening methods are to be approved by the Society.

502. Steel castings for chains

1. Application

(1) These requirements are to apply to steel castings used for chain link, shackle, swivel, etc. of Grades 2 and 3 chains specified in **Pt 4, Ch 8** (hereinafter referred to as "steel castings").
(2) Steel castings having characteristics differing from those specified in **502.** are to comply with the requirements in **101.2.**

2. Kinds

The steel castings are classified as specified in **Table 2.1.69.**

Table 2.1.69 Grade of Steel Casting

Grade	Application
$RSCC$ 50	Grade 2 chain
$RSCC$ 70	Grade 3 chain
$RSCCR$ 3	Grade $R3$ chain
$RSCCR$ 3S	Grade $R3S$ chain
$RSCCR$ 4	Grade $R4$ chain

3. Heat treatment

(1) Steel castings are to be annealed or quenched and tempered or heat treated by the process approved by the Society.
(2) Steel castings which are locally heated or subjected to any cold work after heat treatment, are to be stress-relieved by the approved methods.
(3) Flame cutting or scarfing to remove risers and surplus metals is to be completed before final heat treatment of the steel castings.

4. Chemical composition

Chemical composition of steel castings is to be subjected to the special approval by the Society.

5. Mechanical properties

The mechanical properties of steel castings are to comply with the requirements given in **Table 2.1.70.**

Table 2.1.70 Mechanical Properties

Grade	Tensile test				Impact test[1]	
	Yield strength (N/mm^2) [2]	Tensile strength (N/mm^2) [2]	Elongation (%) ($L = 5d$)	Reduction of area (%)	Testing temp. (°C)	Average absorbed energy (J)
$RSCC$ 50	295 min.	490~690	22 min.	–	–	–
$RSCC$ 70	410 min.	690 min.	17 min.	40 min.	0	60 min.
$RSCCR$ 3	410 min.	690 min.	17 min.	40 min.	– 20[3]	40 min.[3]
$RSCCR$ 3S	490 min.	770 min.	15 min.	40 min.	– 20[3]	45 min.[3]
$RSCCR$ 4	580 min.	860 min.	12 min.	35 min.	– 20	40 min.

NOTE:
(1) When the absorbed energy of two or more test specimens among a set of test specimens is less in value than the specified average absorbed energy or when the absorbed energy of a single test specimen is less in value than 70% of the specified average absorbed energy, the test is considered to have failed.
(2) The yield ratio (the aim value of yield to tensile ratio) for grade $RSCCR$3, $RSCCR$3S, or $RSCCR$4 is to be maximum 0.92.
(3) Impact test of grade $RSCCR$3 and $RSCCR$3S may be carried out at the temperature of 0°C where approved by the Society. In this case, minimum mean absorbed energy is to be not less than 60J for grade $RSCCR$3 and 65J for grade $RSCCR$3S.

6. Selection of test specimens

(1) One test sample is to be taken from castings of similar dimensions originating from the same heat treatment charge and the same cast of steel. In this case, the test sample may be the test assembly cast with the body of casting and similar area. The tensile and impact test specimens are to be taken from the test sample in the longitudinal direction at a depth of 1/6 diameter from the surface specified in **Fig. 2.1.5.**

(2) For Grade 2 chain castings, one tensile test specimen, and for other grades of chain castings, one tensile test specimen and one set (3 pieces) of impact test specimens are to be taken from the test sample.

7. Surface inspection

Steel castings are to be subjected to the surface inspection after completion of the final heat treatment.

8. Quality

Steel castings are to be of uniform quality and free from harmful defects.

9. Non-destructive inspection

(1) For grades $RSCCR$3, $RSCCR$3S and $RSCCR$4, all steel castings are subjected to ultrasonic test at an appropriate stage of the manufacture after heat treatment and it is to be confirmed that there are no harmful defects.

(2) For grades $RSCC$50 and $RSCC$70, a suitable non-destructive inspection, such as an ultrasonic test, may be required where deemed necessary by the Society.

10. Repair of defects

The repair of defects for steel castings is generally to be carried out in accordance with the requirements in **501.10.**

11. Retest procedure

Where the tensile test or impact test on the selected first test specimens fails to meet the requirements, additional tests may be conducted according to the requirements given in **306.7.**

12. Marking

Steel castings which have satisfactorily complied with the required tests are to be marked with the identification mark in accordance with the requirements in **501.12** (1).

503. Stainless steel castings

1. Application

(1) The requirements are to apply to the stainless steel castings for valves and pipe fittings in piping systems used at low temperature (–165°C and over in design temperature) service or corrosion-resisting service (hereinafter referred to as “steel castings”).

(2) Steel castings having characteristics differing from those specified in **503.** are to comply with the requirements in **101.2.**

2. Kinds

The steel castings are classified as specified in **Table 2.1.71.**

3. Heat treatment

Steel castings are generally to receive a solid solution treatment.

4. Chemical composition

The chemical composition of steel castings is to comply with the requirements given in **Table 2.1.71.**

5. Mechanical properties

(1) The mechanical properties of steel castings are to comply with the requirements give in **Table 2.1.72.**

(2) Where deemed necessary by the Society, impact test or corrosion-resistance test may be required in addition to the specified tests.

6. Selection of test specimens

(1) Where a stainless steel casting is 500 Kg and over in weight, one tensile test specimen and one hardness test specimen are to be taken from each casting.

(2) Where a number of stainless steel castings of similar form and size, each of which weight less than 500 Kg, are cast from the same charge, two tensile test specimens and two hardness test specimens are to be taken from each group of castings simultaneously heat treated in the same furnace.

(3) Hardness test specimen may be a portion of tensile test specimen.

7. Marking

Steel castings which have satisfactorily complied with the required tests are to be marked with the identification mark in accordance with the requirements in **110.**

504. Steel castings for low temperature service

1. Application

(1) The requirements are to apply to the steel castings for valves and pipe fittings in piping systems intended to be used at the design temperature lower than 0°C in liquefied gas carriers (hereinafter referred to as "steel castings").

(2) Steel castings other than specified in **504.** or those used in other parts than specified in (1) are to comply with the requirements given in **101.2.**

2. Kinds

The steel castings are classified as given in **Table 2.1.73.**

3. Heat treatment

Steel castings are to be normalized or normalized and tempered.

4. Deoxidation practice and chemical composition

The deoxidation practice and chemical composition of steel castings are to comply with the requirements given in **Table 2.1.73.**

5. Mechanical properties

Table 2.1.72 Mechanical Properties

Grade	Tensile test			Hardness test
	Yield strength (N/mm^2)	Tensile strength (N/mm^2)	Elongation ($L = 5.65\sqrt{A}$)	Brinell H_B
$RSSC13$	185 min.	440 min.	26 min.	183 max.
$RSSC14$				
$RSSC16$	175 min.	390 min.	31 min.	
$RSSC17$	205 min.	440 min.	26 min.	
$RSSC18$	185 min.			
$RSSC19$		390 min.	31 min.	
$RSSC21$	205 min.	440 min.	26 min.	

Table 2.1.71 Grades and Chemical Composition

Grade	Chemical composition (%)								
	C	Si	Mn	P	S	Ni	Cr	Mo	Others
$RSSC13$	0.08 max.	2.00 max.	2.00 max.	0.040 max.	0.030 max.	8.00~11.00	18.00~21.00	—	—
$RSSC14$		1.50 max.				10.00~14.00	17.00~22.00	2.00~3.00	—
$RSSC16$	0.030 max.					12.00~16.00			—
$RSSC17$	0.08 max.	2.00 max.				12.00~15.00	22.00~26.0	—	—
$RSSC18$						19.00~22.00	23.00~27.0	—	—
$RSSC19$	0.030 max.					8.00~12.00	17.00~21.0	—	—
$RSSC21$	0.08 max.					9.00~12.00	18.00~21.0	1.35 ≥ Nb+Ta ≥ 10 × C	

Table 2.1.73 Grades and Chemical Composition

Grade	Deoxidation	Chemical composition (%)						
		C	Si	Mn	P	S	Ni	Mo
$RLCA$	Fully killed fine grain	0.30 max.	0.60 max.	1.00 max.	0.035 max.	0.035 max.	—	—
$RLCB$		0.25 max.		0.50~0.80				0.45~0.65
$RLC2$		0.25 max.			0.030 max.	0.030 max.	2.00~3.00	—
$RLC3$		0.15 max.					3.00~4.00	

(1) The mechanical properties of steel castings are to comply with the requirements given in **Table 2.1.74.**

(2) Where deemed necessary by the Society, other tests may be required in addition to the tests specified in (1).

6. Selection of test specimens

(1) Where a steel casting is 500 kg and over in weight, one tensile test specimen and one set of three impact test specimens are to be taken from each casting.

(2) Where a number of steel castings of similar form and size, each of which less than 500 kg in weight, are cast from the same charge, two tensile test specimens and two sets of six impact test specimens are to be taken from each group of castings simultaneously heat treated in the same furnace.

7. Retest procedures

(1) Where the tensile tests fail to meet the requirements, additional tests may be carried out according to the requirements given in **109.**

(2) Regarding the impact tests, additional tests are to be carried out according to the requirements given in **304.9** (2).

8. Marking

Steel castings which have satisfactorily complied with the required tests are to be marked with the identification mark in accordance with the requirements in **501.12** (1) and in case the requirement in Note (1) of **Table 2.1.74** has been applied, "impact test temperature T" is to be suffixed to the marking. (e.g. $RLCA$ - 25T)

505. Iron castings

1. Application

(1) These requirements are to apply to the grey iron castings and spheroidal or nodular graphite iron castings etc. (hereinafter referred to as "iron castings") intended to be used for propeller or important parts of machinery.

(2) Where deemed necessary by the Society, KS or equivalent thereto may be applied.

2. Grade and mechanical properties

(1) Grey iron castings are to comply with the requirements for "Grey iron casting grade Nos. 2 to 6", specified in $KS\ D$ 4301.

(2) Spheroidal or nodular graphite iron castings

Table 2.1.74 Mechanical Properties

Grade	Tensile test				Impact test (2)	
	Yield strength (N/mm^2)	Tensile strength (N/mm^2)	Elongation (%) (L = 5d)	Reduction of area (%)	Test temp. (°C)	Average absorbed energy (J)
$RLCA$	245 min.	450 min.	21 min.	35 min.	− 40(1)	27 min.
$RLCB$					− 50(1)	
$RLC2$	275 min.				− 70	34 min.
$RLC3$					− 95	

NOTES:
(1) Impact test temperature for castings specified in **Pt 7, Ch 5** is to be 5°C below the design temperature or –20°C, whichever is the lower.
(2) When the absorbed energy of two or more test specimens among a set of test specimens is less in value than the specified average absorbed energy or when the absorbed energy of a single test specimen is less in value than 70% of the specified average absorbed energy, the test is considered to have failed.

Table 2.1.75 Mechanical Properities for Spheroidal or Nodular Graphite Iron Castings

Grade	Yield strength(N/mm^2)	Tensile strength(N/mm^2)	Elongation(%)($L = 5.65\sqrt{A}$)	Hardness(1) (H_B)
$RGCD$ 370	230 min.	370 min.	17 min.	180 max.
$RGCD$ 400	240 min.	400 min.	12 min.	200max.
$RGCD$ 450	280 min.	450 min.	10 min.	140~220
$RGCD$ 500	340 min.	500 min.	7 min.	170~240
$RGCD$ 600	370 min.	600 min.	3 min.	190~270
$RGCD$ 700	420 min.	700 min.	2 min.	230~300
$RGCD$ 800	480 min.	800 min.	2 min.	250~350

NOTE:
(1) Typical Brinell hardness values are intended for information purpose only.

hereinafter referred to as spheroidal iron castings are to comply with the **Table 2.1.75.**

3. Testing and inspection

(1) For grey and spheroidal iron castings intended to be used for the important parts of machinery, testing and inspection may not require the presence of the Society's surveyors, except where specially specified in connection with the design.

(2) For grey and spheroidal iron castings for propeller, testing and inspection may require the presence of the Society's surveyor.

4. Test samples

(1) Where separately cast test samples are used, they are to be cast in moulds made of the same type of material as used for the castings. For spheroidal iron casting test samples are to be taken towards the end of pouring of the castings.

(2) Test samples for grey iron casting are to be in the form of cylindrical bars with 30 *mm* diameter and of a suitable length, The dimension of test samples for spheroidal or nodular graphite iron castings are to KS D 4302 or be left to the discretion of the Society.

(3) Test samples are not to be stripped from the moulds until the temperature is below 500°C.

5. Number of test specimens

Number of test specimens is to comply with the requirements of **Table 2.1.76.**

6. Quality and rectification of defective casting

(1) All castings are to be of uniform quality and free from harmful defects.

(2) At the discretion of the Surveyor, small surface blemishes may be removed by local grinding.

(3) Subject to the prior approval of the Surveyor, castings containing local porosity may be rectified by impregnation with a suitable plastic filler, provided that the extent of the porosity is such that it does not adversely affect the strength of the casting.

(4) Repairs by welding are generally not permitted.

7. Marking

Grey and spheroidal iron castings which have satisfactorily complied with the required tests are to be marked with the identification mark in accordance with the requirements in **110.**

Table 2.1.76 Number of Test Specimens

Condition of casting	Number of test specimens
For large casting where more than one ladle of treated metal is used.	One tensile test specimen for each ladle
For a number of small casting with a fettled weight of 1 *ton* or less which are to be of similar type and dimensions, cast from the same ladle of treated metal	One tensile test specimen each multiple of 2 *tons*
Other than Prescribed in above	One tensile test specimen for each casting

SECTION 6
Steel Forgings

601. Steel forgings

1. Application

(1) The requirements in **601.** are to apply to the steel forgings intended to be used for the components of hull construction, equipments, and machinery specified in each Part, and rolled steel bars for shafts or bolts except those specified in **602., 603.** and **604.** (hereinafter referred to as the "steel forgings").

(2) Steel forgings having characteristics differing from those specified in **601.** are to comply with the requirements in **101.2.**

2. Manufacturing process

(1) Steel forgings are to be manufactured from the killed ingot.

(2) Adequate discards are to be made from the top and bottom of each ingot to ensure freedom from piping and harmful segregation in the finished forgings.

(3) Steel forgings are to be hot worked by press or hammer from ingots, blooms forged or rolled from ingots or blooms made from ingots by a combination of rolling and forging.

(4) Steel forgings are to be gradually and uniformly hot worked and are to be brought as nearly as possible to the finished shape and size. Where practicable, they are to be worked so as to cause metal flow in the most favourable direction having regard to the mode of stressing in service.

(5) The reduction ratio is to comply with the following;

(a) For components where the fibre deformation is mainly longitudinal; the total reduction ratio is to be not less than those shown in **Table 2.1.77.**

Table 2.1.77 Reduction Ratio

Method of manufacture	Description(1)	Total reduction(2)(3)
Made directly from ingots or from forged blooms or billets	$L > D$	3 : 1
	$L \leq D$	1.5 : 1
Made from rolled products	$L > D$	4 : 1
	$L \leq D$	2 : 1

NOTES:
(1) L and D are the length and diameter respectively of the part of the forging under consideration.
(2) The reduction ratio is to be calculated with reference to the average cross-sectional area of the ingot. Where an ingot is initially upset, this reference area may be taken as the average cross-sectional area after this operation.
(3) For rolled bars used as a substitute for forgings the reduction ratio is to be not less than 6:1.

(b) *Disc type forgings such as gearwheels are made by upsetting*

(i) The thickness of any part of the disc is to be not more than one half of the length of the billet from which it was formed provided that this billet has received an initial forging reduction of not less than 1.5:1.

(ii) Where the piece used has been cut directly from an ingot or where the billet has received an initial reduction of less than 1.5: 1, the thickness of any part of the disc is to be not more than one third of the length of the original piece.

(c) *Rings and other types of hollow forgings* These forgings are to be made from pieces cut from ingots or billets and which have been suitably punched, bored or trepanned prior to expanding or drawing on a suitable mandrel. Alternatively, pieces from hollow cast ingots may be used. The wall thickness of the forging is to be not more than one half of the thickness of the prepared hollow piece from which it was formed.

(6) The shaping of forgings or rolled slabs and billets by flame cutting, scarfing or arc-air gouging is to be undertaken in accordance with recognized good practice and, unless otherwise approved, is to be carried out before the final heat treatment. Preheating is to be employed when necessitated by the composition and/or thickness of the steel.

(7) When two or more forgings are joined by welding to form a composite component, details of the proposed procedure are to be submitted for approval. Welding procedure qualification tests may be required.

3. Kinds

The steel forgings are classified as specified in Table **2.1.80.**

4. Heat treatment

(1) Except as provided in (5) forgings are to be supplied in one of the conditions given in **Table 2.1.78.** However, the tempering temperature is to be not less than 550°C.

(2) Alternatively, alloy steel forgings may be supplied in the normalized and tempered condi-

Table 2.1.78 Heat Treatment

Kind	Heat treatment
Carbon steels	Annealed
	Normalized
	Normalized and tempered
	Quenched and tempered
Alloy steels	Quenched and tempered

tion, in which case the specified mechanical properties are to be agreed with the Society.

(3) Steel forgings which are subjected to any hot work after heat treatment, are to be heat treated again.

(4) Steel forgings which are subjected to any cold work are to be stress-relieved by the approved methods.

(5) Where induction hardening or nitriding is to be carried out after machining, forgings are to be heat treated at an appropriate stage to a condition suitable for this subsequent surface hardening.

(6) Heat treatment is to be carried out in properly constructed furnaces which are efficiently maintained and have adequate means for control and recording of temperature. The furnace dimensions are to be such as to allow the whole forging to be uniformly heated to the necessary temperature. In the case of very large forgings alternative methods of heat treatment will be specially considered by the Society.

5. Chemical composition

(1) The chemical composition of steel forgings is to comply with the requirements given in **Table 2.1.79.** Where carbon steel forgings are intended for welded construction, the carbon content is generally not to exceed 0.23%.

(2) At the option of the manufacturer, suitable grain refining elements such as aluminium, niobium or vanadium may be added. The content of such elements is to be reported in the ladle analysis.

6. Mechanical properties

(1) The mechanical properties of steel forgings are to comply with the requirements given in **Table 2.1.78.**

(2) When impact tests are required they are to be carried out at ambient temperature (18~25°C) and unless otherwise specified either Charpy V-notch or Charpy U-notch test specimens may be used at the option of the manufacturer. For carbon steel forgings and rolled steel bars, impact test may be required in case where deemed necessary by the Society.

(3) Where more than one tensile test is taken from a forging the variation in tensile strength is not to exceed the following:

Specified minimum tensile strength (N/mm^2)	Difference in tensile strength (N/mm^2)
< 600	70
≥ 600, < 900	100
≥ 900	120

(4) *Hardness test*: Where material tests are made in accordance with the requirement in **Par 7**(1) (c) and (d), the Surveyor may require hardness test for each forging. In this case, the difference between the highest and the lowest values in the same lot is to comply with the following:

Specified minimum tensile strength (N/mm^2)	Difference in hardness (H_B)
< 600	Not more than 25
≥ 600, < 900	Not more than 35
≥ 900	Not more than 42

(5) Gears and gear rims are to comply with the requirements in **Par 17** (4).

7. Selection of test specimens

(1) Unless otherwise specially specified, the test specimens for steel forgings are, after final heat treatment, to be taken lengthwise from a part having a sectional area not less than that of the body of forging. But they are to be taken crosswise where deemed necessary according to the form of the forgings.

(2) The test sepcimens are not to be separated from the body before the final heat treatment has been completed. In the case of stamp forging or other case of forging requiring the surface hardening process, the test specimens may be prepared at a proper stage before the final heat treatment providing that such is approved by the Surveyor.

(3) Number of test specimens is to be as given in (a) through (f) of the following requirements:

(a) Where a steel forging exceeds 4 *tons* in weight of body of forging as heat treated (hereinafter referred to as "weight") or 3*m*

Table 2.1.79 Chemical Composition

Kind	Chemical composition (%)							
	C	Si	Mn	P	S	Ni	Cr	Mo
Carbon steel forgings and rolled bars	0.60 max.	0.15~0.45	0.30~1.50	0.030 max.	0.035 max.	—	—	—
Low alloy steel forgings and rolled bars	0.50 max.		0.35~1.00	0.030 max.	0.030 max.	3.50 max.	3.50 max.	0.70 max.

NOTES:
1. Where special deoxidation practice is applied, the value of Si content given in the above Table may be decreased.
2. Cu content of the residual element is not to exceed 0.30%.

Table 2.1.80 Grade and Mechanical Properties

Kind	Grade (Correspond to tensile strength)	Tensile strength (N/mm^2)	Yield strength (N/mm^2)	Elongation (%)(min.)값) ($L = 5.65\sqrt{A}$)		Reduction of area (%) (min)		Impact test average value of absorbed energy (J)				Hardness (H_B)
								V-notch		U-notch		
				L	T	L	T	L	T	L	T	
Carbon steel forgings and rolled steel bars	RSF 41	400 min.	200 min.	26	19	50	35	—	—	—	—	100~150
	RSF 45	440 min.	220 min.	24	18	50	35					125~160
	RSF 49	480 min.	240 min.	22	16	45	30					135~175
	RSF 53	520 min.	260 min.	21	15	45	30					150~185
	RSF 57	560 min.	280 min.	20	14	40	27					160~200
	RSF 61	600 min.	300 min.	18	13	40	27					175~215
	RSF 65	640 min.	320 min.	17	12	40	27					185~230
	RSF 69	680 min.	340 min.	16	12	35	24					200~240
	RSF 73	720 min.	360 min.	15	11	35	24					210~250
	RSF 78	760 min.	380 min.	14	10	35	24					225~265
Low alloy steel forgings and rolled steel bars	RSF 61 A	600 min.	420 min.	18	14	50	35	41 min.	24 min.	35 min.	24 min.	175~215
	RSF 66 A	650 min.	450 min.	17	13	50	35	32 min.	22 min.	30 min.	23 min.	190~235
	RSF 71 A	700 min.	480 min.	16	12	45	30	32 min.	22 min.	30 min.	23 min.	205~245
	RSF 77 A	760 min.	530 min.	15	11	45	30	32 min.	20 min.	30 min.	22 min.	215~260
	RSF 82 A	800 min.	590 min.	14	10	40	27	32 min.	20 min.	30 min.	22 min.	235~275
	RSF 87 A	850 min.	635 min.	13	9	40	27	27 min.	18 min.	26 min.	20 min.	245~290
	RSF 92 A	900 min.	685 min.	13	9	40	27	27 min.	18 min.	26 min.	20 min.	260~320
	RSF 97 A	950 min.	755 min.	12	8	35	24	25 min.	16 min.	25 min.	18 min.	275~340
	RSF 102 A	1000 min.	815 min.	12	8	35	24	25 min.	16 min.	25 min.	18 min.	290~365
	RSF 107 A	1050 min.	875 min.	11	7	35	24	21 min.	13 min.	23 min.	15 min.	310~375
	RSF 112 A	1100 min.	930 min.	11	7	35	24	21 min.	13 min.	23 min.	15 min.	320~385

NOTE:

1. For intermediate values of the tensile strength, the minimum values for yield strength, elongation reduction of area and impact energy may be obtained by interpolation and the value at the first decimal place is to be subjected to the method of counting fractions over 1/2 as one and disregarding the rest.
2. The upper limit of tensile strength is to be within following range from minimum tensile strength of each grade.

Kind	tensile strength (N/mm^2)	Upper limit (N/mm^2)
Carbon steel forgings and rolled bars	600 less than	120
	600 min.	145
Low alloy steel forgings and rolled bars	900 less than	145
	900 min.	195

3. L (or T) denotes that the longitudinal axis of the test specimen is arranged parallel (or normal) to the direction of forging.

in length of body of forging as heat treated, one set each of test specimens is to be taken from both ends of the steel forging.

(b) Where a steel forging is 500 kg up to 4 $tons$ in weight, one set of test specimens is to be taken from one end of the forging.

(c) Where a number of steel forgings of similar form and size, each of which is 250 kg up to 500 kg in weight, are made from the same ingot (or bloom) and heat treated simultaneously, one set of test specimens is to be taken from each three forgings or fraction thereof.

(d) Where a number of steel forgings of similar form and size, each of which is less than 250 kg in weight, are made from the same ingot (or bloom) and heat treated simultaneously, one set of test specimens is to be taken from each ingot (or bloom).

(e) In place of the requirements given in (a) or (d) above, one set of test specimens of rolled carbon steel bar is to be taken from the steel bars of the same charged steel subjected to the same heat treatment of 5 *tons* in weight or fraction thereof.

(f) “One set of test specimens” means one tension test specimen for carbon steel forgings, and one tension test specimen and three impact specimens for low alloy steel forgings.

8. Surface inspection

(1) When heat treatment and final machining are completed and, if necessary, at a proper time during machining, surface inspection is to be carried out.

(2) Dimension inspection of the steel forgings is to be conducted under the responsibility of the manufacturer, unless otherwise specified.

9. Quality

Steel forgings are to be of uniform quality and free from harmful defects.

10. Non-destructive inspection

(1) *Ultrasonic test*

(a) The following steel forgings are to be subjected to ultrasonic test at an appropriate stage of the manufacturing process and the test reports are to be showed or submitted to the Surveyor.

(i) Rudder stock and pintle.

(ii) Steel forgings given in **Pt 5, Ch 2, 201.1.**

(iii) Thrust shafts, intermediate shafts and propeller shafts.

(iv) Reduction gears and reduction gear shafts.

(v) Turbine rotors, turbine discs and turbine blades.

(b) Performances of ultrasonic testing apparatus are to be of good efficiency for testing of those forgings.

(c) Each operator intended to engage in the ultrasonic test is to have a sufficient technique and experience for the testing of the forgings.

(2) *Magnetic particle or liquid penetrant testing*: The important parts of the following steel forgings are to be subjected to magnetic particle or liquid penetrant test at an appropriate stage of the manufacturing process.

(a) Steel forgings given in **Pt 5, Ch 2, 201.1.**

(b) Propeller shafts.

(c) Reduction gears.

(d) Turbine rotors, turbine discs and turbine blades.

(3) The Society may require sulphur print test for the portion of gear teeth.

(4) In place of the test methods given above, the Society may accept the application of other non-destructive inspections considered adequate by the Society.

(5) The Society may require non-destructive inspectionfor the steel other than those specified in (1) and (2) when such is deemed necessary by the Society.

(6) The welded parts of steel forgings used for welded construction are to be subjected to the non-destructive inspections considered adequate by the Society.

11. Repair of defects

(1) In the event of finding defects in the steel forgings, the defects may be removed by grinding, etc.

(2) After removing the defects, adequate non-destructive inspections are to be carried out to ensure that all defects have been completely removed.

(3) The steel forgings from which defects have been removed are to be approved by the Surveyor.

(4) The grooves caused by removing the defects are not to be generally repaired by welding.

12. Retest procedures

(1) Where the results of tensile tests or hardness tests do not comply with the requirements, additional test may be carried out in accordance with the requirements of **109.**

(2) Additional test for impact test is to comply with the requirements in **301.11** (3).

13. Marking

(1) Steel forgings which have satisfactorily complied with the required tests are to be marked with the identification mark in accordance with the requirements in **110.**

(2) For steel forgings to which the requirements given in note 1. of the **Table 2.1.80** applied, the material symbols are specified as RSF - (or *RSF - A*) and the specified tensile strength is to be filled in symbol " - ". (e.g. For carbon steel forgings which the specified tensile strength is 420 N/mm^2, *RSF* 43)

(3) Where carbon steel forgings are intended for welded construction specified in **Par 5** (1), “*W*” is to be suffixed to the marking. (e.g. RSF 45-W)

(4) Teg grade of Steel bars is to be indicated by suffixing a letter "B" to the symbol "RSF". (e.g. RSFB61)

14. Additional requirements for crank shafts

(1) Where solid crank shafts of 250 *mm* and over in finished diameter are manufactured by free forging, the heat treatment is normally to be carried out after crank parts are machined as nearly as possible to the finished shape.

(2) Where solid crank shafts, semibuilt-up crank throws and full built up crank arms are manu factured by special manufacturing processes,

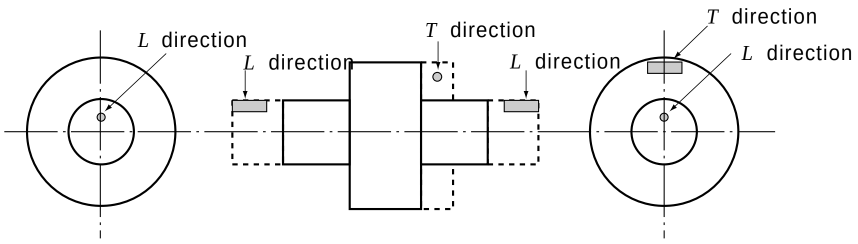


Fig. 2.1.13 Selection of Test Specimen for Turbine Rotor

the preliminary tests instructed by the Society are to be carried out, in connection with the manufacturing processes and the selection of test specimens.

(3) Where special manufacturing processes are adopted to reduce the size of crank shaft (refer to the requirements in **Pt 5, Ch, 208.** the preliminary tests instructed by the Society are to be carried out.

15. Additional requirements for turbine rotors

(1) The test specimens for turbine rotors are to be taken in accordance with the following requirements:

(a) Where the turbine rotor is greater than 3 *tons* in weight, one set of longitudinal test specimens is to be taken from each end of the shaft portion and one set of transverse test specimens from the body portion respectively. (See **Fig. 2.1.13**)

(b) Where the turbine rotor is not exceeding 3 *tons* in weight, one set of longitudinal test specimens is to be taken from one end of the shaft portion and one set of transverse test specimens from the body portion respectively.

(2) For each turbine disc, one set of transverse test specimens is to be taken from the boss portion. (See **Fig. 2.1.14**)

(3) Solid forged turbine rotors intended for main propulsion service where the inlet steam temperature exceeds 400°C are to be subjected to stability tests at least once at a suitable time after rough machining or heat treatment. This requirement is also applicable to rotors fabricated by welding. The method of stability test is to be approved by the Society prior to the test.

16. Additional requirements for turbine blades

Turbine blades are to be tested in accordance with the approved test specification.

17. Additional requirement for reduction gears, etc.

(1) Pinions intended for reduction gears are to conform to the following requirements:

(a) Where the finished diameter over the portion where teeth will be cut is not exceeding 200 *mm*, one set of longitudinal test specimens is to be taken from one end of the journal. (see **Fig. 2.1.15**)

(b) (i) Where the above finished diameter is gre ater than 200 *mm* and the weight greater than 3 *tons*, one set of transverse test specimens is to be taken from each end of the adjacent where the teeth will be cut (see **Fig. 2.1.16** (a)) In the case of pinions where the diameter of journal precludes the preparation of test specimens from this portion, above tran sverse test specimens may be taken from the ends of the journals (see **Fig. 2.1.16** (b)). Where the finished journal diameter is not exceeding 200 *mm*, one set of longitudinal test specimens may be taken from each end of the journals (see **Fig. 2.1.16** (c)).

(ii) Where the finished diameter is greater than 200 *mm* and the weight is not exceed ing 3 *tons*, one set of test specimens is to be taken from one end of the pinion in accordance with (i).

(c) Where the pinions are so designed that the tooth body is inserted in the shaft the number of test specimens is to be taken in accordance with (i) and (ii).

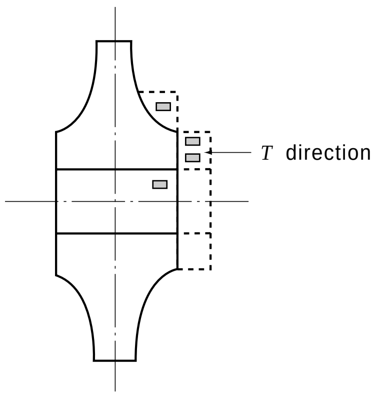
(i) Where finished length less than 1.25 *m*, one set of test specimens is to be taken from each forging in a transverse direction (test position A or B in **Fig. 2.1.17.**)

(ii) Where finished length exceeds 1.25 m, one set of test specimens is to be taken from each end (test position A and B in **Fig. 2.1.18.**)

(d) Where a number of pinions, each of which weight less than 250 *kg*, are made from the same ingot and heat treated simultaneously, one set of test specimens is to be taken from every two pinions at least.

(2) Rims intended for reduction gears and for cam shaft driving gears of diesel engine (see **Pt 5, Ch 2 201.1**) are to comply with the following requirements.

(a) Where the finished diameter of a rim exceeds 2.5 *metres* or the weight exceeds 3 *tons*, one set of transverse test specimens is to be taken from each end of the rim from diametrically opposite positions. (see **Fig. 2.1.18**) In this case, the mechanical properties are to comply with the requirements applicable to the case of test speci mens taken is the direction parallel to the



Note: One set of test specimens may be taken from one location given in the Figure.

Fig. 2.1.14 Selection of Test Specimen for Trubine Disc

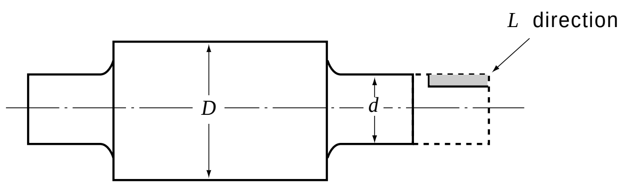


Fig. 2.1.15 Selection of Test Specimen for Pinion not Exceeding 200 mm in Finished Diameter

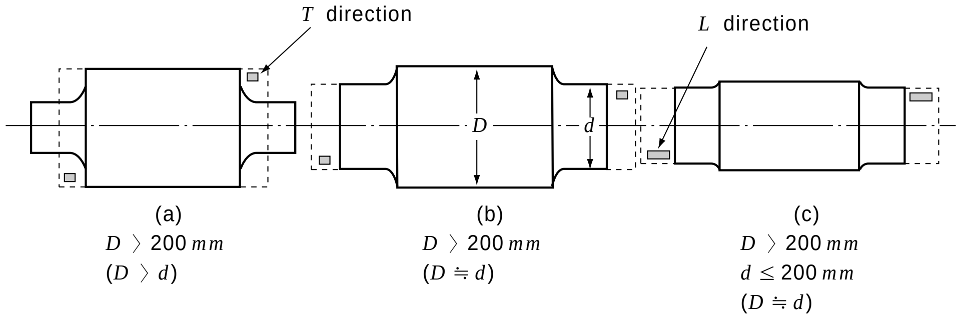


Fig. 2.1.16 Selection of Test Specimen for Pinion Greater than 200 mm in Finished Diameter

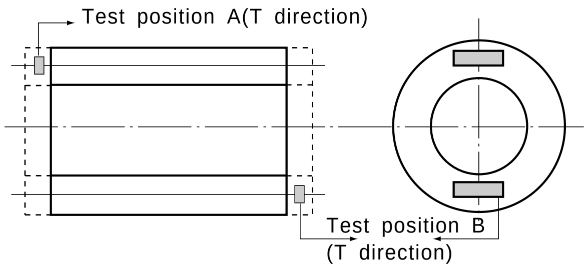


Fig. 2.1.17 Selection of Test Specimen for Pinion Sleeve

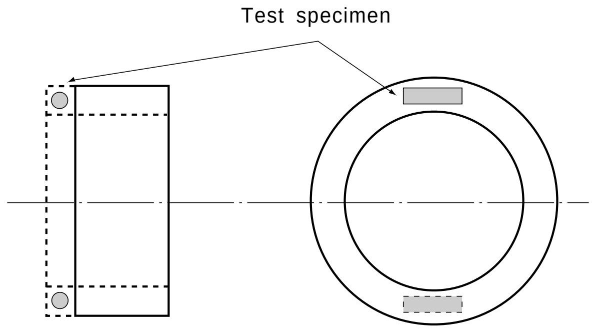


Fig. 2.1.18 Selection of Test Specimen for Rim

forging direction.

(b) Where the weight and finished diameter are different from those given in (a), one set of test specimens may be taken from one end of the rim.

(c) Where a number of separate forgings, each of which is not exceeding 250 kg in weight, are made from the same ingot (or bloom) and heat treated simultaneously, one set of test specimens is to be taken from every two rims at least, in accordance with (b).

(3) Where gears are to be subjected to the surface hardening, the detailed information relating to manufacturing is to be submitted and the test procedure is to be approved by the Society before the work is commenced. In this case, a preliminary test is to be carried out where deemed necessary by the Society.

(4) The gears specified in (1) to (3) are to be subjected to the following hardness tests:

(a) *Non-surface-hardened gears*: Four hardness test are to be made at equal distances round the circumference prior to machining the gear teeth. Where the width of the toothed portion is exceeding 500 mm, hardness tests are to be made at each end of the toothed portion.

(b) *Surface-hardened gears*: Hardness test are to be made on the surface of gear teeth when surface hardening has been completed.

(c) The values of hardness are to be approved by the Society.

18. Surface hardening treatment

Where the surface of steel forgings is hardened by induction hardening, nitriding, cold rolling or other methods, the above hardening methods are to be approved by the Society.

602. Stainless steel forgings

1. Application

(1) The requirements are to apply to the stainless steel forgings for valves and pipe fittings in piping systems used at low temperature (–165°C and over in design temperature) service or corrosion-resisting service (hereinafter referred to as “steel forgings”).

(2) Steel forgings having characteristics differing from those specified in **602.** are to comply with the requirements in **101.2.**

2. Kinds

Steel forgings are classified as specified in **Table 2.1.81.**

3. Heat treatment

Steel forgings are generally to receive a solid solution treatment.

4. Chemical composition

The chemical composition of steel forgings is to comply with the requirements given in **Table 2.1.81.**

5. Mechanical properties

(1) The mechanical properties of steel forgings are to comply with the requirements given in **Table 2.1.82.**

(2) Where deemed necessary by the Society, impact test or corrosion resistance test may be required in addition to the specified tests.

6. Selection of the specimens

(1) The number of tensile test specimens is to be in accordance with the requirements in **601.7.**

(2) Tensile test specimens are to be taken with their longitudinal axes parallel to the direction of forging, unless otherwise specially provided by the Society.

(3) Where tests are made in accordance with the requirements in **601.7** (3) (c) and (d), the Surveyor may require hardness test for each forging.

7. Marking

Steel forgins which have satisfactorily complied with the required test are to be marked with the identification mark in accordance with the requirements in **110.**

603. Steel forgings for chains

1. Application

(1) The requirements are to apply to the steel forgings intended to be used for shackle, swivel, e of chains specified in **Pt 4, Ch 8** (hereinafter referred to as “steel forgings”).

(2) Steel forgings having characteristics differing from those specified in (1) are to comply with the requirements in **101.2.**

(3) In addition to the requirements given in **603.**, general requirements may be considered by the Society.

2. Kinds

The steel forgings are classified as specified in **Table 2.1.83.**

Table 2.1.81 Grade sand Chemical Composition

Grade	Chemical composition (%)							
	C	Si	Mn	P	S	Cr	Ni	Others
RSSF304	0.08 max.	1.00 max.	2.00 max.	0.040 max.	0.030 max.	18.00~20.00	8.00~12.00	—
RSSF304L	0.030 max.							
RSSF309S	0.08 max.					22.00~24.00	12.00~15.00	
RSSF310S						24.00~26.00	19.00~22.00	
RSSF316						16.00~18.00	10.00~14.00	Mo 2.00~3.00
RSSF316L	0.030 max.							Mo 2.00~3.00
RSSF317	0.08 max.					18.00~20.00	10.00~15.00	Mo 3.00~4.00
RSSF321						17.00~19.00	9.00~12.00	Ti ≥ 5 × C
RSSF347							9.00~13.00	Nb+Ta ≥ 10 × C

Table 2.1.82 Mechanical Properties

Grade	Tensile test			
	Yield strength(N/mm^2)	Tensile strength(N/mm^2)	Elongation(%)($L = 5.65\sqrt{A}$)	Reduction of area (%)
RSSF304L	175 min.	450 min.	37 min.	50 min.
RSSF316L				
Other forgings	205 min.	520 min.	37 min.	50 min.

3. Heat treatment

The steel forgings are to be normalized, quenched and tempered or heat treated by the process approved by the Society.

4. Deoxidation practice and chemical compostion

The deoxidation practice and chemical composition of each grade are to comply with the requirements given in **Table 2.1.84.** Elements other than specified in **Table 2.1.84** may be added subject to a special approval by the Society.

5. Mechanical properties

The mechanical properties of each grade are to comply with the requirements given in **Table 2.1.85.**

6. Selection of test specimens

(1) One test sample is to be selected from each lot of every 25 steel forgings or fraction thereof, which belong to the same heat. In case of steel forgings having small diameter, the number of test samples may be reduced subject to approval of the Society. Where specially approved by the Society, the test sample may be taken from the representative part of the steel forging at a proper time during manufacturing, or a separate sample forged to the forge ratio equivalent to that of the steel forgings. In this case, the test sample is to be heat treated simultaneously with the steel forgings.

(2) For Grade 1 and Grade 2 chain bars, one tensile test specimen is to be taken from the test sample; for Grade 3 chain bars, one tensile test specimen and one set (3 pieces) of impact test specimens are to be taken from the test sample.

(3) The tensile and impact test specimens are to be taken from the test sample in the direction of forging at a depth of 1/6 diameter from the surface or as close as possible to this position (see **Fig. 2.1.5**)

7. Surface inspection

Surface inspection for all grades is to be carried out and it is to be confirmed that there are no harmful defects.

8. Non-destructive inspection

For grades *RSFCR*3, *RSFCR*3*S* and *RSFCR*4, all steel forgings are subjected to ultrasonic test at an appropriate stage of the manufacture and it is to be confirmed that there are no harmful defects.

9. Retest procedure

Where the tensile test or impact test on the selected first test specimens fails to meet the requirements, additional tests may be carried out according to the requirements given in **306.7.**

10. Marking

Steel forgings which have satisfactorily complied with the required tests are to be marked with the identification mark in accordance with the requirement in **110.**

Table 2.1.83 Grades of Steel Forgings

Grade		Application
Steel forging for Grade 1 chain	*RSFC*31	Unstudded chain
		Grade 1 chain
Steel forging for Grade 2 chain	*RSFC*50	Grade 2 chain
Steel forging for Grade 3 chain	*RSFC*70	Grade 3 chain
Steel forging for Grade *R*3 chain	*RSFCR*3	Grade *R*3 chain
Steel forging for Grade *R*3*S* chain	*RSFCR*3*S*	Grade *R*3*S* chain
Steel forging for Grade *R*4 chain	*RSFCR*4	Grade *R*4 chain

604. Steel forgings for low temperature service

1. Application

(1) The requirements are to apply to the steel forgings for valves and pipe fittings in piping systems intended to be used at the design temperature lower than 0°C in liquefied gas carriers (hereinafter referred to as “steel forgings”).

Table 2.1.84 Deoxidation Practice and Chemical Composition (%)

Grade	Deoxidation	C	Si	Mn	P	S	Al(1)
RSFC 31	Killed	0.20 max.	0.15~0.35	0.40 min.	0.040 max.	0.040 max.	–
RSFC 50	Fine-grained killed	0.24 max.	0.15~0.55	1.60 max.	0.035 max.	0.035 max.	0.020 min.
RSFC 70		0.36 max.	0.15~0.55	1.00~1.90	0.035 max.	0.035 max.	0.020 min.
RSFCR 3	Fine-grained killed	(2)(3)					
RSFCR 3 *S*							
RSFCR 4							

NOTE:
(1) Al content is to be represented by the total Al content and may be replaced partly by other fine graining elements.
(2) Detailed chemical composition is to be approved by the Society.
(3) For Grade *RSFCR*4, the steel should contain a minimum of 0.2% molybdenum.

Table 2.1.85 Mechanical Properties

Grade	Tensile test				Impact test (1)	
	Yield strength (N/mm^2) (2)	Tensile strength (N/mm^2) (2)	Elongation (%) ($L=5d$)	Reduction of area (%)	Test temp. (°C)	Average absorbed energy (J)
RSFC 31	–	370~490	25 min.	–	–	–
RSFC 50	295 min.	490~690	22 min.	–	–	–
RSFC 70	410 min.	690 min.	17 min.	40 min.	0	60 min.
RSFCR 3	410 min.	690 min.	17 min.	50 min.	– 20(3)	40 min.(3)
RSFCR 3 *S*	490 min.	770 min.	15 min.	50 min.	– 20(3)	45 min.(3)
RSFCR 4	580 min.	860 min.	12 min.	50 min.	– 20	50 min.

NOTE:
(1) When the absorbed energy of two or more test specimens among a set of test specimens is less in value than the specified average absorbed energy or when the absorbed energy of a single test specimen is less in value than 70% of the specified average absorbed energy, the test is considered to have failed.
(2) The yield ratio (the aim value of yield to tensile ratio) for grade *RSFCR*3, *RSFCR*3*S*, or *RSFCR*4 is to be maximum 0.92.
(3) Impact test of grade *RSFCR*3 and *RSFCR*3*S* may be carried out at the temperature of 0°C where approved by the Society. In this case, minimum mean absorbed energy is to be not less than 60*J* for grade *RSFCR*3 and 65J for grade *RSFCR*3*S*.

Table 2.1.86 Grades and Chemical Composition

Grade	Deoxidation	Chemical composition (%)								
		C	Si	Mn	P	S	Ni	Cr	Cu	Al
RLFA	Fully killed fine grain	0.23 max.	0.15~0.35	1.10 max.	0.030 max.	0.030 max.	—	—	—	—
RLFB		0.20 max.	0.15~0.35	1.60 max.						
RLFC		0.12 max.	0.10~0.35	0.55~1.00			0.50~0.95	0.50~0.95	0.40~0.75	0.04~0.30
*RLF*3		0.20 max.	0.15~0.35	0.90 max.			3.25~3.75	—	—	—
*RLF*9		0.10 max.	0.10~0.35	0.90 max.			8.50~9.60			

(2) Steel forgings other than those specified in **604.** are to comply with the requirements given in **101.2.**

2. Kinds

The steel forgings are classified as given in **Table 2.1.86.**

3. Heat treatment

The steel forgings are to be normalized, normalized and tempered, quenched and tempered or double normalized and tempered.

4. Deoxidation practice and chemical composition

The deoxidation practice and chemical composition of each grade are to comply with the requirements given in **Table 2.1.86.**

5. Mechanical properties

(1) The mechanical properties of steel forgings are to comply with the requirements given in **Table 2.1.87.**
(2) Where deemed necessary by the Society, other tests may be required in addition to the tests specified in (1).

6. Selection of tests specimens

(1) The number of test specimens is to be in accordance with the requirements specified in **601.7.**
(2) The test specimens for tensile and impact tests are to be cut with their longitudinal axes parallel to the direction of forging except where otherwise specially specified.
(3) Where tests are made in accordance with the requirements in **601.7** (3) (c) and (d), the Surveyor may require a hardness test for each forging.

7. Retest procedures

(1) Where the tensile tests fail to meet the requirements, additional tests may be carried out according to the requirements given in **109.**
(2) Regarding the impact tests, additional tests are to be carried out according to the requirements given in **304.9** (2).

8. Marking

Marking for steel castings is to comply with the requirements given in **601.13** (1) and in case the requirement in Note (1) of **Table 2.1.87.** has been applied, "impact test temperature *T*" is to be suffixed to the marking (e.g. *RLFA* - 25*T*)

Table 2.1.87 Mechanical Properties

Grade	Tensile test				Impact test [2]	
	Yield strength (N/mm^2)	Tensile strength (N/mm^2)	Elongation (%) ($L = 5.65\sqrt{A}$)	Reduction of area (%)	Test temp. (°C)	Average absorbed energy (J)
$RLFA$	205 min.	410 min.	23 min.	40 min.	− 40[1]	27 min.
$RLFB$	275 min.	490 min.	20 min.		− 50[1]	
$RLFC$	205 min.	410 min.	23 min.		− 60[1]	
$RLF\,3$	275 min.	490 min.	23 min.	50 min.	− 95	34 min.
$RLF\,9$	520 min.	680 min.	19 min.	45 min.	− 196	41 min.

NOTES:
(1) Impact test temperature for steel forgings specified in **Pt 7, Ch 5** is to be 5°C below the design temperature or –20°C, Whichever is the lower.
(2) When the absorbed energy of two or more test specimens among a set of test specimens is less in value than the specified average absorbed energy or when the absorbed energy of a single test specimen is less in value than 70% of the specified average absorbed energy, the test is considered to have failed.

SECTION 7
Copper and Copper Alloy

701. Copper and copper alloy pipes and tubes

1. Application

(1) The requirements are to apply to the copper and copper alloy pipes and tubes.
(2) Copper and copper alloy pipes and tubes are to comply with the requirements in *KS D* 5301 or equivalent thereto.
(3) Copper and copper alloy pipes and tubes having characteristics differing from those specified in **701.** are to comply with the requirements in **101.2.**

2. Kinds

Copper and copper alloy pipes and tubes are classified as specified in **Table 2.1.88.**

3. Mechanical properties

The mechanical properties of copper and copper alloy pipes and tubes are to comply with the requirements given in **Table 2.1.89.**

4. Testing and inspection

Testing and inspection of pipes and tubes are to com ply with the requirements specified in *KS D* 5301. Those subjected to the maximum working pressure not exceeding 1 MPa may not require the presence of the Society's Surveyor.

5. Marking

Copper and copper alloy pipes and tubes which have satisfactorily complied with the required tests are to be marked with the identification mark in accordance with the requirements in **110.**

702. Copper alloy castings

1. Application

(1) These requirements are to apply to the copper alloy castings to be used for propellers and propeller blades (hereinafter referred to as "propeller castings").
(2) Copper alloy castings to be used for important parts differing from those specified in **702.** are to comply with the requirements of *KS* or equivalent thereto. The tests and inspections need not in general to be made in the presence of the Surveyor except where special requirements are given in connection with the design.

Table 2.1.88 Kinds and Grades

Kinds		Grades
Copper pipes and tubes.	Phosphorus deoxidized copper seamless pipes and tubes.	*C* 1201, *C* 1220
Copper alloy pipes and tubes	Brass seamless pipes and tubes	*C* 2600, *C* 2700, *C* 2800
	Brass seamless pipes and tubes for condenser	*C* 4430, *C* 6870, *C* 6871, *C* 6872
	Cupro-nickel seamless pipes and tubes for condenser	*C* 7060, *C* 7100, *C* 7150

Table 2.1.89 Mechanical Properties

Kinds	Grade	Tensile test	
		Tensile strength (N/mm^2)	Elongation (%)
Phosphorus deoxidized copper seamless pipes and tubes.	*C* 1201 *C* 1220	206 min.	40 min.
Brass seamless pipes and tubes	*C* 2600	275 min.	45 min.
	C 2700	294 min.	40 min.
	C 2800	314 min.	35 min.
Brass seamless pipes and tubes for condenser	*C* 4430	314 min.	30 min.
	C 6870 *C* 6871 *C* 6872	373 min.(1)	40 min.
		353 min.(2)	40 min.
Cupro-nickel seamless pipes and tubes for condenser	*C* 7060	275 min.	30 min.
	C 7100	314 min.	30 min.
	C 7150	363 min.	30 min.

NOTES:
(1) It is applicable to those having 5 mm and up to 50 mm in outside diameter.
(2) It is applicable to those having over 50 mm up to 200 mm in outside diameter.

(3) Copper alloy castings characteristics differing from those specified in **702.** are to comply with the requirements in **101.2.**

2. Kinds

Propeller castings are classified as specified in **Table 2.1.90.**

Table 2.1.90 Kinds and Gredes

Kinds	Grade
High strength brass casting, Grade 1	RHB_SC 1
High strength brass casting, Grade 2	RHB_SC 2
Aluminium bronze casting, Grade 3	$RAlBC$ 3
Aluminium bronze casting, Grade 4	$RAlBC$ 4

3. Heat treatment

Heat treatment is to be as deemed appropriate by the Society

4. Chemical composition

The chemical composition of propeller castings is to comply with the requirements given in **Table 2.1.91.**

5. Mechanical properties

Mechanical properties of propeller castings are to comply with the requirements in **Table 2.1.92.**

6. Test sample

The test samples may be separately cast or integral with any blade surface. Separately-cast test samples are to be poured from the same ladle of metal used for the castings in the presence of the Surveyor. In case where more than one ladle of metal is required for a castings, a test sample is to be provided for each ladle. Shapes of the moulds for separately-cast test samples are to comply with, as a rule, the requirements of *KS D* 6007 and other *Korean Industrial Standard* and the moulds are to be of the same material as used for the casting.

Table 2.1.92 Mechanical Properties

Grade	Yield strength[(1)] (N/mm^2)	Tensile strength (N/mm^2)	Elongation (%) (L=5 d)
RHB_SC 1	175 min.	440 min.	20 min.
RHB_SC 2	175 min.	440 min.	20 min.
$RAlBC$ 3	245 min.	590 min.	16 min.
$RAlBC$ 4	275 min.	630 min.	18 min.

NOTE:
(1) Yield point or 0.2% proof stress is applicable to the case which is specially required relating to the design.

7. Selection of test specimens

One tensile test specimen is to be taken from each casting when integral test samples are provided and one tensile test specimen is to be taken from each ladle when separately-cast test samples are provided.

8. Surface inspection

Propeller castings are to be subjected to the surface inspection at the final process.

9. Quality

Propeller castings are to be of uniform quality and free from harmful defects.

10. Non-destructive inspection

The important parts of propeller castings are to be inspected by non-destructive inspections such as liquid penetrant test, etc.

11. Repair of defects

(1) In the event of finding defects in the propeller castings, the defects may be removed by grinding, etc.
(2) After removing the defects, adequate non-destructive inspections are to be carried out to ensure that all defects have been completely removed.
(3) Where the propeller castings from which defects where removed are used in that condition or after repaired by welding, the propeller castings are to be approved by the Surveyor. But, no repair welding is to be permitted in the blade roots at the pressure side of propeller castings.
(4) After weld repairs, the portions repaired by welding are to be subjected to the stress-relieving treatments.
(5) It is to be confirmed that the portions repaired by welding are free from harmful defects by the non-destructive inspections such as liquid

Table 2.1.91 Chemical Composition (%)

Grade	Cu	Al	Mn	Zn	Fe	Sn	Ni	Pb
RHB_SC 1	52~62	0.5~3.0	0.5~4.0	35~40	0.5~2.5	0.1~1.5	1.0 max.	0.5 max.
RHB_SC 2	50~57	0.5~2.0	1.0~4.0	33~38	0.5~2.5	0.15 max.	3.0~8.0	0.5 max.
$RAlBC$ 3	77~82	7.0~11.0	0.5~4.0	1.0 max.	2.0~6.0	0.1 max.	3.0~6.0	0.03 max.
$RAlBC$ 4	70~80	6.5~9.0	8.0~20.0	6.0 max.	2.0~5.0	1.0 max.	1.5~3.0	0.05 max.

penetrant test, etc.

12. Retest procedure

Where the results of tensile tests fail to meet the requirements, additional test may be carried out in accordance with the requirements of **109.**

13. Marking

Propeller castings which have satisfactorily complied with the required tests are to be marked with the identification mark in accordance with the requirements in **110.**

SECTION 8
Aluminium Alloys

801. Aluminium alloys

1. Application

(1) These requirements are to apply to the aluminium alloy plates and extruded shapes(hereinafter referred to as "aluminium alloys") intended to be used in the construction of hulls, superstructures, other marine structures and tanks of liquefied gas carriers.

(2) Where aluminium alloys exceeding the maximum value of plate thickness or size specified in **Table 2.1.94** and **Table 2.1.95.** are manufactured, a new approval test is required by the Society.

(3) Aluminium alloys having characteristics differing from those specified in **801.** are to comply with the requirements in **101.2.**

2. Kinds

The aluminium alloys are classified as specified in **Table 2.1.93.**

3. Chemical composition

The chemical composition of aluminium alloys is to comply with the requirements given in **Table 2.1.93.**

4. Heat treatment

The heat treatment(hereinafter referred to as "temper condition") of the aluminium alloys is to comply with the requirements given in **Table 2.1.94** and **Table 2.1.95.**

5. Mechanical properties

(1) The mechanical properties in tension tests are to comply with the requirements given in **Tables 2.1.94.** and **2.1.95.**

(2) Where deemed necessary by the Society, other tests may be required in addition to the specified tests.

6. Selection of test samples

(1) For test samples for rolled products, if the weight of one lot exceeds 2 tonnes, one extra test specimen is to be taken from every 2 tonnes of the product or fraction thereof, in each lot except where specially approved by the Society.
One lot is made up of rolled products of the same alloy and from the same cast, of the same thickness, manufactured by the same process and having been submitted simultaneously to the same temper condition.
For single plate or coil weighting more than 2 tonnes each, one lot is made up of a single plate or coil.

(2) For test samples for extruded shapes with a nominal weight of less than 1*kg/m*, except where specially approved by the Society, one test specimen is to be taken from each 1 tonne, or fraction thereof, in each lot. For nominal weights between 1 and 5 *kg/m*, one test specimen is to be taken from each 2 tonnes or fraction hereof, in each lot. If the nominal weight exceeds 5 *kg/m*, one test specimen is to be taken for each 3 tonnes of the product

Table 2.1.93 Chemical Composition

<table>
<tr><th rowspan="3">Grades</th><th colspan="11">Chemical composition(%)</th></tr>
<tr><th rowspan="2">Si</th><th rowspan="2">Fe</th><th rowspan="2">Cu</th><th rowspan="2">Mn</th><th rowspan="2">Mg</th><th rowspan="2">Cr</th><th rowspan="2">Zn</th><th rowspan="2">Ti</th><th colspan="2">Others(1)</th><th rowspan="2">Al</th></tr>
<tr><th>Each</th><th>Total</th></tr>
<tr><td>5083P
5083S</td><td rowspan="3">0.40 max.</td><td>0.40 max.</td><td rowspan="3">0.10 max.</td><td>0.40～1.0</td><td>4.0～4.9</td><td rowspan="2">0.05～0.25</td><td rowspan="2">0.25 max.</td><td rowspan="3">0.15 max.</td><td rowspan="6">0.05 max.</td><td rowspan="6">0.15 max.</td><td rowspan="6">Remainder</td></tr>
<tr><td>5086P
5086S</td><td>0.50 max.</td><td>0.20～0.7</td><td>3.5～4.5</td></tr>
<tr><td>5754P(2)</td><td>0.40 max.</td><td rowspan="2">0.50 max.</td><td>2.6～3.6</td><td rowspan="2">0.30 max.</td><td rowspan="2">0.20 max.</td></tr>
<tr><td>6005AS(3)</td><td>0.50～0.9</td><td>0.35 max.</td><td>0.30 max.</td><td>0.40～0.7</td><td>0.10 max.</td></tr>
<tr><td>6061P
6061S</td><td>0.40～0.8</td><td>0.7 max.</td><td>0.15～0.40</td><td>0.15 max.</td><td>0.8～1.2</td><td>0.04～0.35</td><td>0.25 max.</td><td>0.15 max.</td></tr>
<tr><td>6082S</td><td>0.7～1.3</td><td>0.50 max.</td><td>0.10 max.</td><td>0.40～1.0</td><td>0.6～1.2</td><td>0.25 max.</td><td>0.20 max.</td><td>0.10 max.</td></tr>
</table>

(Notes)
(1) When the existence of the other elements is presumed in the course of routine analysis, further analysis thereof is to be conducted.
(2) $0.10 \leq Mn + Cr \leq 0.60$
(3) $0.12 \leq Mn + Cr \leq 0.50$

Table 2.1.94 Mechanical Properties for Rolled Products

Grades	Temper condition(2)	Thickness, t (mm)	Tensile test		
			Yield strength (N/mm^2)	Tensile strength (N/mm^2)	Elongation(%)(3) (L = 5.65 $\sqrt{A}$)
5083P	O	$t \leq 50$	125 $min.$	275 ～ 350	15 $min.$
		$50 < t \leq 80$	120 ～ 195	275 ～ 345	14 $min.$
		$80 < t \leq 100$	110 $min.$	265 $min.$	
		$100 < t \leq 120$		260 $min.$	12 $min.$
		$120 < t \leq 160$	105 $min.$	255 $min.$	
		$160 < t \leq 200$	100 $min.$	250 $min.$	10 $min.$
	H111	$t \leq 50$	125 $min.$	275 ～ 350	15 $min.$
	H112			275 $min.$	10 $min.$
	H116		215 $min.$	305 $min.$	
	H32			305 ～ 380	9 $min.$
	H321	$t \leq 50$			
		$50 < t \leq 80$	200 ～ 295	285 ～ 380	
5086P	O	$t \leq 50$	100 $min.$	240 ～ 310	16 $min.$
	H111				
	H112	$t \leq 12.5$	125 $min.$	250 $min.$	-
		$12.5 < t \leq 50$	105 $min.$	240 $min.$	9 $min.$
	H116	$t \leq 50$	195 $min.$	275 $min.$	
	H32		185 $min.$	275 ～ 335	
	H321				
5754P	O	$t \leq 50$	80 $min.$	190 ～ 240	17 $min.$
	H111				
6061P	T6	$t \leq 6.5$	245 $min.$	295 $min.$	-

(Notes)

(1) Aluminium alloy may be subject to any other standards in lieu of the requirements given in this Table where they are approved by the Society.

(2) Symbols used in temper condition are as follows :

O : Annealing
H111 : Work hardened
H112 : Work hardened
H116 : Stabilizing treatment after work hardened
H32 : Stabilizing treatment after work hardened
H321 : Stabilizing treatment after work hardened
T6 : Artificial age hardening treatment after solution treatment

(3) The standards for elongation given in this Table applies to the tensile test using the proportional specimen for aluminium alloys whose thickness is more than 12.5 mm. Where test specimens other than the proportional specimens are applied to the tensile test or thickness of aluminium alloys is not more than 12.5 mm, the standards for elongation is subject to the discretion of the Society.

or fraction thereof, in each lot.
One lot is made up of rolled products of the same alloy and from the same cast, of the same dimension, manufactured by the same process and having been submitted simultaneously to the same temper condition.

(3) Test samples are to be taken out of the place at one third of the width from a longitudinal edge of rolled products, or in the range 1/3 to 1/2 of the distance from the edge to the centre of the thickest part of extruded products.

7. Selection of test specimens

Tensile test specimens are to be taken according to (1) to (4) below.

(1) One test specimen is to be taken out of each test sample.

(2) For rolled products, the longitudinal axis of the test specimen is to be taken transversely to the rolling direction. If the width is insufficient to obtain transverse test specimen or in the case of strain hardening alloys, however, the longitudinal direction may be taken parallel to the rolling direction.

(3) For extruded shapes, the longitudinal axis of the test specimen is to be taken parallel to the extruding direction.

(4) For thickness of test sample up to and including 40 mm, the longitudinal axis of the test specimen is to be located at a distance from the surface equal to half of the thickness. For thickness of test sample over 40 mm, the longitudinal axis of the test specimen is to be located at a distance from one of the surfaces equal to one quarter of the thickness.

8. Surface inspection and dimensional tolerance

Table 2.1.95 Mechanical Properties for Extruded Shapes

Grades	Temper condition(2)	Thickness, t (mm)	Tensile test		
			Yield strength (N/mm^2)	Tensile strength (N/mm^2)	Elongation (%)(3) (L = 5.65 $\sqrt{A}$)
5083*S*	O	$t \leq 50$	125 *min.*	270 *min.*	12 *min.*
		$50 < t \leq 130$	110 *min.*	275 ~ 355	
	H111	$t \leq 50$	110 *min.*	270 *min.*	
	H112		125 *min.*		
5086*S*	O	$t \leq 50$	95 *min.*	240 ~ 320	16 *min.*
	H111				
	H112			240 *min.*	12 *min.*
6005*AS*	T5	$t \leq 50$	215 *min.*	260 *min.*	6 *min.*
	T6				
6061*S*	T5	$t \leq 50$	240 *min.*	260 *min.*	8 *min.*
	T6				
6082*S*	T5	$t \leq 50$	260 *min.*	310 *min.*	8 *min.*
	T6				

(Notes)
(1) Aluminium alloy may be subject to any other standards in lieu of the requirements given in this Table where they are approved by the Society.
(2) Symbols used in temper condition are as follows :
O : Annealing
H111 : Work hardened
H112 : Work hardened
T5 : Artificial age hardening treatment after elevated temperature working and succeeding cooling
T6 : Artificial age hardening treatment after solution treatment
(3) The standards for elongation given in this Table applies to the tensile test using the proportional specimen for aluminium alloys whose thickness is more than 12.5 mm. Where test specimens other than the proportional specimens are applied to the tensile test or thickness of aluminium alloys is not more than 12.5 mm, the standards for elongation is subject to the discretion of the Society.

Table 2.1.96 Underthickness Tolerance for Rolled Products

Nominal thickness, t (mm)	Nominal width W (mm)		
	$W < 1500$	$1500 \leq W < 2000$	$2000 \leq W < 3500$
	Underthickness tolerance (mm)		
$3 \leq t < 4$	0.10	0.15	0.15
$4 \leq t < 8$	0.20	0.20	0.25
$8 \leq t < 12$	0.25	0.25	0.25
$12 \leq t < 20$	0.35	0.40	0.50
$20 \leq t < 50$	0.45	0.50	0.65

(1) Surface inspection and verification of dimensions are left to the responsibility of the manufacturer.
(2) The underthickness tolerances are to comply with the requirements given in **Table 2.1.96** and **2.1.97.**
(3) Dimensional tolerance except those specified in (2) above is left to the discretion of the Society.

9. Quality

(1) Aluminium alloys are to be of uniform quality and free from internal and surface harmful defects prejudicial to the use of the concerned material for the intended application.
(2) Slight surface imperfections may be removed by smooth grinding or machining as long as the thickness of the materials remains within the tolerances given in **Table 2.1.96** and **2.1.97.**

10. Retest procedures

(1) When the tensile test from the first piece selected fails to meet the requirements given in **Table 2.1.94** and **2.1.95**, two further tensile tests may be made from the same piece. If both of these additional tests meet all of the requirements, the piece and the remaining

Table 2.1.97 Underthickness Tolerance for Extruded Shapes

Nominal thickness, t (mm)	A diameter of the circumscribing circle, D (mm)		
	$D < 250$	$250 \leq D < 400$	$400 \leq D$
	Underthickness tolerance (mm)		
$3 \leq t < 6$	0.25	0.35	0.40
$6 \leq t < 50$	0.30	0.40	0.45

pieces from the same lot may be accepted.

(2) If one or both of the additional tests referred to above (1) are unsatisfactory, the piece is to be rejected. However, the remaining materials from the same lot may be accepted provided that two of the remaining pieces in the lot selected in the same way, are tested with satisfactory results.

11. Marking

Aluminium alloys which have satisfied with the required tests are to be marked with the identification mark in accordance with the requirements in **110. 1**. In this case, the mark of temper conditions is to be put subsequent to the mark of material grade. ⚓

CHAPTER 2
WELDING

Section

SECTION 1
General

101. Application

1. Welding to be used in hull construction and important equipment is to be in accordance with the requirements in this Chapter unless otherwise specified.

2. The welding in boiler, pressure vessel, main engine, auxiliary engine and pipe arrangement is to be in accordance with the requirements in **Pt 5, Chs 2, 5** and **6** except where prescribed in this Chapter.

102. Matters to be approved

1. The welding is to be carried out in accordance with the procedures previously approved, with the electrodes, the wire and flux (hereinafter referred to as welding consumables") or equivalent materials and by the welders qualified by the Society.

2. Where deemed appropriate by the Society, National Standards, internationally recognized Codes or Standards considered as equivalent for those may be applied instead of requirements of this Chapter.

103. Special weldings

Where special welding and material not complied with the requirements in this Chapter is used, the welding procedures and the welding consumables are to be specially approved by the Society.

SECTION 2
Test Specimens and Testing Procedures

201. General

1. Test specimens and mechanical testing procedures specified in this Chapter for welding procedure qualification tests, welders and qualification tests, approval test and periodical inspection of welding consumables are to comply with the requirements in this Section.

2. Where specimens and mechanical testing procedures differing from those prescribed in this Section are used, they are to be approved by the Society.

202. Selection of test specimens

1. Test specimens are to be selected according to respective requirements in each Section.

2. Except where otherwise specified or agreed with the Surveyor, test specimens are not to be detached from the test assembly until having been stamped by the Surveyor.

3. If test specimens are cut from test assemblies by flame cutting or shearing, a reasonable margine is required to enable sufficient material to be removed from the cut edges during final machining.

4. The preparation of test specimens is to be done in such a manner that test specimens are not subjected to any significant cold straining or heating.

5. If any test specimen shows defective machining or defects having no relation to the substantial nature, it may be discarded and substituded by another test specimen.

203. Size and dimensions of test specimens

1. Tensile test specimens

(1) Tensile test specimens are to be of size and dimensions given in **Table 2.2.1,** and the both ends of the test specimen may be machined to such a shape as to fit the holder of the testing machine.
(2) The upper and lower surfaces of weld are to be filed, ground or machined flush with the surface of plate.
(3) When the capacity of the available testing machine does not permit testing the full thickness specimen, two or more thinner than full thickness specimens may be prepared by cutting the full thickness specimens into section, each of which is to meet the requirements.

2. Bend test specimens

(1) Bend test specimens are to be of size and dimensions given in **Table 2.2.2** according to the kind of test assemblies.
(2) Where the thickness of test assemblies is greater than the thickness of the bend test specimen prescribed in **Table 2.2.2,** the face bend or root bend specimen may be machined on its compression side.
(3) Reinforcements and back straps are to be ma chined flush with base metal.

3. Impact test specimens

Impact test specimens are to be $R4$ specimens specified in **Ch 1, 202.3** and to be of size and dimensions given in **Fig. 2.1.3, Tables 2.1.3** and **2.1.4.**

4. Confirmation for test specimens

The size and dimensions of test specimens are to be carefully inspected and verified by suitable means before testing

204. Mechanical testing procedures

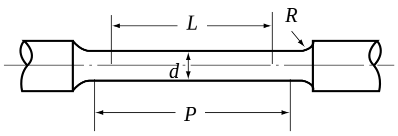
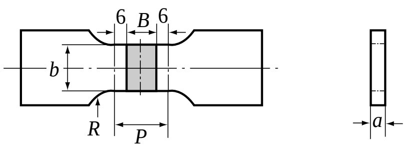
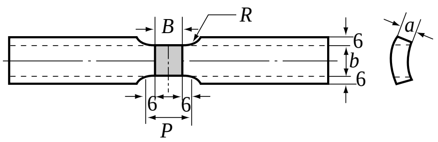
1. Tensile test and impact test

Tensile tests and impact tests are to be carried out in accordance with the procedures prescribed in **Ch 1, 203.**

2. Bend test

(1) Except where guided bend tests are required, bend test is roller bend test carried out by the jig of which the plunger has a bending radius specified in each Section with supporting rollers adjustable for their spans.
(2) Guided bend test jigs are to be as shown in **Figs. 2.2.1** and **2.2.2.**
(3) Roller bend test jigs are to be as shown in **Fig. 2.2.3.**

Table 2.2.1 Size and Dimensions of Tensile Test Specimens (Unit : mm)

Type	Size of specimen	Dimensions	Intended for
$R14A$		d = 10 L = 50 P = 60 $R \geq 5$ Alternatively. L = 5d P = 6d $R \cong 12$	Deposited metal tensile test Longitudinal tensile test
$R10$		t = 12 / t = 19~25 d = 6.0 / d = 12.5 L = 24 / L = 50 P = 32 / P = 60 $R \cong 6$ / $R \cong 15$	Deposited metal tensile test(Welding consumables for stainless steel)
$R2A$		a = t b = 30 P = B + 12 $R \geq 50$ a = t b = 30 P = B + 2t or 3t. Whichever is the greater $R \geq 25$ The weld to be machined (or ground) flush with the surface of the plate	Butt weld tensile test for plate
$R2B$		a = t $t \leq 25$, / t 〉 25 b = 38, / b = 25 P = B + 12 $R \geq 50$	Butt weld tensile test for pipe

NOTE:
The notations used are defined as follows:
- d : Diameter
- a : Thickness
- b : Width
- L : Gauge length
- P : Parallel test length
- B : Width of weld
- R : Transition radius
- t : Thickness of material

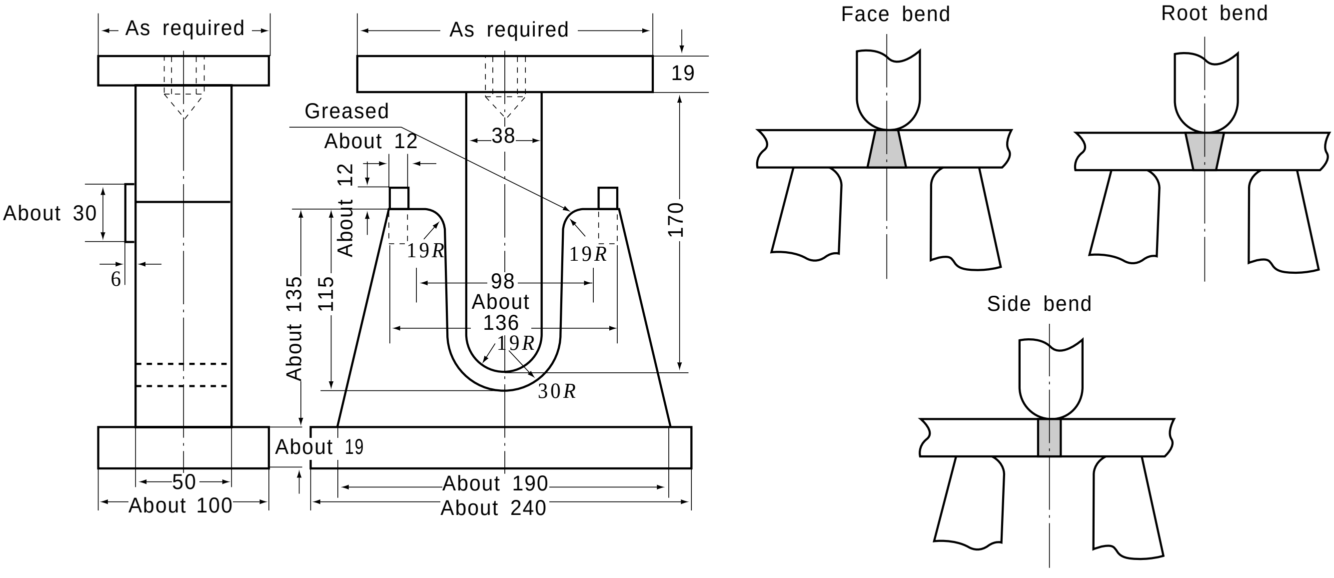


Fig. 2.2.1 Guided Bend Test Jig (For 9 mm in thick., Unit : mm)

Table 2.2.2 Size and Dimensions of Bend Test Specimens (Unit : *mm*)

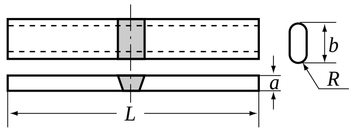
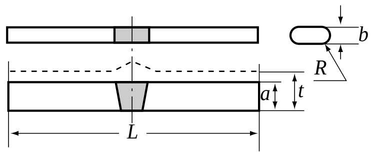
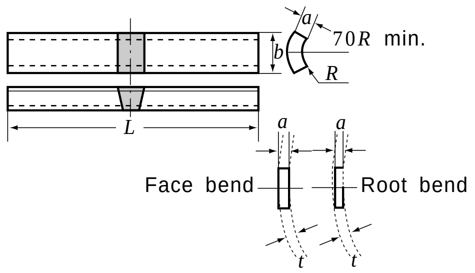
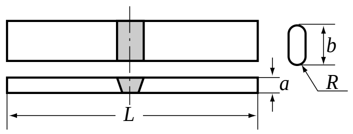
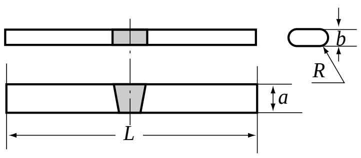
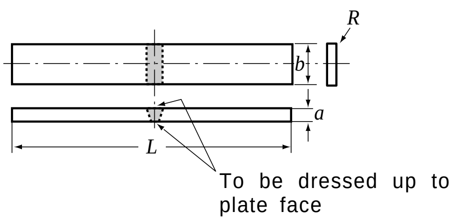
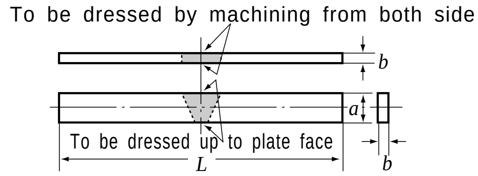
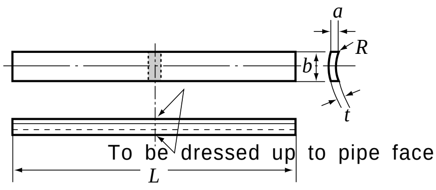
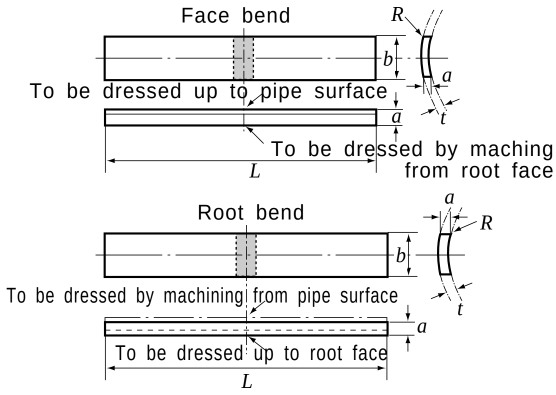
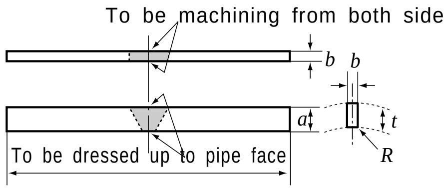
Used for		Type	Size of specimen	Dimensions[1]	Intended for
Welding procedure qualification tests	Face and root bend specimen	*RB*1		$t \leq 20$ $a = t$ $b = 30$ $L \geq 200$ $R = 1 \sim 2$	Butt weld bend test for plate Longitudinal bend test for plate[2]
Welding procedure qualification tests	Side bend specimen	*RB*2		$t > 20$ $a = t$ [3] $b = 10$ $L \geq 200$ $R = 1 \sim 2$	Butt weld bend test for plate or pipe
Welding procedure qualification tests	Face and root bend specimen	*RB*3		① $0 < t < 9$ $a = t$ $b = t + D/10$ $L \fallingdotseq 250$ $R \leq a/6$ ② $9 \leq t \leq 20$ $a = 9$ $b = 40$ $L \fallingdotseq 250$ $R \leq 1.5$	Butt weld bend test for pipe
Approval test and periodical inspection for welding consumables	Face and root bend specimen	*RB*4		$a = t$ $b = 30$ $L \geq 200$ $R \leq 1.5$ Where the thickness of test assemblies exceeds 25 *mm*, the thickness of test specimen may be reduced to 25 *mm* with its surface machined on one side only(compression side)	Butt weld bend test
Approval test and periodical inspection for welding consumables	Side bend specimen	*RB*5		$a = t$ $b = 10$ $L \geq 200$ $R \leq 1.5$	Butt weld bend test (welding materials for electro-slag and electro-gas)
Approval test and periodical inspection for welding consumables	Side bend specimen	*RB*6		$a = t$ $b = 9$ $L \geq 200$ $R \leq 1.5$	Butt weld bend test (MIG double side, one layer each, butt welding for aluminium alloy)
Welder's qualification test	Face and root bend specimen	*RB*7		$t < 9.5$ $a = t$ $b = 40$ $L \fallingdotseq 250$ $R \leq 1.5$	Butt weld bend test for pipe

Table 2.2.2 Size and Dimensions of Bend Test Specimens (Continued) (Unit : mm)

Used for		Type	Size of specimen	Dimensions	Intended for
Welder's qualification test	Side bend specimen	$RB8$		$t \geq 9.5$ $a = t^{(3)}$ $b = 9$ $L \fallingdotseq 150$ $R \leq 1.5$	Butt weld bend test for plate
	Face and root bend specimen	$RB9$		$t \leq 9.5$ $a = t$ $L \fallingdotseq 150$ $R \leq 1.5$ $b = 40$ $(D > 100)$ or $25(D \leq 100)$	Butt weld bend test for pipe
		$RB10$		$t > 9.5$ $a = 10$ $L \fallingdotseq 150$ $R \leq 1.5$ $b = 40$ $(D > 100)$ or $25(D \leq 100)$	
	Side bend specimen	$RB11$		$t \geq 9.5$ $a = t^{(3)}$ $b = 9$ $L \fallingdotseq 150$ $R \leq 1.5$	

NOTES:

(1) The following designations are used.

- a : Thickness
- b : Width
- R : Edge radius
- D : External pipe diameter
- t : Thickness of test assembly
- L : Length

(2) The specimen also applies to longitudinal bend test for welding consumables for 9% Ni steel. The width of Specimen, b, is to be B+12 where breath of weld, B, is 26 mm and over.

(3) For plates over 40mm thick, the side bend specimen may be subdivided, each part being at least 20 mm wide and each part may be tested.

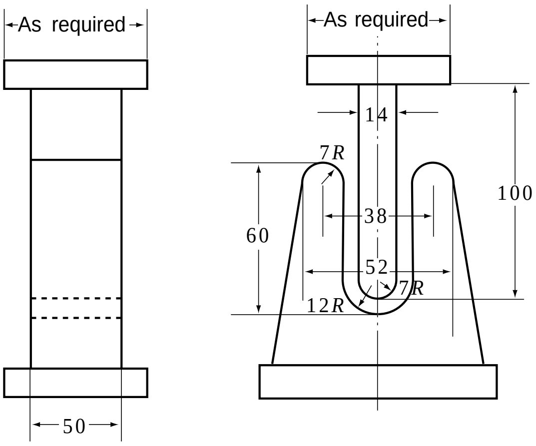
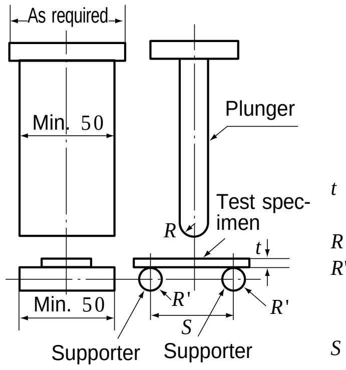


Fig. 2.2.2 Guided Bend Test Jig
(For 3.2 *mm* in thick., Unit : *mm*)



t : Thickness of test specimen
R : Radius of plunger
R' : Radius of supporting roller (not specified)
S : Span between Supports 2 (R + R'+ t + 2)

Fig. 2.2.3 Jigs for Roller Bend Test (Unit: *mm*)

SECTION 3
Welding Work and Inspection

301. Details of joints

1. Application

The details of joints for manual welding are to be in accordance with the following Paragraphs. For other welding procedures such as automatic welding and in case where the specified details of joint are deemed unpracticable, full details of joint are to be submitted for approval.

2. Butt joints

(1) In general, edge preparations of butt welds are to be as shown in **Fig. 2.2.4.**

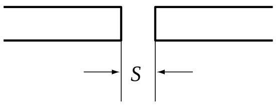
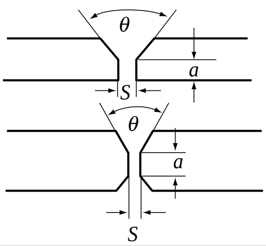
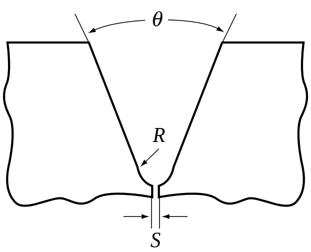
Thickness(mm)	Edge preparation	Dimensions
$t \leq 6.0$		$S \leq 3.0mm$
$t > 6.0$		$S \leq 5.0mm$ $a \leq 3.0mm$ $\theta \geq 50°$

Fig. 2.2.4 Edge preparation

(2) Butt welded joints of plates having difference over 4 mm in thickness are to be properly tapered at the end of thicker plate.

3. Butt joints of thick materials

The groove of thick materials, such as cast steel, is in general to be prepared as shown in **Fig. 2.2.5.**



θ : Min. 20°
R : Min. 6 mm
S : Max. 5 mm

Fig. 2.2.5 Butt Joint of Thick Material

4. Lap joints

(1) The breadth of overlap for lap joints which may be subjected to bending is not to be less than obtained from the following formula, but need not exceed 50 mm.

$$b = 2t + 25 \quad (mm)$$

where:
t = Thickness of the thinner plate (mm)

(2) Where plates are joggled, the breadth of overlap for joints which may be subjected to bending is not to be less than obtained from the following formula, but need not exceed 40 mm.

$$b = t + 25 \quad (mm)$$

where:
t = Thickness of the thinner plate (mm).

302. Welding Practice

1. Welding Practice, which is the detailed statement of the general welding works for hull structure, is to contain welding process, standard of welding and its quality control, application of welding consumables, welding procedures specification(WPS) and welding sequence of main hull structure and be submitted to the Society.

2. The welding procedure specification(WPS) specified above is to be those satisfactorily complying with the welding procedure qualification tests specified in **Section 4.**

303. Application of welding consumables

Welding consumables used for welded joints of hull structure are to be of the grades as specified in the relevant Articles of **Section 6** according to the following requirements:

(1) Application of welding consumables for welded joints of various grades of steel is to be as specified in **Table 2.2.3.**

(2) Welding consumables for lower toughness of steel may be used for welded joints of different toughness of steel of the same specified strength.

(3) In case of welding of steels of different specified strength, the welding consumables required for the steel of lower specified strength may be used, provided that adequate means for preventing cracks are considered.

(4) Low hydrogen electrodes are to be used for the welding of the higher strength steels or for shield metal are welding of the higher strength steel and normal strength steel except that ordinary electrodes may be used at the discretion of this Society when the carbon equivalent of steel is not exceeding 0.40 %.

304. Preparation for Welding

1. Edge preparation

(1) The edge preparations are to be in accordance with the plans, and are to be free from mois-

Table 2.2.3 Application of Welding Consumables

Welding consumables	Rolled steels for hull										Rolled steels for low temperature service				Extra high strength rolled steels for structures		
	Normal strength steels			Higher strength steels													
	RA	*RB* *RD*	*RE*	*RA*32, *RA*36	*RD*32, *RD*36	*RE*32, *RE*36	*RF*32, *RF*36	*RA*40, *RD*40	*RE*40	*RF*40	*RL*24*A*	*RL*24*B*, *RL*27, *RL*33	*RL*37	*RL*9*N*53 *RL*9*N*60	*RA*47	*RD*47	*RE*47
*RMW*1, *RAW*1, *RSW*1, *REW*1	○																
*RMW*2, *RAW*2, *RSW*2, *REW*2	○	○															
*RMW*3, *RAW*3, *RSW*3, *REW*3	○	○	○														
*RMW*51, *RAW*51, *RSW*51, *REW*51	○			○													
*RMW*52, *RAW*52, *RSW*52, *REW*52	○	○		○	○												
*RMW*53, *RAW*53, *RSW*53, *REW*53	○	○	○	○	○	○											
*RMW*54, *RAW*54, *RSW*54, *REW*54	○	○	○	○	○	○	○				○						
*RMW*52*Y*40, *RAW*52*Y*40, *RSW*52*Y*40, *REW*52*Y*40	○	○		○	○			○									
*RMW*53*Y*40, *RAW*53*Y*40, *RSW*53*Y*40, *REW*53*Y*40	○	○	○	○	○	○		○	○								
*RMW*54*Y*40, *RAW*54*Y*40, *RSW*54*Y*40, *REW*54*Y*40	○	○	○	○	○	○	○	○	○	○	○						
*RMW*2*Y*46, *RAW*2*Y*46, *RSW*2*Y*46, *REW*2*Y*46								○							○		
*RMW*3*Y*46, *RAW*3*Y*46, *RSW*3*Y*46, *REW*3*Y*46								○	○						○	○	
*RMW*4*Y*46, *RAW*4*Y*46, *RSW*4*Y*46, *REW*4*Y*46								○	○	○					○	○	○
*RMWL*1, *RAWL*1, *RSWL*1, *REWL*1	○	○	○								○						
*RMWL*2, *RAWL*2, *RSWL*2, *REWL*2	○	○	○	○(1)	○(1)	○(1)	○(1)				○	○					
*RMWL*3, *RAWL*3, *RSWL*3, *REWL*3	○	○	○	○	○	○	○				○	○	○				
*RMWL*91, *RAWL*91, *RSWL*91, *REWL*91														○			
*RMWL*92, *RAWL*92, *RSWL*92, *REWL*92														○			

NOTES :
(1) Welding consumables of *RMWL*2, *RAWL*2, *RSWL*2 or *REWL*2" are applicable to steel grade of *RA*32, *RD*32, *RE*32 or *RF*32

ture, grease, rust and paint which may cause injurious defects in welded joints.

(2) The edges to be welded shall be smooth, uniform and free from notches, laminations, cracks and other discontinuities which would adversely affect the quality or strenghth of the weld.

(3) Any injurious defects on the edges are to be removed. When weld repairs are required, controlled low hydrogen type welding consumables are to be used as far as practicable and grinding the complete weld smooth and flush with the adjacent surface.

2. Tack welding

(1) Tack welding is to be carried out by the welders qualified by this Society.

(2) Tack welding is to be removed before the main welding for joints of strength deck plating, sheer strakes, shell plating, and other important structural members or is to be carried out by the same procedure as the main welding without injurious defect in welded joints and made with the same or higher grade of welding consumables as intended to use for main welding.

(3) Injurious defects or any deviations from groove

design due to tack welding to obstruct proceedings of main welding are to be completely removed.

(4) In case of tack welding higher strength steels, extra high strength steels or joining under high restraint, preheating is to be taken as necessary prior to tack welding.

3. Fixtures

(1) Setting appliances to be used for welding fabrications are to be so arranged as to give restraint without cracks and other defects in welded joints.

(2) Tack welding for temporary fittings is not to leave any defect on base metal after the tack welds have been removed.

305. Welding sequence and direction of welding

1. Welding sequence and direction of welding are to be so determined as to prevent defects in welded joints and to minimize deformations caused by welding.

2. The joints which may cause excessive contraction by welding are to be welded as far as practicable prior to the joints which cause smaller contraction by welding.

3. Welding is to be proceeded to free ends of the joints as far as practicable and welding with direction of vertical-downward is not to be carried out, except the special approval of this Society.

306. Main welding

1. Welding is to be carried out so that no injurious defects may exist in the joints.

2. Welding is to be carried out under conditions of protection against the deleterious effect of moisture, rain, wind and snow, and is to be preheated in cold weather if found necessary.

3. The ends of important welded joints are to be fitted with run-off tabs or are to have proper extensions, which are to be cut off after finished welding.

4. Butt welded joints are to be back chipped to remove the defects in root of welds before applying the closing bead, except in case of one side welding or other approved procedures.

5. In case of welding under excessive restraint or welding for thick steel plate, cast steel or forged steel, special precaution is to be taken as necessary, such as preheating of the material, use of low hydrogen electrodes, etc. so as to prevent cracks.

6. In the parts subject to excessive stress concentration, the fillet welding is to be carried around the ends of member, but in other parts, the fillet welding may not be carried out around the ends, provided that the craters at the ends of welds are filled up.

7. Excessive gaps in butt joint are to be either deposited with welding on grooves, fitted with backing strips to the joints or partly replaced, and are not to be spanned with welding nor filled by slugging.

8. Where the gap between the members in fillet joints is not greater than 2 mm, the welding may be done with the given size of fillet. Where the gap is not less than 2 mm nor more than 5 mm, the welding is to be done with an increased size of fillet corresponding to the amount of gap. Where the gap exceeds 5 mm, the welding is to be done inserting a liner of suitable size or with a chill strip, or plates to be welded are to be partly renewed.

9. Preheating, intermediate temperature and post heat treatment are to be carried out in accordance with the welding procedure approved beforehand or the special approval of the Society.

307. Automatic welding

1. The grooves for automatic welding are to be finished in specially accurate dimensions.

2. Automatic welding is to be carried out within the inclination approved in the welding procedure qualitication test.

3. In the cross but joints of 16 mm or over in thickness, one joint is to be welded after the automatic welding of the other joint has been completed on both sides.

4. Special precaution is to be taken as necessary for the automatic welding of rimmed steel to prevent cracks.

308. Welding for higher strength steel

1. Arc strike and short bead are to be avoided as far as practicable.

2. As to matters not specified in this Article, the requirements for welding of normal strength steel are to be applied.

309. Quality of welds

1. The weld is to have a regular and uniform surface and it to be reasonably free from excessive reinforcements, injurious defects, such as undercuts, overlaps, etc.

2. Welded structures are to be reasonably free from welding deformation.

3. Non-destructive inspection is to be carried out for welded joints as specified elsewhere.

4. The welding defects found in an appropriate non-destructive inspection including the visual inspection or watertight test are to be removed and corrected by rewelding.

310. Repairs

1. The removal of weld defects shall be done by gouging, grinding, chipping, etc. with such a manner that the remaining weld metal or base metal is not damaged, however oxygen gouging is not to be used in extra high strength rolled steels.

2. The removed weld defects parts are to be so machined as not to affect repair welding and repair welding shall be carried out with low hydrogen type welding consumables and an electrode preferably smaller than that used for making the original weld.

3. Members distorted by welding may be straightened by mechanical means or locallized heat treatment, however in case of locallized heat treatment, the temperature of heated areas is to be so limited as not to affect the mechanical properties of base metal.

SECTION 4
Welding Procedure Qualification Tests

401. General

1. Application

(1) The welding procedures to be applied to hull construction specified in this Chapter as well as cargo tank, secondary barriers and piping arrangements in ships carrying liquefied gases in bulk, are to be those satisfactorily complying with the welding procedure qualification tests specified in this Section.
(2) The welding procedures qualification test for areas other than those specified in (1) is to be in accordance with the Guidances in relating to Rules.

2. Definitions

(1) Welding procedure specification(WPS)
A specification of materials, detailed methods, welding parameters etc. to be applied in the welding of a particular joint.
(2) Welding procedure qualification tests(WPQT)
A test carried out in order to demonstrate that a weld made according to a specific welding procedure specification meets the given requirements.
(3) Welding procedure qualification record(PQR)
The record of the actual parameters employed during welding of the qualification test piece according to the requirement of (2), and results from the non-destructive inspection and mechanical testing.

3. General requirements of WPQT

(1) The manufacturers are to obtain the approval of the welding procedure qualifications before the welding works in the following case specified in (A) through (B)
(A) Where the welding procedure is first adopted for welding works specified in **1.**
(B) Where the welding variables specified in **402. 2,** (1) through (9) are changed beyond the extent of those described in the approved welding procedure specifications.
(2) For the approval of welding procedure qualification, the welding procedure qualification tests specified in **404.** or **405.** are to be carried out with satisfactory results, and welding procedure specification specified in **402.** is to be approved by the Society.

402. Welding procedure specification

1. Before welding procedure qualification test is carried out, the manufacturer is to submit the preliminary welding procedure specification for review together with the detailed documents related with actual welding works to the Society.

2. The welding procedure specification is to include, at least, the following welding variables.

(1) Welding process
(2) Kind of base metal and thickness range
(3) Welding consumables(grade, shielded gas, backing, etc.)
(4) Welding position
(5) Joint and groove details
(6) Electrical characteristics(amperage, voltage and pole nature etc.)
(7) Preheat and maximum interpass temperature
(8) Post weld heat temperature (if any)
(9) Other conditions necessary for the welding procedure (ex. : welding speed, heat input etc.)

403. Welding procedure qualification tests(WPQT)

1. Where procedure qualification test is required, the test assembly is to be welded in the same or similar environment and the qualification tests are to be carried out under the welding conditions given in the welding procedure specifications.

2. The qualification test is to be carried out in the presence of the Society's surveyor.

3. For qualification tests for stainless clad steels, the requirements specified in **404.** and **405.** are to be complied with. However the impact test may be dispensed with where other welding procedure qualification on the stainless clad steel base metal under the same welding condition has been approved.

4. Where materials other than those specified in this Section are used, the qualification tests are to be carried out in accordance with the testing standard approved by the Society.

5. Tests or test conditions other than those specified in this Section for the welding procedure qualification may be required, where deemed necessary by the Society.

404. Tests for butt welded joints

1. Application

The requirements stated hereunder apply to the butt joints welded by manual welding, semi-automatic welding or automatic welding.

2. Kinds of test

According to the materials to be tested, kinds of test and number of test specimens are to be given in **Table 2.2.4.** Additional test may be required where found necessary by the Society.

3. Test assemblies

(1) Test assemblies are to be prepared with the same or equivalent meterial used in the actual work.
(2) The dimensions and types of test assembly

are to be as indicated in **Fig. 2.2.6.**

(3) Test assemblies are to be welded in the same welding positions as the actual work.

(4) Test assemblies for the pipes over 500 mm in diameter at the actual work may be those for the plates.

(5) For butt welded joints of rolled steel plates, the direction of welding according to rolling direction is to be as follows.

(A) When steel plates impact tested in longitudinal direction are used for test assemblies, the direction of welding of test assembly is perpendicular to the rolling direction of the two plates.

(B) When steel plates impact tested in transverse direction are used for test assemblies, the direction of welding of test assembly is parallel to the rolling direction of the two plates.

4. Visual inspection

Welding surface is to be regular and uniform surface and is to be free from injurious defects, such as cracks, undercuts, overlaps, etc.

5. Tensile tests

(1) Tensile tests are to be carried out with the test specimen shown in **Table 2.2.1.** The tensile strength is not to be less than the minimum tensile strength specified for the base metal except for those specified in **Table 2.2.5.**

(2) The number of tensile test specimens taken from each test assembly is to be as shown in **Table 2.2.4.**

(3) In those cases where the consumables are not unavoidably approved by the Society, it is to be required additionally to prepare a R14 deposited metal tensile test specimen as shown in **Table 2.2.1** in entirely weld metal and the mechanical properties are not to be less than the minimum mechanical properties specified for the base metal.

6. Bend tests

(1) The shape and dimension of face bend specimen, root bend specimen or side bend specimen are to be as indicated in $RB1$, $RB2$ or $RB3$ of **Table 2.2.2.** Bend test procedure and inside bend radius are to be as indicated in **Table 2.2.6.** There is to be no crack nor any other defect greater than 3 mm in length in any direction on the surface of bend specimen.

(2) The number of bend test specimens taken from each test assembly is to be as shown in **Table 2.2.4**, and the position of specimen is to be as shown in **Fig. 2.2.6.**

7. Impact tests

(1) Tehe thest specimen is to be R4 test specimen as shown in **Table 2.1.3** and to be taken from the position in **Fig. 2.2.6.** Where the weld metal cross-section size or shape does not allow the R4 test specimen to be in deposited metal, the requirements in **202.,** (3) of **Ch 1** are to be applied.

(2) The number of test specimens taken from test assemblies and the position of notch for the test specimen are as specified in **Table 2.2.4** and **Fig. 2.2.7.**

(3) The test temperature and average absorbed energy are to be in accordance with the requirements for the base metal except for those specified in **Table 2.2.7, Tables 2.2.8** and **2.2.9.**

(4) The test specimens are to be taken from the automatically welded part for the combined joint welded by automatic welding and manual or semiautomatic welding. It may be required to take another set of test specimens from the manually or semi-automatically welded part, where deemed necessary by the Society.

8. Macro-structure inspection

The transverse section of test specimen taken from the welded joint to be etched and examined, and is to free from any cracks, poor penetration, lact of fusion and other harmful defects.

9. Non-destructive inspection

Welded joints are to be examined for the whole length(excepting discard area of test assembly of **Fig. 2.2.6**) by non-destructive inspection, and are to show the there are no cracks or other injurious defects, and acceptance criteria is to be in accordance with the relevant requirements of the relevant Rules.

10. Hardness test

Where found necessary by the Society, the hardness test is to be only required for the weld, HAZ and base metal and the values are to be reported for consideration

11. Butt welds between different steel grades

(1) Where the plates are of different toughness grade, the requirements for qualification tests are to be in accordance with the requirements for the lower toughness grade of steels.

(2) Where the plates are of different strength grade, the requirements for qualification tests are to be in accordance with the requirements for the lower strength grade of steels.

405. Tests for fillet welded joints

1. Application

The requirements stated hereunder apply to the fillet joints welded by manual, semi-automatic or automatic welding in any welding position.

2. Kinds of test

Fillet weld joints are to be subjected to visual inspection, macro-structure inspection and fracture test. Additional tests may be required if found

Table 2.2.4 Kinds of Test for Butt Welded Joints

Grades and material symbols of test specimens			Visual inspection	Tensile test	Bend test	Impact test(2): No. of sets	Impact test(2): Position of notch	Macro-structure inspection	Non-destructive inspection(3)
			Kinds and number of specimens for test(1)						
Rolled steels for hull	normal strength steel	*RA*, *RB*, *RD*, *RE*	Welding positions of whole length	2	2	1	A(5)	1	Welding positions of whole length
Rolled steels for hull	higher strength steel	*RA*32, *RD*32, *RE*32, *RF*32, *RA*36, *RD*36, *RE*36, *RF*36, *RA*40, *RD*40, *RE*40, *RF*40	Welding positions of whole length	2	2	3	A,B,C(6)	1	Welding positions of whole length
Rolled steels for low temperature service		*RL*24*A*, *RL*24*B*, *RL*27, *RL*33, *RL*37 *RL*2*N*30, *RL*3*N*32, *RL*5*N*43	Welding positions of whole length	2	2	5	A,B,C,D,E	1	Welding positions of whole length
Rolled steels for low temperature service		*RL*9*N*53, *RL*9*N*60	Welding positions of whole length	4(4)	2	5	A,B,C,D,E	1	Welding positions of whole length
Steel pipes for low temperature service		*RLPA*, *RLPB*, *RLPC*, *RLP*2, *RLP*3, *RLP*9	Welding positions of whole length	2	4	5	A,B,C,D,E	1	Welding positions of whole length
Extra high strength rolled steels for structures		*RA*43, *RD*43, *RE*43, *RF*43, *RA*47, *RD*47, *RE*47, *RF*47, *RA*51, *RD*51, *RE*51, *RF*51, *RA*56, *RD*56, *RE*56, *RF*56, *RA*63, *RD*63, *RE*63, *RF*63, *RA*70, *RD*70, *RE*70, *RF*70	Welding positions of whole length	2	2	5	A,B,C,D,E	1	Welding positions of whole length
Rolled stainless steels		*RSUS*304, *RSUS*304*L*, *RSUS*304*N*1, *RSUS*304*N*2, *RSUS*304*LN*, *RSUS*309*S*, *RSUS*310*S*, *RSUS*316, *RSUS*316*L*, *RSUS*316*N*, *RSUS*316*LN*, *RSUS*317, *RSUS*317*L*, *RSUS*317*LN*, *RSUS*321, *RSUS*347,	Welding positions of whole length	2	2	(7)	-	1	Welding positions of whole length
Stainless steel pipes		*R*304*TP*, *R*304*LTP*, *R*309*STP*, *R*310*STP*, *R*316*TP*, *R*316*LTP*, *R*317*TP*, *R*317*LTP* *R*321*TP*, *R*347*TP*	Welding positions of whole length	2	4	(7)	-	1	Welding positions of whole length
Aluminium alloys(8)	5000 series	5754*P*-*O*	Welding positions of whole length	2	4	-	-	1	Welding positions of whole length
Aluminium alloys(8)	5000 series	5086*P*-*O*	Welding positions of whole length	2	4	-	-	1	Welding positions of whole length
Aluminium alloys(8)	5000 series	5083*P*-*O*, 5083*P*-*H*321	Welding positions of whole length	2	4	-	-	1	Welding positions of whole length
Aluminium alloys(8)	6000 series	6082*S*(9)	Welding positions of whole length	2	4	-	-	1	Welding positions of whole length

NOTES:
(1) Where found necessary by the Society, microscopic test, hardness test and tests other than these may be required.
(2) Position of notch is as shown in **Fig. 2.2.7.**
(3) Internal inspections by radiographic examination or ultrasonic examination and surface inspections by magnetic particle examination or liquid penetrant examination are to be carried out.
(4) Two specimens are to be taken longitudinally and transversely respectively (See. **Fig. 2.2.6**)
(5) Where welding heat input is greater than 100KJ/cm, additional test specimens notched at B, C, D and E are to be taken.
(6) Where welding heat input is greater than 100KJ/cm, additional test specimens notched at D and E are to be taken.
(7) Where found necessary by the Society, impact tests up to steels specially used for may be required.
(8) Material symbols of aluminium alloys include the symbols of which is the temper condition.
(9) Other rolled aluminium alloys of 6000 series with minimum tensile strength 260 N/mm^2 may be used.

necessary by the Society.

3. Test assemblies and welding

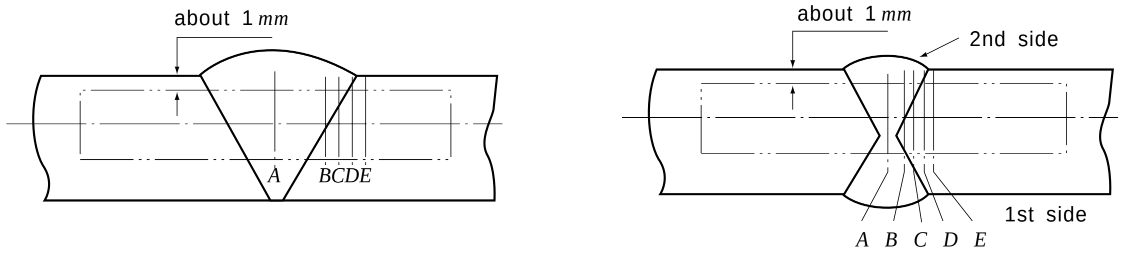
(1) Test assembly is to be prepared with the same or equivalent material used in the actual work.
(2) Dimensions and type of test assembly are to be as indicated **Fig. 2.2.8.**
(3) Test assembly is to be welded in the same welding positions as the actual work.
(4) The assembly is to be welded on one side only, except in case deemed necessary by the surveyor.
(5) For manual welding and semi-automatic welding, a stop/restart position should be included at middle of the test assemblies in longitudinal direction.

Table 2.2.5 Tensile Test Requirements for Butt Welded Joint

Kind of testing materials	Grade of testing materials	Tensile strength (N/mm^2)	Yield strength (N/mm^2)
Rolled steels for lower temperature service	$RL9N53$, $RL9N60$	590 min.(1)	315 min.
		630 min.(2)	-
Steel pipes for low temperature service	$RLP9$	630 min.	-
Aluminium alloys	5083P-H321	275 min.	-
	6082S(3)	170 min.	-

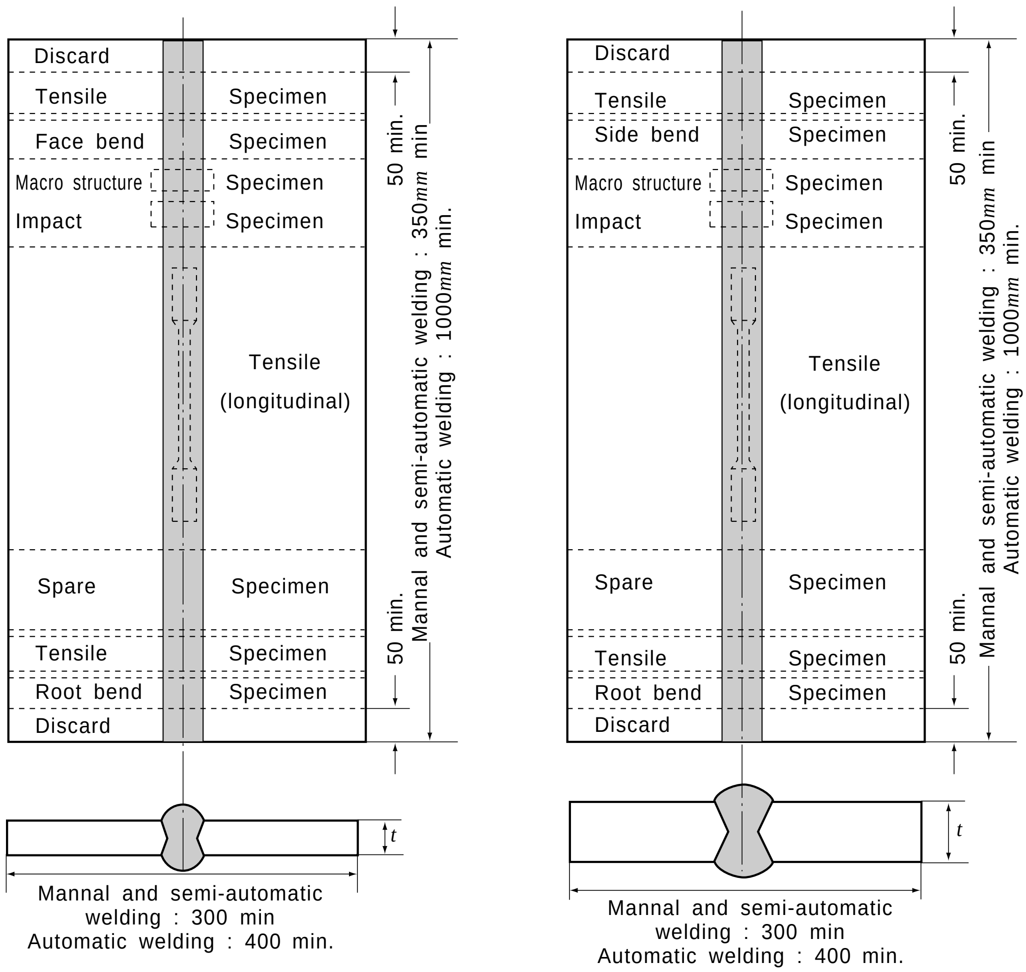
(Notes) (1) For test specimen in longitudinal direction
(2) For test specimen in transverse direction
(3) See notes (9) of **Table 2.2.4.**

a) For Single or Multi-run Technique
b) For Two-run Technique

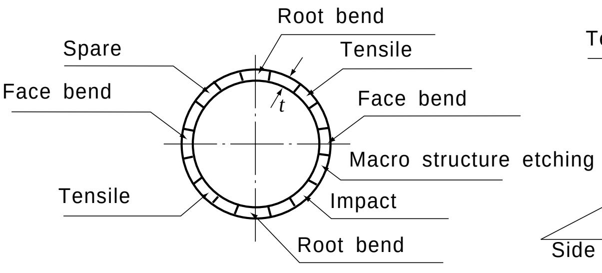


Location of notch:
A : Centre line of the welds
B : Fusion line (F.L.)
C : 1 mm from the F.L.
D : 3 mm from the F.L.
E : 5 mm from the F.L.

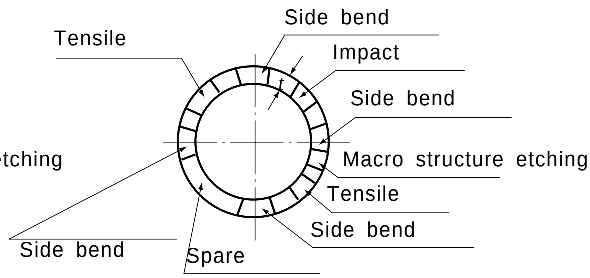
Fig. 2.2.7 Location of Charpy V-notch Test Specimens



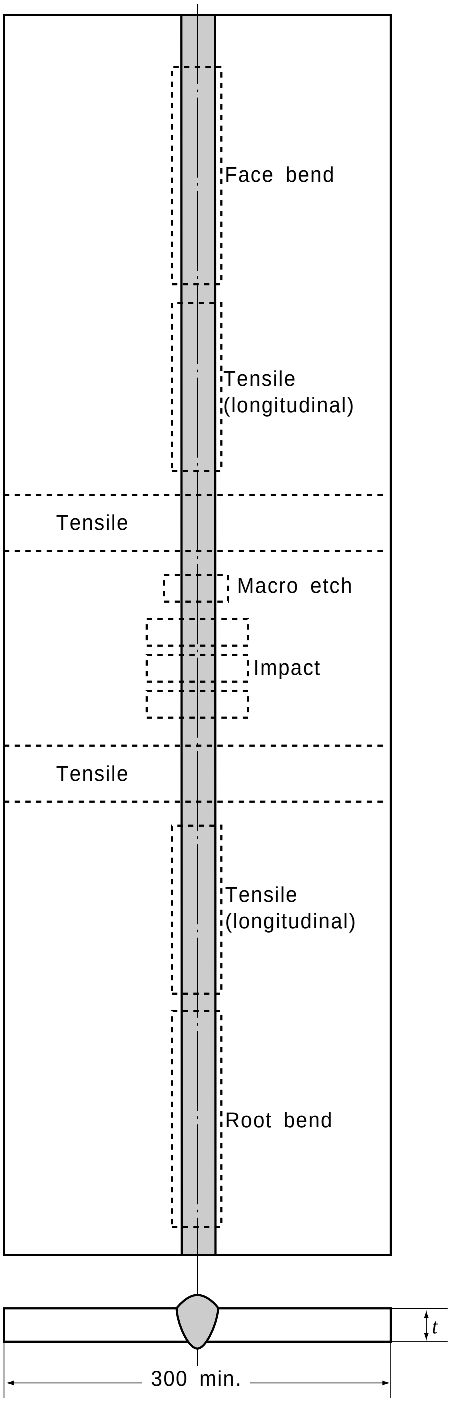
(A) Test Assembly for Plates up to 20 mm in Thickness (B) Test Assembly for Plates over 20 mm in Thickness



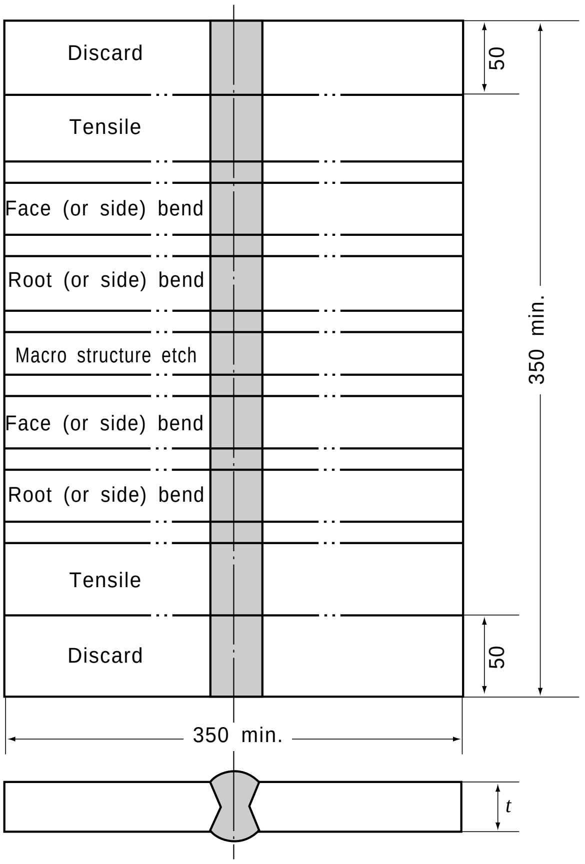
(C) Test Assembly for Pipes up to 20 *mm* in Thickness



(D) Test Assembly for Pipes over 20 *mm* in Thickness



(E) Test Assembly for *RL9N*53 or *RL9N*60



(F) Test Assembly for Plates of Stainless Steel or Aluminium Alloy

(Note)
For stainless steels, a face and a root bend test specimen are to be taken from test assembly.

Fig. 2.2.6 Welding Procedure Test Assemblies (Unit: *mm*)

Table 2.2.6 Bend Test Requirements

Kind of testing materials	Grade of testing materials	Inside bend radius(mm)(1)	Bending angle
Steel pipes for low temperature service	*RLP*9	$\frac{10}{3}t$	180°
Extra high strength rolled steels for structures	*RA*56, *RD*56, *RE*56, *RF*56, *RA*63, *RD*63, *RE*63, *RF*63, *RA*70, *RD*70, *RE*70, *RF*70,	$\frac{5}{2}t$	
Aluminium alloys	5754*P-O*	$\frac{3}{2}t$	
	5086*P-O*	$3t$	
	5083*P-O*, 5083*P-H*321		
	6082*S*(2)		
Other materials		$2t$	

(Notes)
(1) t is the thickness of the test specimen.
(2) See Notes (9) of the **Table 2.2.4.**

Table 2.2.7 Impact Test Requirements for Butt Welded Joint (For rolled steels for hull)

Grade of steel	Test temp. (°C)	Average absorbed energy(J)		
		For manually or semi-automatically welded joints (1)		For automatically welded joints (1)
		Flat, Horizontal	Vertical upward, Vertical downward	
RA	20	47 min.	34 min.	34 min.
RB, *RD*	0			
RE	– 20			
*RA*32, *RA*36	20			
*RD*32, *RD*36	0			
*RE*32, *RE*36	– 20			
*RF*32, *RF*36	– 40			
*RA*40	20		41 min.	41 min.
*RD*40	0			
*RE*40	– 20			
*RF*40	– 40			

NOTES:
(1) When the absorbed energy of two or more test specimens among a set of test specimens is less in value than the specified average absorbed energy or when the absorbed energy of a single test specimen is less in value than 70% of the specified average absorbed energy, the test is considered to have failed.

Table 2.2.8 Impact Test Requirements for Butt Welded Joint (Steels for low temperature Service)

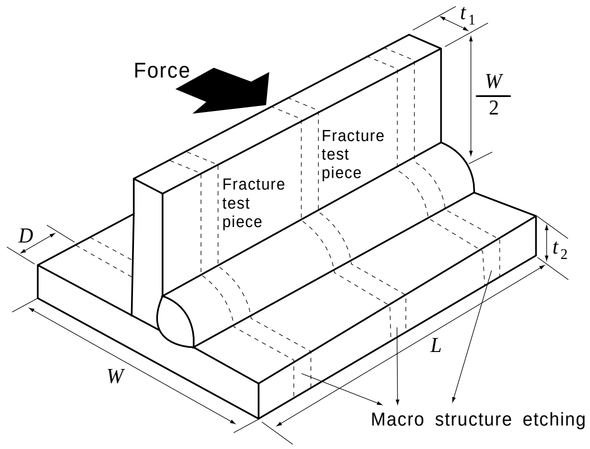
Grade of steel	Test temp. (°C)(4)	*A* (1)	*B*, *C*, *D*, *E* (1)	
		Value of average absorbed energy(J)(3)	Value of average absorbed energy(J)(3)	
			L(2)	*T*(2)
*RL*24*A*	– 40	27 min.	41 min.	27 min.
*RL*24*B*	– 50			
*RL*27	– 60			
*RL*33	– 60			
*RL*37	– 60			
*RL*2*N*30	– 70			
*RL*2*N*32	– 95			
*RL*5*N*43	– 110			
*RL*9*N*53	– 196			
*RL*9*N*60	– 196			
RLPA	– 40		27 min.	—
RLPB	– 50			
RLPC	– 60			
*RLP*2	– 70		34 min.	
*RLP*3	– 95			
*RLP*9	– 196		41 min.	

NOTES:
(1) Position of notch as shown in **Fig. 2.2.7.**
(2) *L*(or *T*) indicates that the direction of welding is transverse (or parallel) to the rolling direction of test materials.
(3) When the absorbed energy of two or more test specimens among a set of test specimens is less in value than the specified average absorbed energy or when the absorbed energy of a single test specimen is less in value than 70% of the specified average absorbed energy, the test is considered to have failed.
(4) Where requirements in **Pt 7, Ch 5** apply, the impact test temperature is to be as given as follows:
(a) Impact test temperature for *RL*24*A* through *RL*5*N*43 is to be the lower of the temperatures given in **Table 2.1.18** specified in **Pt 2, Ch 1.**
(b) Impact test temperature for *RLPA* through *RLPC* is to be either 5°C below the design temperature or –20°C whichever is the lower.

Table 2.2.9 Impact Test Requirements for Butt Welded Joint(For extra high strength steels)

Grade of steel	Test temp. (°C)	Value of average absorbed energy(J)(1)		
		$A^{(2)}$	$B,C,D,E^{(2)}$	
			$L^{(3)}$	$T^{(3)}$
RA43	0	47 min.	47 min.	28 min.
RD43	-20			
RE43	-40			
RF43	-60			
RA47	0		46 min.	31 min.
RD47	-20			
RE47	-40			
RF47	-60			
RA51	0	50 min.	50 min.	33 min.
RD51	-20			
RE51	-40			
RF51	-60			
RA56	0	55 min.	55 min.	37 min.
RD56	-20			
RE56	-40			
RF56	-60			
RA63	0	62 min.	62 min.	41 min.
RD63	-20			
RE63	-40			
RF63	-60			
RA70	0	69 min.	69 min.	46 min.
RD70	-20			
RE70	-40			
RF70	-60			

(NOTES)
(1) When the absorbed energy of two or more test specimens among a set of test specimens is less in value than the specified average absorbed energy or when the absorbed energy of a single test specimen is less in value than 70% of the specified avergtge absorbed energy, the test is considered to have failed.
(2) Position of notch as shown in **Fig. 2.2.7.**
(3) L(or T) indicates that the direction of welding is transverse (or parallel) to the rolling direction of test materials



NOTES :
1. The length of test specimen is as follows :
   (1) Manual and semi-automatic welding :
   L = 350mm min., W = 200mm min., D = 50mm min.
   (2) Automatic welding
   L = 1000mm min., W = 300mm min., D = 75mm min.
2. Thickness of webs and flanges of the test assembly, t_1 and t_2 are to be of ordinary thicknesses used in the actual work.
3. Tack weld may be applied to the test assembly.
4. The fillet length is to be of ordinary length used in the actual work.

Fig. 2.2.8 Test Assembly for Fillet Weld Joint(Unit :mm)

4. Visual inspection

Fillet welding is to have a regular and uniform surface, and is to be free from cracks, undercuts, overlaps and other injurious defects.

5. Macro-structure inspection

In macro etched test specimen showing the transverse section of fillet weld joint, welded joints are to be free from excessive difference between upper and lower fillet lengths, lack of fusion, cracks and other injurious defects. In addition, for manual welding and semi-automatic welding, one of the macro etched specimens is to be from the stop/restart position, if present.

6. Fracture tests

The remaining test assemblies after the macro-structure test specimen has been removed are to be broken by pressing as shown in **Fig. 2.2.8** and there shall be no cracks, blow holes, poor penetrations and any other injurious defects in the fractured surface. However, where the sum of lenghs having blow holes and poor penetration, except at both ends of the test specimen, is not greater than 10% of the total welded length,the test may be regarded as satisfactory.

406. Retests and Procedure qualification records(PQR)

1. Retests

(1) Where visual inspection or non-destructive inspection fails to meet the requirements, the new test specimens welded under the same welding condition, are to be subject to retest and all of these test specimens are to pass the test.

(2) Where the result of a tensile or bend test does not comply with the requirements, twice as many test specimens as the number of specimens of failed test are to be selected from either the first test material or test materials welded under the same welding conditions, and all of these test specimens are to be satisfactorily tested.

(3) (a) Where the result of the impact test is unsatisfactory, additional tests may be carried out, with the exception of the cases specified in (i) and (ii) below, by taking a set of test specimens out of the same test material from which the above-mentioned test specimens have been taken.

(i) The absorbed energy of all test specimens is under the required average absorbed energy.

(ii) The absorbed energy of two of the test specimens is under 70% the required average absorbed energy.

(b) In case of the previous (a), the test specimens may be accepted, provided that the average absorbed energy of the six test specimens, including those which have been rejected as unsatisfactory, is not less than the required average abosorbed energy, and that not more than two individual results are lower than the required average absorbed energy and of these, not more than one result is below 70% of the required average absorbed energy.

(4) Where the retest fails to meet the requirements, the test may be made over again. In this case, where the whole tests specified on the test assembly are carried out and are complied with requirements, the tests are accepted as successful.

2. Procedure qualification records(PQR)

Three copies of the procedure qualification records showing the results of procedure test are to be submitted to the Society for approval.

407. Validity of qualified welding procedure specification

1. Qualification of a welding procedure remains valid provided the welding variables are kept within the qualified range during production welding. When one or more variables outside the qualified range occur, the welding procedure is to be respecified and requalified.

2. Validity of welding variables for new qualification of welding procedure specification is to be in accordance with the Guidances relating to Rules.

SECTION 5
Welders and Welder Performance Qualification Tests

501. General

1. Welders

(1) Each welder intended to engage in the manual and semi-automatic welding work specified in this Section is to pass the performance qualification tests required according to the applicable welding procedure and kinds of materials to be welded and to have the performance qualification by the Society. The term "semi-automatic welding" means that the weld is made manually by a welder holding a gun through which the electrode wire is continuously fed.

(2) Tack welders, intended to engage in tack welding, are to have the same performance qualification as the welder intend to engage in main welding.

(3) Operators intended to engage in automatic welding work are to be those skillful for the actual welding work in which they will engage.

(4) The performance qualification test of welder intended to engage in the special material and welding work not prescribed in this Section are to be at the discretion of the Society.

(5) The application of more suitable requirements instead of the requirements of this Section is left to the discretion of the Society.

2. General requirements for qualification validity

(1) The responsibility for selection, training and testing of the welders rests with the employer of welder with the performance qualification by the Society.

(2) Where welder has not engaged in a particular process and equipment for a period exceeding six months, his qualification is automatically withdrawn.

(3) The welder failed to meet the required qualify of this Society in welding work may be suspended his qualification.

3. Retests

(1) Where any test specimen is not finished to the specified dimension due to the defective machining, the test assembly is to be rewelded.

(2) For the welder who fails to meet the requirements in a part of the tests, the retests as to the failed tests may be made on duplicate test specimens from the test assemblies welded within 1 *month* from the date of the failure and the welder may be treated to have passed the requirements where all test specimens fully comply with the test requirements.

(3) The welder who fails to meet the requirements in all parts of the tests or in the retest of previous (2), is not to take the next test within 1 month from the date of the failure.

4. Welding and treatment

(1) Test assemblies may be welded with either alternating current or direct current.

(2) The test assemblies are not to be changed their up-and-down or right-and-left position throughout the welding operation. The welding in vertical position is to be done upward procedure.

(3) The welding is to be carried out only on one side and the back welding is not to be carried out unless specified otherwise.

(4) In general, the test assemblies for plates are to be so restrained or prestrained that the warping due to the welding does not exceed an angular distortion of 5 *degrees*.

(5) The test assemblies are not to be subjected to peening or heat treatment throughout the period before, during and after the welding.

(6) The backing strips of the test assembies may be used steel plates, copper plate, ceramic or similar materials to obtain the enough penetration.

502. Grades, and range of qualification

1. Grades of performance qualification

The grades of performance qualification for plates and pipes are to be classified as given in **Table 2.2.10** and **Table 2.2.11.**

Table 2.2.10 Grades, Thickness of Test Assembly, Testing Procedure and Range Qualified of Performance Qualification for Plates

Grade	Nominal thickness of test assembly of plate $t(mm)$	Number of bend test specimens(1)			Norminal plate thickness qualified for actual welding work(mm)
		Face	Root	Side	
Grade 1(2)	$t < 9.5$	1	1	-	3~19
Grade 2(3)	$9.5 \leq t < 25$	-	-	2	3~2t
Grade 3(4)	$t \geq 25$	-	-	2	min. 3

NOTE:
(1) Where deemed appropriate by the society, radiographic testing may be made in lieu of bend tests.
(2) Dimensions and types of assembly for plates are to comply with **Fig. 2.2.11.**
(3) Dimensions and types of assembly for plates are to comply with **Fig. 2.2.12.**
(4) Dimensions and types of assembly for plates are to comply with **Fig. 2.2.13.**

Table 2.2.11 Grades, Thickness of Test Assembly, Testing Procedure and Range Qualified of Performance Qualification for Pipes

Grade	Test assembly of pipe(mm)		Number of bend test specimens(1)						Norminal dimension qualified for actual welding work(mm)	
			1G-P and 2G-P			5G-P, 6G-P and 6GR-P				
	Nominal outside diameter, D	Nominal test thick-ness, t	Face	Root	Side	Face	Root	Side	Norminal outside diameter	Nominal thickness of pipes
Grade 1(4)	$D \leq 100$	Unlimited	-	2(2)	-	2	2	-	19~100	3~19
Grade 2(5)	$D > 100$	$t \leq 9.5$	1	1	-	2	2	-	min.100(3)	3~19
Grade 3(6)		$t > 9.5$	-	-	2	-	-	4		min. 5
Grade 3R(7) (T, K & Y connection)	$D > 150$	$t \geq 12.5$	-	-	-	-	-	4	min. 100	min. 5

NOTES:
(1) Where deemed appropriate by the society, radiographic testing may be made in lieu of bend tests.
(2) Face bend test and root bend test for aluminium(refer to **Fig. 2.2.14**)
(3) The minimum pipe size qualified is to be 1/2 the test diameter or 100mm, whichever is greater.
(4) Dimensions and types of assembly for pipes are to comply with **Fig. 2.2.14.**
(5) Dimensions and types of assembly for pipes are to comply with **Fig. 2.2.15.**
(6) Dimensions and types of assembly for pipes are to comply with **Fig. 2.2.16.**
(7) Dimensions and types of assembly for pipes are to comply with **Fig. 2.2.17.**

Table 2.2.12 Welding Positions for Performance Qualification

Grade	Test Positions(1)(2)	Positions qualified for actual welding work(3)	
		Plates	Pipes
For each grade of plates	Welding in flat position(1G)	F	F(5)
	Welding in horizontal position(2G)	F, H	F, H(5)
	Welding in vertical position(3G)	F, V	F, V(5)
	Welding in overhead position(4G)	F, OH	F, OH(5)
	(4)	All	All(5)
For each grade of pipes	Welding in horizontal rolled position(1G-P)	F	F
	Welding in vertical fixed position(2G-P)	F, H	F, H
	Welding in horizontal fixed position(5G-P)	F, V, OH	F, V, OH
	Welding in vertical fixed position(2G-P) + Welding in horizontal fixed position(5G-P)	All	All
	Welding in inclined fixed position(6G-P)	All	All
	Welding in inclined fixed position with restriction ring(6GR-P)	All(6)	All(6)

NOTES:
(1) Test positions are to comply with **Fig. 2.2.9** and **Fig. 2.2.10.**
(2) A Welder of higher grade may be regarded as the welder of lower Grade with in the same Test Position.
(3) F = Flat, V = Vertical, H = horizontal, OH = Overhead
(4) Applicants are to pass the two performance qualification tests described in the following table at the same time in connection with the materials used in practical welding work.

Grade \ Material	Steel and Stainless steel	Aluminium alloy
Grade 1	3G and 4G	2G and 4G
Grade 2		
Grade 3	2G and 3G	

(5) Only qualified for pipe over 600mm in diameter with backing strips or backgouging.
(6) Test in the 6GR-P position qualify welding in T, K & Y connection(Grade 3R) and welds with restricted acess.

2. Positions of performance qualification

The positions for qualification test and positions qualified for actual welding work are to comply with the **Table 2.2.12.**

503. Testing procedure

1. Testing materials and welding consumables

(1) *Testing materials and welding consumables for mild steels*

(a) The materials used for test assembly of plates are to conform to one of the following requirements or to be of equivalent quality approved by the Society.

(i) Rolled steel plate for hull (*RA*, *RB*, *RD*, *RE*)

(ii) Rolled steel plate for boiler (*RSP*42, *RSP*46)

(iii) *KS D* 3503, Rolled steel for general structure (*SS*400)

(iv) *KS D* 3560, Rolled steel for boiler (*SBB*42, *SBB*46)

(v) *KS D* 3515, Rolled steel for welded structure (*SWS*41*A*, *SWS*41*C*)

(b) The materials used for test assemblies of pipes are to conform to one of the following requirements or to be of equivalent quality approved by the Society.

(i) Steel pipes of Grades 1 to 3 for pressure pipes (*RST*1—*RST*3)

(ii) *KS D* 3563, Carbon steel for boiler and heat exchanger tubes (*STH*42)

(iii) *KS D* 3562, Carbon steel for pressure tubes (*SPPS*42)

(iv) Pipe fabricated with the plates specified in (a)

(c) Welding consumables to be used for testing are to be of the materials for mild steels approved by the Soicety.

(2) *Testing materials and welding consumables for stainless steel*

(a) The consumables to be used for test assemblies of plates or pipes are to be stainless steel specified in **Chapter 1** or to be of equivalent quality approved by the Society.

(b) The welding materials to be used for the testing are to be of the materials for stainless steels approved by the Society.

(3) *Testing materials and welding consumables for aluminium alloy*

(a) The materials to be used for test assemblies of plates are to be of *R*5083*P-O* specified in **Chapter 1** or to be of equivalent quality approved by the Society.

(b) Test assemblies for pipes are to be fabricated with the rolled materials used for the test assemblies specified in (a).

(c) Welding consumables to be used for testing are to be of the materials for aluminium alloy approved by the Society.

2. Test specimens

(1) Face bend and root bend test specimens from plate test assemblies Grades 1 are to be of type *RB*7 shown in **Table 2.2.2** and side bend tests specimens from plate test assemblies for Grade 2 and 3 are to be of type RB8 shown in **Table 2.2.2.**

(2) Face bend and root bend test specimens from pipe test assemblies for each Class of Grades 1 and 2 are to be of type *RB*9 or type *RB*10 shown in **Table 2.2.2**, respectively, and side bend tests specimens from pipe test assemblies for Grade 3 or 3R are to be of the type *RB*11 shown in **Table 2.2.2.**

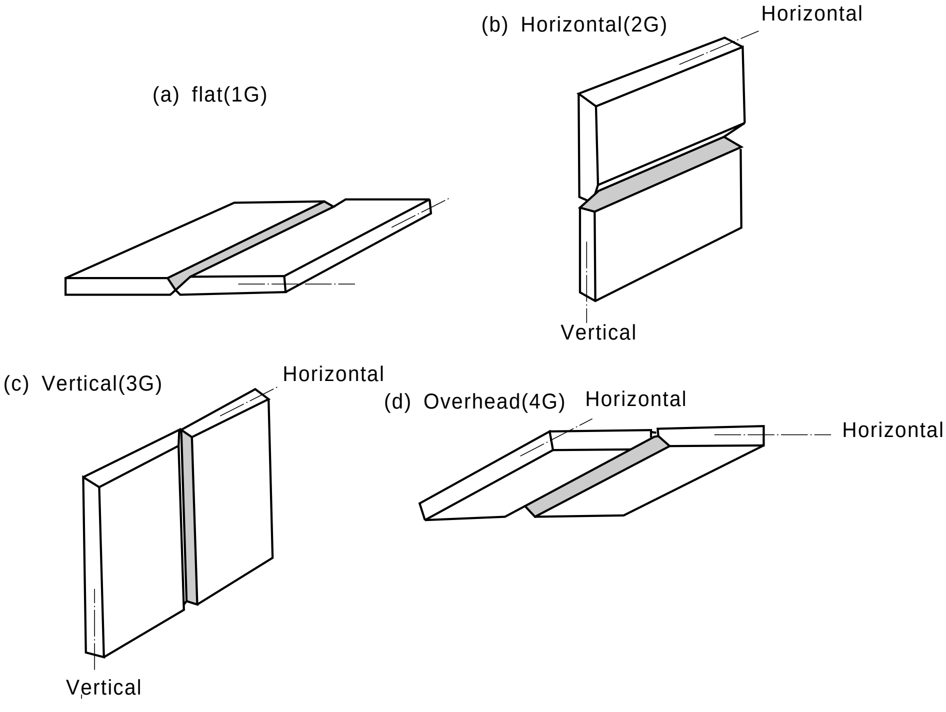


Fig. 2.2.9 Welding Positions of Plates

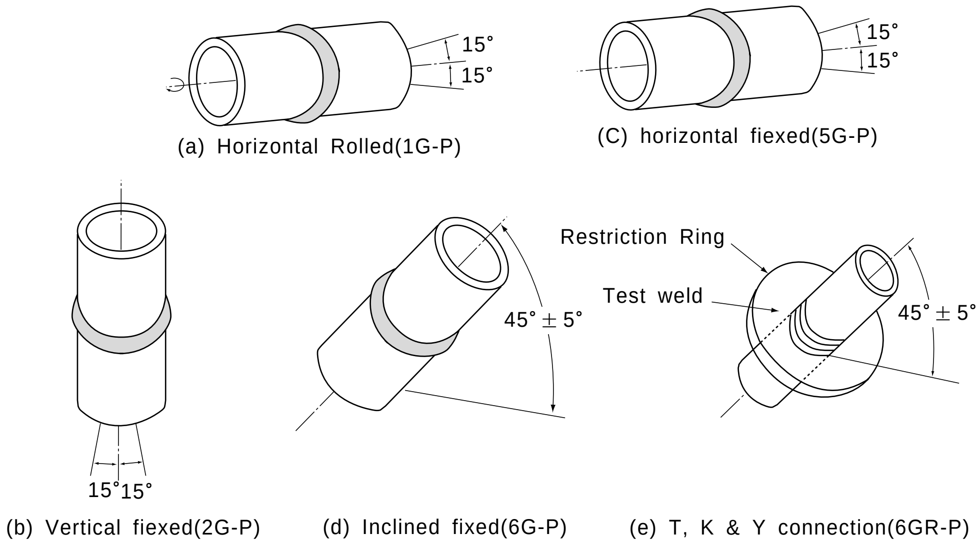


Fig. 2.2.10 Welding Positions for Pipes

3. Bend test

(1) The test is to be of bend test either by guided bend test or roller bend test. The test specimens are to be bent through 180 *degrees*. In the case of aluminium alloy, the roller bend test is to be carried out. However, proper method of guided bend test may be substituted at the approval of the Surveyor. Where deemed appropriate by the society, radiographic testing may be made in lieu of bend tests.

(2) In the case of guided bend test, the test specimen taken from either plate or pipe test assembly is to be tested with the bending jig as indicated in **Fig. 2.2.1** or **Fig. 2.2.2**, and the test specimen taken from either plate or pipe test assembly of Grades 2 and 3 is to be tested with the bending jig as indicated in **Fig. 2.2.2.** However, the test specimen taken from pipe test assembly of Grade 1 is to be tested by the roller bend test.

(3) In the case of roller bend test, the bend test is to be carried out with the bending jig as shown in **Fig. 2.2.3** under the test conditions shown in **Table 2.2.13.**

(4) There are to be neither cracks nor other defects greater than 3 *mm* in length on the surface of bent specimen.

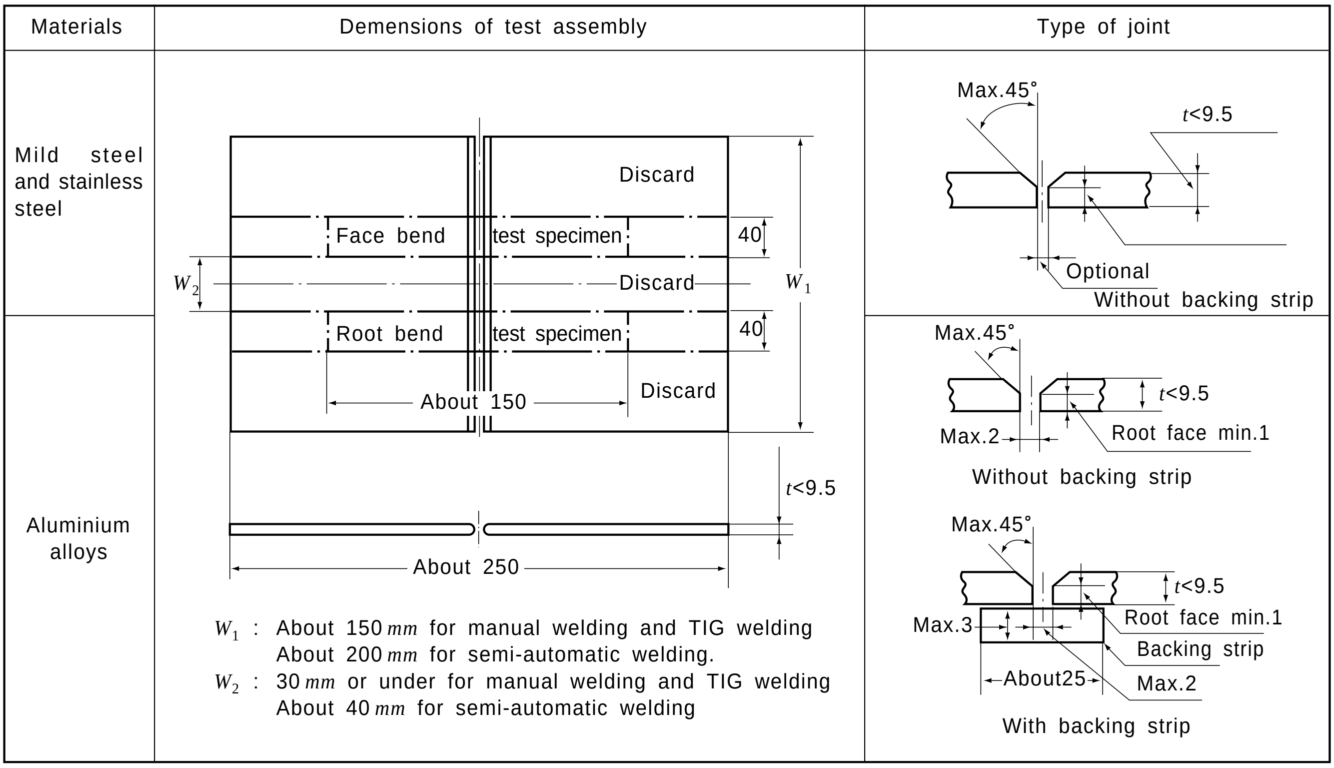


Fig. 2.2.11 Dimensions and Types of Test Assemblies for Plates of Grade 1 (unit: *mm*)

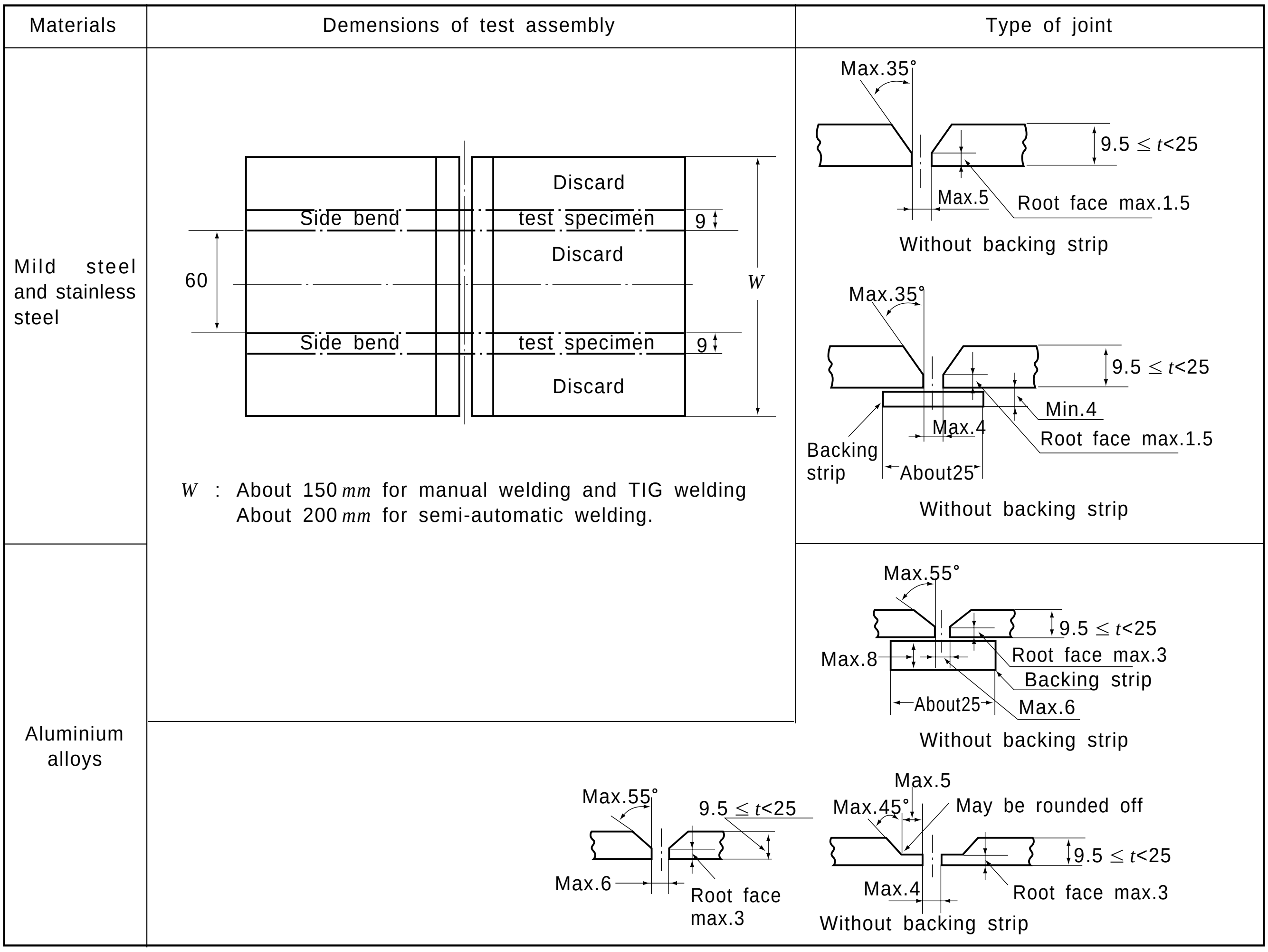


Fig. 2.2.12 Dimensions and Types of Assemblies for Plates of Grade 2 (unit: *mm*)

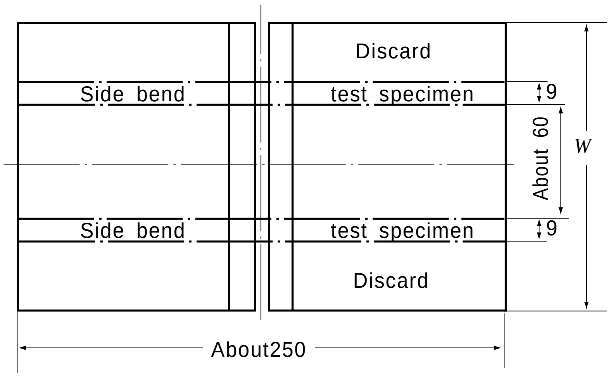
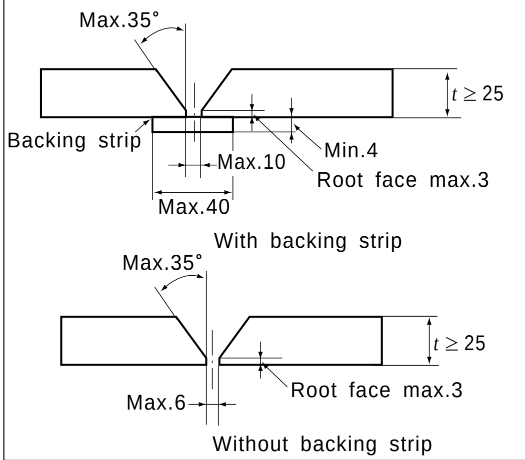
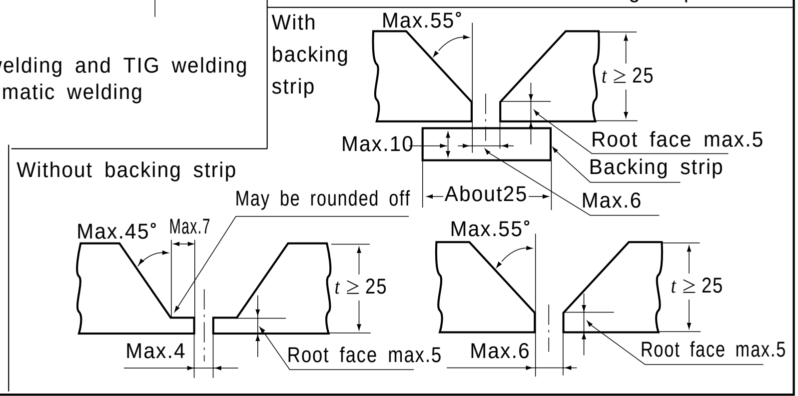
Materials	Demensions of test assembly	Type of joint
Mild steel and stainless steel	 W : About 150 *mm* for manual welding and TIG welding About 200 *mm* for semi-automatic welding	
Aluminium alloys		

Fig. 2.2.13 Dimensions and Types of Test Assemblies for Plates of Grade 3 (unit: *mm*)

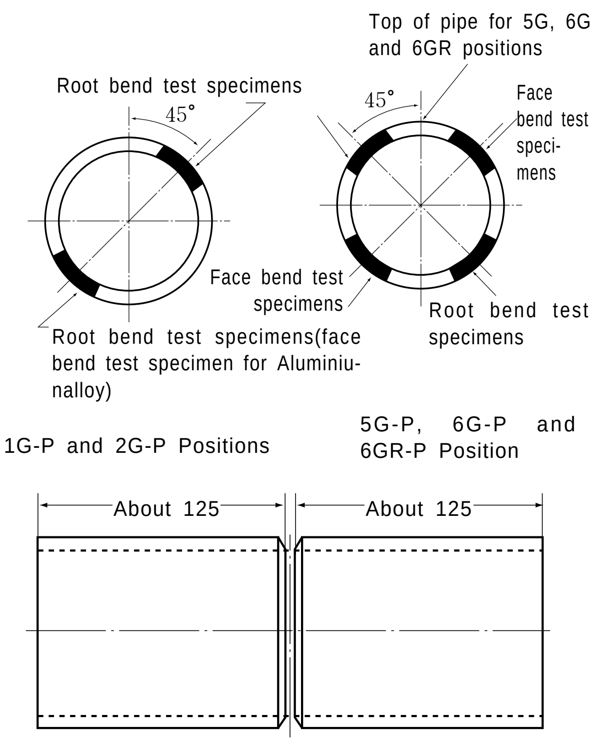
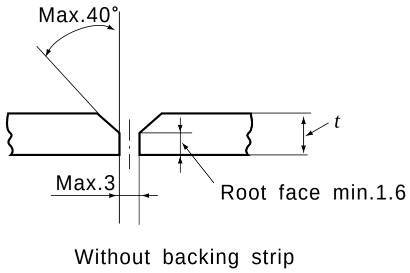
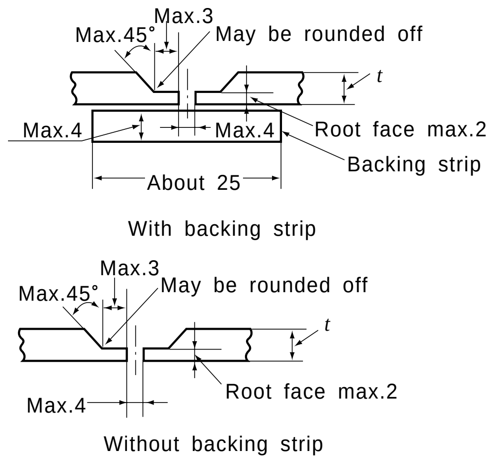
Materials	Demensions of test assembly	Type of joint
Mild steel and stainless steel		
Aluminium alloys		

Fig. 2.2.14 Dimensions and Types of Test Assemblies for Pipes of Grade 1 (unit: *mm*)

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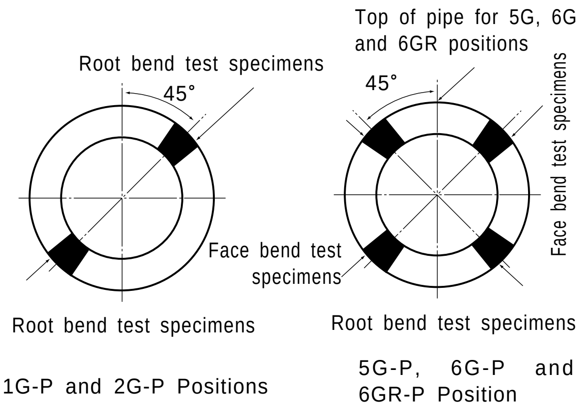
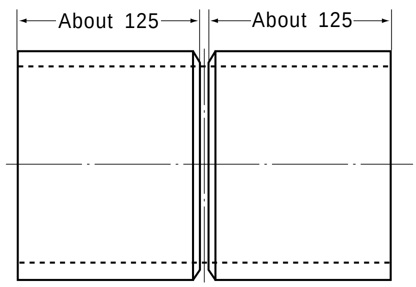
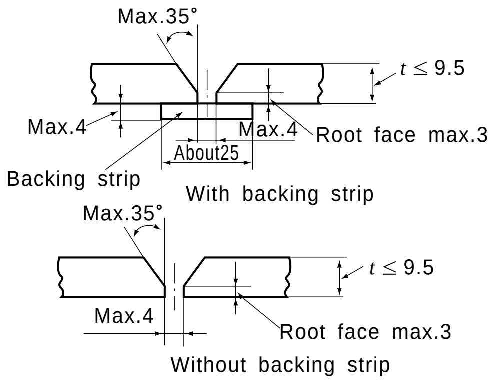
<tr><td>Mild steel and stainless steel</td><td rowspan="2">


</td><td>
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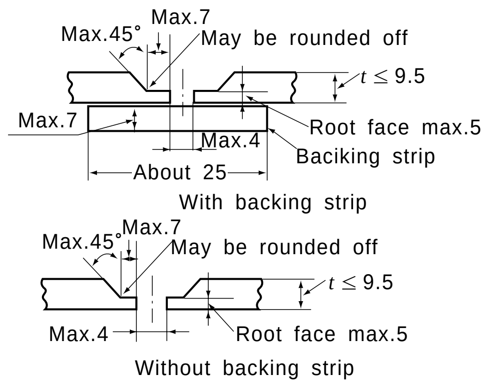
<tr><td>Aluminium alloys</td><td>
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Fig. 2.2.15 Dimensions and Types of Test Assemblies for Pipes of Grade 2 (unit : *mm*)

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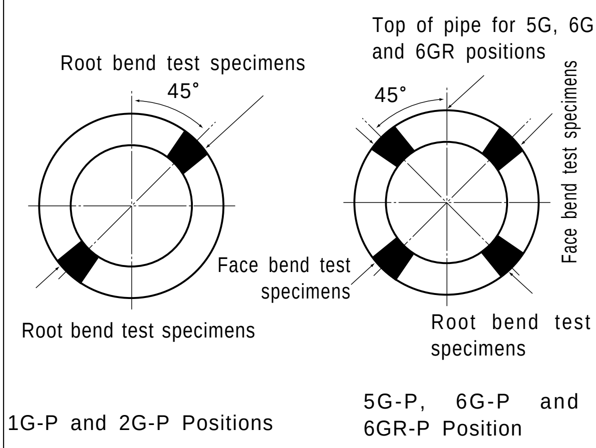
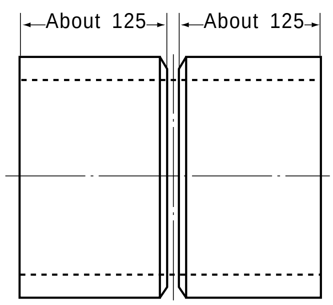
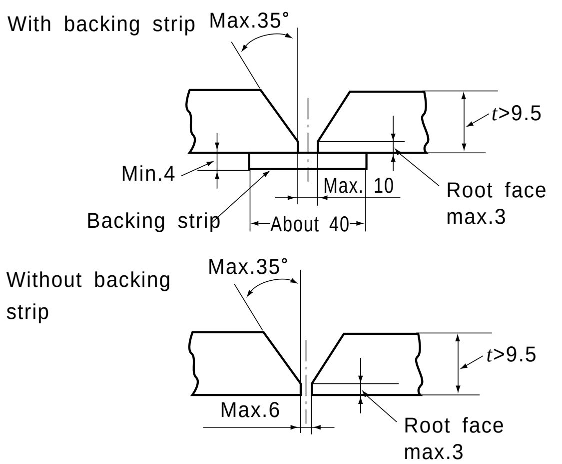
<tr><td>Mild steel and stainless steel</td><td rowspan="2">


</td><td>
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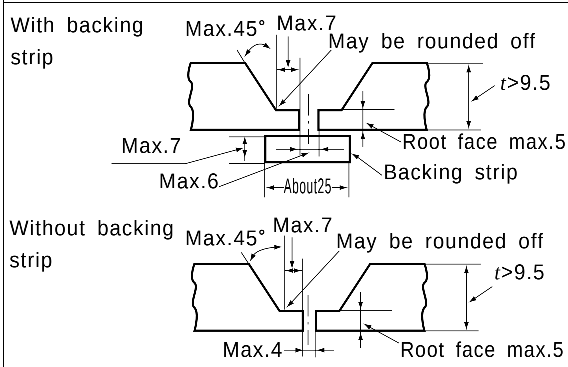
<tr><td>Aluminium alloys</td><td>
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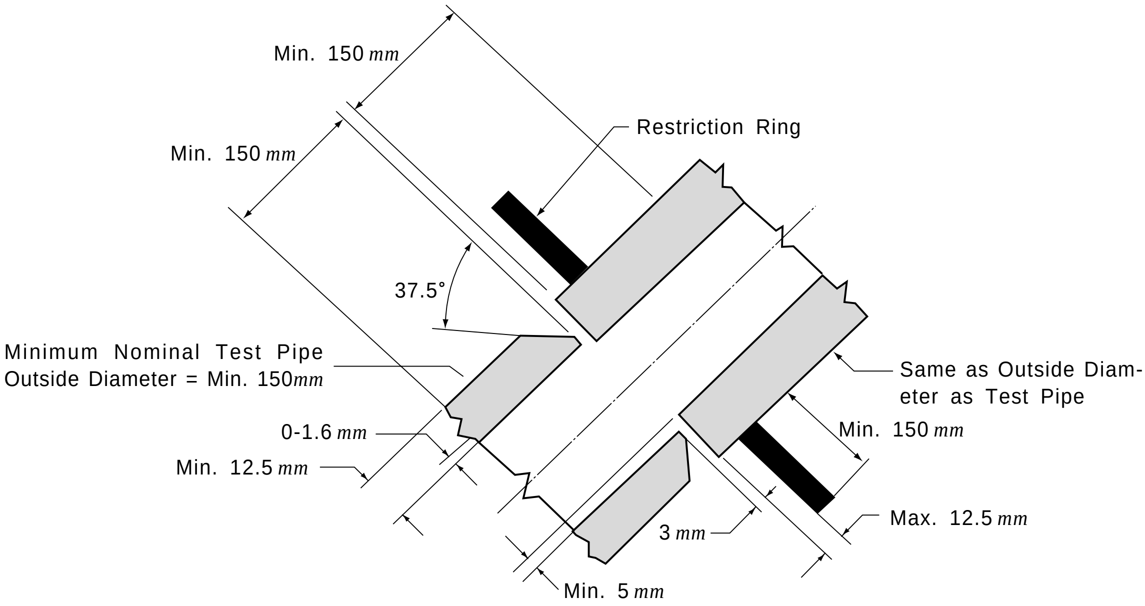
Fig. 2.2.16 Dimensions and Types of Test Assemblies for Pipes of Grade 3 (unit : *mm*)



T, K and Y connection(6GR-P)

Fig. 2.2.17 Dimensions and types of assemblies for pipes or Grade 3R

Table 2.2.13 Test Conditions for Roller Bend Test

Test assembly		Radius of plunger
Mild steel	Grade 1 pipe	$1.5t$
	Grade 1 plate Grate 2 plate Grate 3 plate Grade 2 pipe Grade 3 pipe	$2.0t$
Stainless steel	Grade 1 plate Grade 2 plate Grade 3 plate	
Aluminium alloys	Grade 1 pipe Grade 2 pipe Grade 3 pipe	$3\frac{1}{3}t$
NOTE: t : Thickness of test specimen		

SECTION 6
Welding Consumables

601. General

1. Application

(1) The electrodes for manual arc welding, the welding consumables for automatic welding, the wire for semi-automatic welding, the welding consumables for electro-slag and electro-gas welding and welding consumables for stainless steel and aluminium alloy to be used in welding various constructions specified in the Rules are to be approved by the Society in accordance with the requirements in this Section. The welding consumables for automatic welding prescribed in this Section are defined as the wireflux combinations for automatic submerged arc welding, the wire-gas combinations and flux-cored wires for automatic arc welding.

(2) The welding consumables which are used in welding processes differing from those specified in (1) or where it is considered impracticable to apply the requirements in this Section are to be of the type approved by the Society.

(3) The approval test for welding consumables which are not covered by this Chapter is to be left to the discretion of the Society.

2. Process of manufacture

The approved welding consumables are to be manufactured of uniform quality, under the manufacturer's responsibility, by the process approved by the Society, at works approved by the Society.

3. Approval test

(1) The approved welding consumables are subject to the approval tests and inspections specified in **602.** to **609.** in this Section.

(2) Welding consumables are to be approved at each manufacturing plant and for each brand. However, where are specified in (a) and/or (b) below, the content of approval tests may be partially reduced subject to approval by the Society.

(a) Where welding consumables which have been approved are intended to manufacture at manufacturing plants other than those of the manufacturers who manufacture the said welding consumables.

(b) Where welding consumables which have been approved are intended to manfacture according to technical licencing agreements with those parties who manufacture the said welding consumables.

(3) Tests specified in **602.** through **606.** and **609.** may be carried out on materials which have been approved and the grades relating to the strength or toughness may be changed accordingly. However, as a rule, the time for changes is to be limited to the time for annual inspection.

(4) Where deemed necessary by the Society, tests other than those specified in this Section may be required.

4. Periodical inspection

(1) Especially, as for the manufacturing firm of the controlled approved welding consumables, the methods of periodical inspection are to be adopted with the approval of the Society according to the methods of control of the firm as the periodical inspection.

(2) The facilities and processes of manufacturing approved welding consumables are to be inspected by the Surveyor in a period not exceeding 12 *months*.

5. Retests

(1) Where the tensile test and bend test fail to meet the requirements, twice as many test specimens as the number of specimens of failed test are to be selected from the first test material or from a test material welded under the same welding conditions, and if all of test specimens pass the tests, then the tests are considered to be successful.

(2) (a) Where the result of the impact test is unsatisfactory, additional tests may be carried out, with the exception of the cases specified in (i) and (ii) below, by taking a set of test specimens out of the same test material from which the above-mentioned test specimens have been taken.

(i) The absorbed energy of all test specimens is under the required average absorbed energy.

(ii) The abosorbed energy of two of the test specimens is under 70% the required average absorbed energy.

(b) In case of the previous (a), the test specimens may be accepted, provided that the average absorbed energy of the six test specimens, including those which have been rejected as unsatisfactory, is not less than the required average absorbed energy, and that not more than two individual results are lower than the required average absorb energy and of these, not more than one result is below 70% of the required average absorbed energy.

(3) Where the retest fails to meet the requirements, the test may be made over again with changed welding conditions. In this case, if the whole tests specified for the test assembly are carried out and are in compliance with the requirements, the test is accepted as successful.

6. Revocation of approval

In the following cases, the approval of welding consumables by the Society shall be revoked, after notice is given to the manufacturer:

(a) When the Society has recognized that the quality is remarkably worse than that approved or is not uniform.
(b) When the welding consumables have failed the requirements in the annual inspections.
(c) When the welding consumables are not inspected annually as required by the Rules.

7. Data

The Society may require the submission of the data with respect to the properties of welding consumables if necessary.

8. Packings and markings

(1) The approved welding consumables are to be packed throughly to keep the quality during their transportation and storage.
(2) All packages of approved welding consumables are to clearly marked with the following descriptions together with the approved mark of the Society.
  (a) Brand
  (b) Name of manufacturer
  (c) Kind of gas if used
  (d) Grade or mark of welding consumables
  (e) Electric current and its polarity
  (f) Welding positions
  (g) Date and number of production
  (h) Sizes (diameter of core wire, length of elect rode, grain size of flux for submerged arc welding, etc.)
  (i) Special notices on the treatment

602. Electrodes for manual arc welding for normal strength steels, higher strength steels and steels for low temperature service

1. Application

(1) Electrodes for manual arc welding for normal strength steels, higther strength steels and steels for low temperature service given in the following (a) and (b) (hereinafter referred to as "electrodes") are to be subjected to the approval test and annual inspections in accordance with the requirements in **602.**
  (a) Electrodes for manual welding
    (i) For butt welds
    (ii) For fillet welds
    (iii) For both butt welds and fillet welds
  (b) Electrodes used in gravity welding or similar set-ups
    (i) For fillet welds
    (ii) For both butt welds and fillet welds
(2) Any requirements regarding one side welding without backing are left to the discretion of the Society.

2. Grades and marks of electrode

(1) Electrodes are classified as specified in **Table 2.2.14.**

Table 2.2.14 Grades and Marks

For normal strength steel	For higher strength steel	For steel for low temperature service
RMW 1	*RMW* 52	*RMWL* 1
RMW 2	*RMW* 53	*RMWL* 2
RMW 3	*RMW* 54	*RMWL* 3
	RMW 52 *Y*40	*RMWL* 91
	RMW 53 *Y*40	*RMWL* 92
	RMW 54 *Y*40	

(2) For low hydrogen electrodes which have passed the hydrogen test specified in **Par 10**, the suffixes given in **Table 2.2.22** are to be added to the grade marks of the said electrodes. (e.g. *RMW*52*HHH*)

3. General provisions for tests

(1) Kinds of test, number, thickness and dimension of test assemblies, diameter of electrodes used for welding, welding positions, grades and number of test specimens to be taken from each test assmbly for electrodes given in **Par 1** (1) (a) (i) and (iii) are to be as given in **Table 2.2.15.** However, where deemed necessary by the Society, hot cracking tests may be required by the Society in addition to tests specified in this **Table.**
(2) Kinds of test, number, thickness and dimension of test assemblies, diameter of electrodes used for welding and welding positions, together with grades and number of test specimens to be taken from each test assembly for electrodes given in **Par 1** (1) (a) (ii), are to be as given in **Table 2.2.16.**
(3) Tests for electrodes given in **Par 1** (1) (b) are to be in accordance with the requirements in the following (a) and (b):
  (a) For electrodes given in **Par 1** (1) (b) (i), tests given in **Table 2.2.16** specified in the preceding (2) are to be conducted.
  (b) For electrodes given in **Par 1** (1) (b) (ii), tests specified in the preceding (a) and butt weld test given in **Table 2.2.15** specified in the preceding (1) are to be conducted.
(4) Where electrodes are intended to be used for both items specified in **Par 1** (1) (a) and (b), approval tests required for each electrode are to be conducted. However, deposited metal tests may be omitted for electrodes given in **Par 1** (1) (b).
(5) Steel plates to be used in preparation of test assemblies are to be as given in **Table 2.2.17** according to the grades of electrode.
(6) The welding conditions used such as amperage, voltage, travel speed, etc. are to be within the range recommended by the manufacturer for normal good welding practice. Where a filler metal is stated to be suitable for both alternating current (AC) and direct current (DC),

Table 2.2.15 Kinds of Test for Eiectrode

Kind of test	Test assembly: Welding position	Test assembly: Dimeter of electrode (*mm*)	Test assembly: No. of test assemblies	Test assembly: Dimensions of test assembly	Test assembly: Thickness (*mm*)	Kind and No. of test specimens taken from test assembly
Deposited metal test	Flat	4	1(1)	**Fig. 2.2.18**	20	Tensile test specimen : 1 Impact test specimen : 3
		max. diameter	1(1)			
Butt weld test	Flat	First run. 4; Subsequent runs:5 or over; Last two runs. max. dia.	1	**Fig. 2.2.19**	15~20	Tensile test specimen : 1 Face bend specimen : 1 Root bend specimen : 1 Impact test specimen : 3(5)
		First run. 4; Second run,5 or 6; Subsequent runs. max. dia.	1(2)			
	Horizon-tal(4)	First run. 4 or 5 Subsequent runs, 5	1			
	Vertical upward	First run. 3.2; Subsequent runs. 4 or 5	1			
	Vertical down-ward	(3)	1			
	Over-head	First run. 3.2; Subsequent runs. 4 or 5	1			
Fillet weld test(6)	Horizon-tal-verti-cal	One side; max. dia. The other side; min. dia.	1	**Fig. 2.2.20**	20	Macro structure test specimen : 3(8) Hardness test specimen : 3(8) Fracture test specimen : 2
Hydrogen test(7)	Flat	4	4	(9)	12	Hydrogen test specimen : 1

NOTES:
(1) Where the diameter of the manufactured electrodes is of one type, there is to be one test assembly.
(2) Where the tests are conducted solely in the downhand position, this test assembly has been added.
(3) Electrodes with diameters specified by the manufacturers are to be used.
(4) For electrodes which have passed butt weld tests in the downhand and vertical upward positions, test in the horizontal position may be omitted subject to approval by the Society.
(5) Impact tests are not to conduct for overhead welds.
(6) This test is added solely for electrodes used in both butt welds and fillet welds.
(7) This test is to conduct solely for low hydrogen electrodes.
(8) Test specimens used in macro structure test and hardness tests are considered to be the same.
(9) Dimensions of test assembly are to be as specified in **602.4** (3).

Table 2.2.16 Kinds of Test for Electrode

Kind of test	Test assembly: Welding position	Test assembly: Diameter of electrode (*mm*)	Test assembly: No. of test assemblies	Test assembly: Dimensions of test assembly	Test assembly: Thickness (*mm*)	Kind and No. of test specimens taken from test assembly
Deposited metal test	Flat	4	1	**Fig. 2.2.18**	20	Tensile test specimen : 1 Impact test specimen : 3
		max. diameter	1			
Fillet weld test	Flat	One side; max. dia. The other side; min. dia.	1	**Fig. 2.2.20**	20	Macro structure test specimen : 3(1) Hardness test specimen : 3(1) Fracture test specimen : 2
	Horizontal-vertical		1			
	Vertical upward		1			
	Vertical downward		1			
	Overhead		1			
Hydrogen test(2)	Flat	4	4	(3)	12	Hydrogen test specimen : 1

NOTES:
(1) Test specimens used in macro tests and hardness tests are considered to be the same.
(2) This test is to conduct solely for low hydrogen electrodes.
(3) Dimensions of test assmbly are to be as specified in **602.4** (3).

Table 2.2.17 Grade of Steels used for Test Assembly

Grade of electrode	Grade of steels used for test assembly(1) (2)
RMW1	RA
RMW2	RA, RB or RD
RMW3	RA, RB, RD or RE
RMW52	RA32, RA36, RD32 or RD36
RMW53	RA32, RA36, RD32, RD36, RE32 or RE36
RMW54	RA32, RA36, RD32, RD36, RE32, RE36 RF32 or RF36
RMW52Y40	RA40 or RD40
RMW53Y40	RA40, RD40 or RE40
RMW54Y40	RA40, RD40 RE40 or RF40
RMWL1	RE or RL24A
RMWL2	RE, RL24A, RL24B, RL27 or RL33
RMWL3	RL27, RL33 or RL37
RMWL91	RL9N53 or RL9N60
RMWL92	RL9N53 or RL9N60

NOTES:
(1) Notwithstanding the requirements in this Table normal strength or higher strength steel may be used for the deposited metal test assembly. In this case, test assemblies of grade RMWL91 and RMWL92 are to be appropriately buttered.
(2) The tensile strength of higher strength steels RA32, RD32, RE32 and RF32 used in butt weld test assemblies is to be greater than 490 N/mm^2.

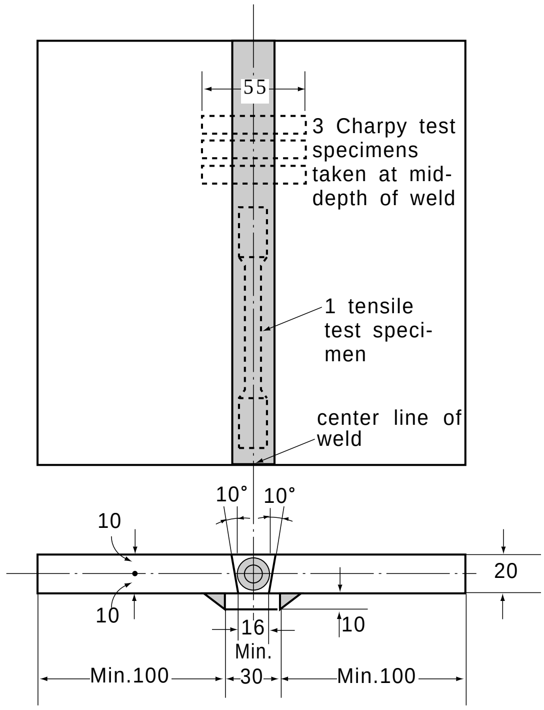


Fig. 2.2.18 Deposited Metal Test Assembly for Electrode for Manual Arc Welding (unit : mm)

AC is to be used for the preparation of the test assemblies.

(7) For the approval of electrodes, the tests specified in the preceding (1) to (4) are to be conducted for each brand of electrodes.

4. Welding of test assemblies

(1) Deposited metal test assemblies
   (a) Test assembly as shown in **Fig. 2.2.18** is to be welded in the downhand position according to the normal practice.
   (b) Test assembly is to be welded in single or multi-run layers welding, and the direction of each run is to alternate from each end of the plate, each run of weld metal being not less than 2 mm but not more than 4 mm thick.
   (c) After each run, the test assembly is to be left in still air until it has cooled to less than 250°C but not below 100°C, the temperature being taken at the centre of the weld on the surface of seam.

(2) Butt weld test assemblies
   (a) Test assembly as shown in **Fig. 2.2.19** is to be welded in each welding position (flat, horizontal-vertical, vertical-upward, vertical downward and overhead) which is recommended by the manufacturer, according to the normal practice.
   (b) Test assembly is to be left in still air until it has cooled to less than 250°C but not below 100°C, the temperature being taken at the centre of the weld on the surface of seam.
   (c) In all cases, the back sealing runs are to be made with 4 mm electrode in the welding position appropriate to each test assembly, after cutting out the root run to clean metal. For electrodes suitable for downhand welding only, the test assemblies may be turned over to carry out the back sealing run.

(3) Hydrogen test assemblies
   (a) As a rule, mild and high tensile steels are to be used for the test assembly, and four test specimens are to be prepared measuring 12 mm by 25 mm in cross section by about 125 mm in length. Before welding, the specimens are to be weighed to the nearest 0.1 $gram$. On the 25 mm surface of each test specimen, a sigle bead of welding is to be deposited, about 100 mm in length, by a 4 mm electrode, using about 150mm of the electrode. The welding is to be carried out with as short an arc as possible and with a current of about 150 amp.

(b) The electrodes, prior to welding, can be submitted to the normal drying process recommended by the manufacturer.

(4) Fillet weld test assemblies

(a) Test assembly as shown in **Fig. 2.2.20** is to be welded in each welding position (flat, horizon-vertical, vertical-up ward, vertical-downward and overhead) which is recommended by the manufacturer.

(b) The first side is to be welded using the maximum size of electrode manufactured and the second side is to be welded using the minimum size of electrode manufactured.

(c) The leg length of fillet welds may be of suitable size.

(d) In case of fillet welds using gravity or similar contact welding method, the fillet welding is to be carried out with electrodes of maximum length.

(5) After welding, the test assemblies are not to be subjected to any heat treatment.

(6) It is recommended that the welded assemblies be subjected to a radiographic examination to ascertain that there are any defects in the weld prior to the preparation of test specimens.

5. Deposited metal tensile test

(1) The tensile test specimen, one from each test assembly, is to be machined to dimensions $R14$ test specimen as shown in **Table 2.2.1**, care being taken that the longitudinal axis coincides with the centre of weld and the mid-thickness of plates.

(2) The tensile test specimen may be subjected to a temperature not exceeding 250°C for a period not exceeding 16 *hours* for hydrogen removal prior to testing.

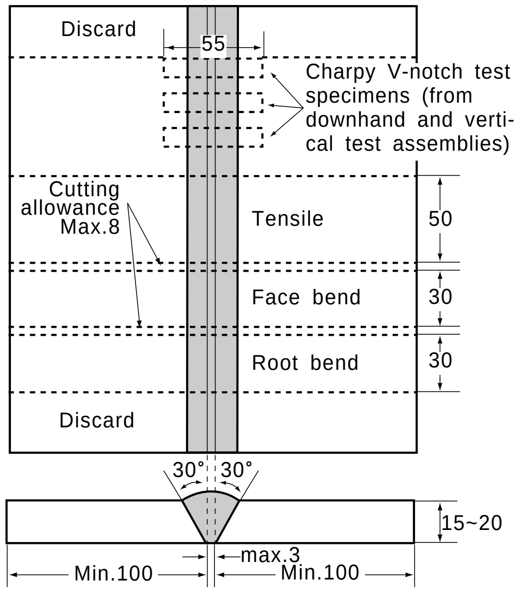
(3) The tensile strength, yield strength and elongation of each test specimen are to comply with the requirements given in **Table 2.2.18**, where the upper limit of tensile strength is exceeded, special consideration will be given to the approval of the electrode, taking into consideration of the other mechanical properties shown in the test results and the chemical composition of deposited metal.

6. Deposited metal impact tests

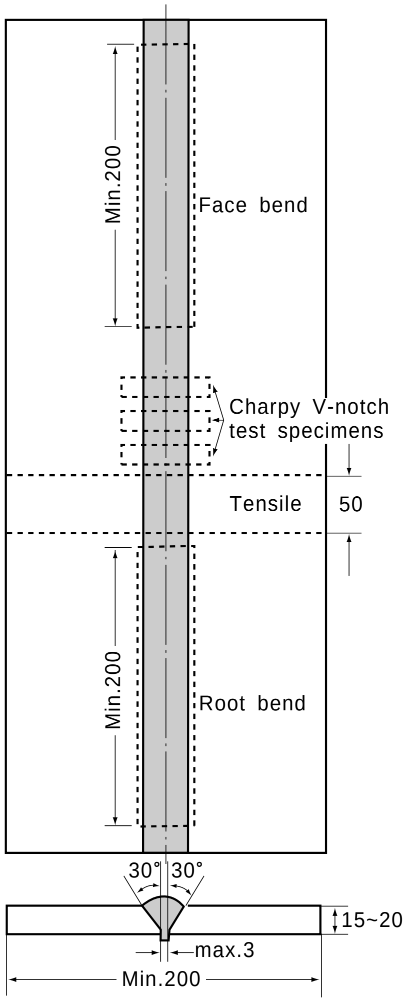
(1) One set of three impact test specimens, from each test assembly, are to be machined to dimensions $R4$ test specimens as shown in **Table 2.1.3.** The test specimen is to be cut with its longitudinal axis transverse to the direction of welding, and the test specimen is to coincide with the mid-thickness of the plate shown in **Fig. 2.2.21.**

(2) The notch is to be positioned in the centre of weld and is to be cut in the face of test specimens perpendicular to the surface of plate.

(3) Test temperature and average absorbed energy are to comply with the requirements given in **Table 2.2.19.**

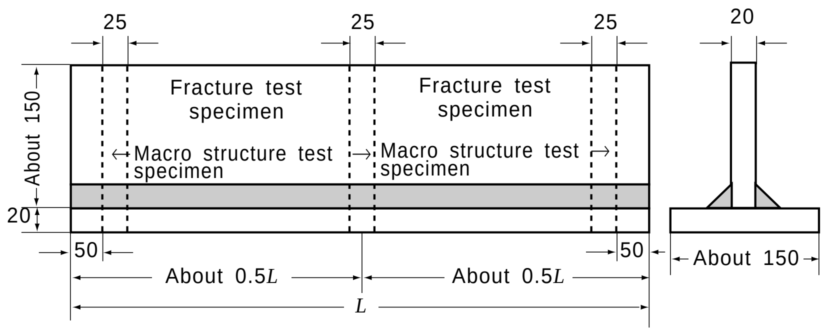


(a) For Other Grades than (b)



(b) For $RMWL91$ or $RMWL92$

Fig. 2.2.19 Butt weld Test Assembly for Electrode for Manual Arc Welding (Unit : *mm*)



(The length of the test assemblies L is to be sufficient to allow at least the deposition of the entire length of the electrode being tested.)

Fig. 2.2.20 Fillet Weld Test Assembly (Unit : *mm*)

Table 2.2.18 Tensile Test Requirements for Deposited Metal

Grade of electrode	Tensile strength (N/mm^2)	Yield strength (N/mm^2)	Elongation (%)
RMW 1 *RMW* 2 *RMW* 3	400~560	305 min	22 min
RMW 52 *RMW* 53 *RMW* 54	490~660	375 min	22 min
RMW 52*Y*40 *RMW* 53*Y*40 *RMW* 54*Y*40	510~690	400 min	22 min
RMWL 1	400~560	305 min	22 min
RMWL 2	440~610	345 min	22 min
RMWL 3	490~660	375 min	21 min
RMWL 91	590 min	375 min(1)	25 min
RMWL 92	660 min	410 min(1)	25 min

NOTE:
(1) 0.2% Yield strength

(4) When the absorbed energy of two or more test specimens among a set of test specimens is less in value than the specified average absorbed energy or when the absorbed energy of a single test specimen is less in value than 70% of the specified average absorbed energy, the test is considered to have failed.

7. Butt weld tensile tests

(1) The tensile test specimen is to be R2A specimen shown in **Table 2.2.1** and the test specimen is to be taken from each test assembly.
(2) The surface of weld is to be machined flush with the surface of plate.
(3) The tensile strength of test specimen is to comply with the requirements given in **Table**

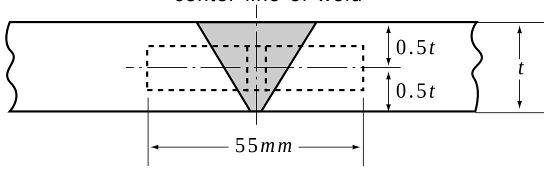


Fig. 2.2.21 Position of Butt Weld Impact Test Specimen (Unit: *mm*, *t* : plate thickness)

Table 2.2.19 Impact Test Requirements for Deposited Metal

Grade of electrode	Test temp.(°C)	Average absorbed energy(*J*)
RMW 1	20	47 min.
RMW 2	0	
RMW 3	− 20	
RMW 52	0	
RMW 53	− 20	
RMW 54	− 40	
RMW 52*Y*40	0	
RMW 53*Y*40	− 20	
RMW 54*Y*40	− 40	
RMWL 1	− 40	34 min.
RMWL 2	− 60	
RMWL 3	− 60	
RMWL 91	− 196	27 min.
RMWL 92	− 196	

2.2.20.

8. Butt weld bend test

(1) The face and root bend test specimens are to be *RB*4 specimen shown in **Table 2.2.2**, and test specimens are to be taken from each test assembly. However, for *RMWL*91 or *RMWL*92, the face and root bend specimens are to be *RB*1 specimen shown in **Table 2.2.2**, and test

Table 2.2.20 Tensile Test Requirements for Butt weld

Grade of electrode	Tensile strength (N/mm^2)
RMW 1, RMW 2, RMW 3	400 min.
RMW 52, RMW 53, RMW 54	490 min.
RMW 52Y40, RMW 53Y40 RMW 54Y40,	510 min.
$RMWL$ 1	400 min.
$RMWL$ 2	440 min.
$RMWL$ 3	490 min.
$RMWL$ 91	630 min.
$RMWL$ 92	670 min.

specimens are to be taken longitudinally from each test assembly.

(2) The test specimens are to be capable of withstanding, without crack exceeding 3 mm long on the outer surface of other defects, being bent through an angle of 120 *degrees* over a former having a radius of 1.5 *times* the thickness of test specimen. The radius and angle of the former for $RMWL$91 and $RMWL$92, however, are to be 2 *times* the thickness of the specimen and 180 *degrees* respectively.

9. Butt weld impact tests

(1) One set of three impact test specimens, from each test assembly, are to be machined to dimensions R4 test specimens as shown in **Table 2.1.3.**

(2) The test specimens are to be prepared as shown in **Fig. 2.2.21** and the dimensions, form, position and direction of notches are to be as specified in **Par 6.**

(3) Test temperature and average absorbed energy are to comply with the requirements given in **Table 2.2.21**, appropriate to the grades of the electrode and welding position.

(4) The requirements in the preceding 6 (4) are to correspondingly apply to this Paragraph.

10. Hydrogen test

(1) The hydrogen test is to be carried out through the glycerine method, mercury method or other methods deemed appropriate by the Society.

(2) Average diffusible hydrogen contents of the four specimens is to comply with the requirements given in **Table 2.2.22** according to the test procedures specified in preceding (1) or the type of suffixes to be added to the grade marks.

11. Fillet weld macro-structure test

(1) For macro-structure test specimens, those with breadths of 25 mm are selected from three places shown in **Fig. 2.2.20.**

(2) The macro-etching test is conducted on the transverse section of fillet weld joint and welded joints are to be free from excessive difference of leg length between upper and lower, cracks and other injurious defects.

Table 2.2.21 Impact Test Requirements for Butt Weld

Grade of electode	Test temp(°C)	Average absorbed energy (J)	
		Flat, Horizontal, Overhead	Vertical upward Vertical downward
RMW 1	20	47 min.	34 min.
RMW 2	0		
RMW 3	− 20		
RMW 52	0		
RMW 53	− 20		
RMW 54	− 40		
RMW 52Y40	0		41 min.
RMW 53Y40	− 20		
RMW 54Y40	− 40		
$RMWL$ 1	− 40	27 min.	27 min.
$RMWL$ 2	− 60		
$RMWL$ 3	− 60		
$RMWL$ 91	− 196		
$RMWL$ 92	− 196		

Table 2.2.22 Requirements for Hydrogen Contents ($cm^3/100g$)

Mark	Mercury method	Glycerine method
H	15 max.	10 max.
HH	10 max.	5 max.
HHH	5 max.	—

12. Fillet weld hardness test

The hardness of weld metal, heat affected zone and base metal are to be measured at places given in **Fig. 2.2.22** for each test specimen which underwent the macro-etching test specified in **Par 11.** and the respective hardnesses are to be in accordance with those deemed appropriate by the Society.

13. Fillet weld fracture test

(1) One of the remaining sections of the fillet weld is to have the weld on the first side gouged or machined to facilitate breaking the fillet weld as shown in **Fig. 2.2.23**, on the second side by closing the two plates together, submitting the root of the weld to tension. On the other remaining section the weld on the second side is to be gouged or machined and the section fractured using the same procedure.

(2) The fractured surfaces are to be examined and there should be no evidence of incomplete penetration, or internal cracking and they should

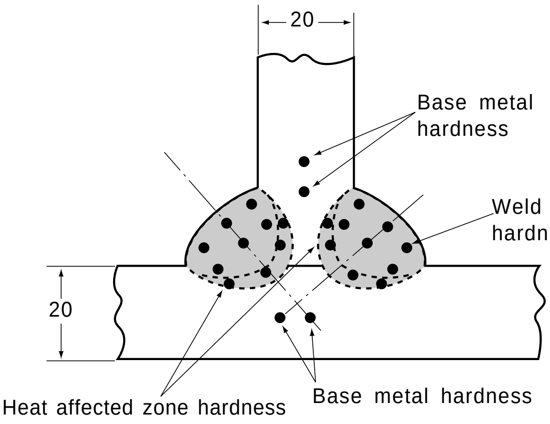


Fig. 2.2.22 Hardness Test (Unit: *mm*)

be reasonably free from porosity.

14. Annual inspections

(1) In the annual inspections, tests specified in the following (2) and (3) are to be conducted for each brand of the approved electrodes and they are to be passed satisfactorily.

(2) The kinds of test, etc. in the annual inspections for manual arc welding electrodes are to be as given in **Table 2.2.23.**

(3) The kinds of test, etc. in the annual inspections of electrodes used in gravity welding or other welding using similar welding devices are to be as given in **Table 2.2.24.**

(4) The welding procedures and requirements for test assemblies of tests specified in the preceding (2) and (3) are to be as specified in **Pars 4** through **9.**

15. Changes in grades

(1) Where changes in the grades relating to the strength or toughness of electrodes approved are to be made, tests specified in the following (2) and (3) are to be carried out and satisfactorily passed in accordance with the requirements in **601.3** (3).

(2) For changes in the grades relating to strength, the butt weld tests, specified in the annual inspection of **Par 14** and in the requirements of **Par 3** (1), are to be conducted.

(3) For changes in the grades relating to toughness, the butt weld impact tests, specified in the annual inspection of **Par 14** and in the requirements of **Par 3** (1), are to be conducted.

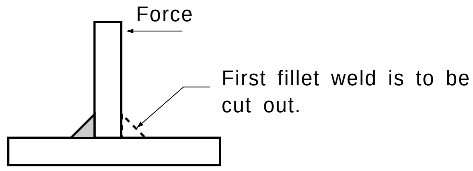


Fig. 2.2.23 Fracture Test

603. Automatic welding consumables for normal strength steels, higher strength steels and steels for low temperature service

1. Application

(1) Welding consumables for normal strength steels, higher strength steels and steels for low temperature service given in the following (a) through (c) (hereinafter referred to as "automatic welding consumables") are to be subjected to the approval tests and annual inspections in accordance with the requirements in **603.**

(a) Submerged arc automatic welding consumables

Table 2.2.23 Kind of Test for Annual Inspection

Kind of test(2)	Test assembly					Kind and no. of test specimens taken from test assembly
	Welding position	Diameter of electrode (*mm*)	Number	Dimensions	Thickness (*mm*)	
Deposited metal test	Flat	4(1)	1	**Fig.2.2.18**	20	Tensile test specimen : 1 Impact test specimen : 3
		exceeding 4, 8 max.	1			

NOTES:
(1) Where deemed necessary by the Society, butt weld tests in the downhand or vertical (either upward or downward) welding position specified in **Table 2.2.15** may be requested in place of deposited metal tests of 4 *mm* diameter electrodes. In this case, impact test specimens (one set of three) are to be selected.
(2) For low hydrogen electrodes, an hydrogen test can also be required at the discretion of the Society.

Table 2.2.24 Kind of Test for Annual Inspection

Kind of test	Test assembly					Kind and no. of test specimens taken from test assembly
	Welding position	Diameter of electrode (*mm*)	Number	Dimensions	Thickness (*mm*)	
Deposited metal test	Flat	4 min.	1	**Fig.2.2.18**	20	Tensile test specimen : 1 Impact test specimen : 3

(b) Gas shielded arc automatic welding consumables(Flux cored wire and solid wire automatic welding consumables with shielding gas)

(c) Self-shielded arc automatic welding consumables(solid wire and Flux cored wire automatic welding consumables without shielding gas).

(2) Approval tests and annual inspections for automatic welding consumables of multiple electrodes are to be as deemed appropriate by the Society.

2. Grades and marks

(1) The automatic welding consumables are classified as specified in **Table 2.2.25.**

Table 2.2.25 Grade and Marks

For normal strength steel	For higher strength steel	For steel for low temperature service
RAW 1 *RAW* 2 *RAW* 3	*RAW* 51, *RAW* 52, *RAW* 53, *RAW* 54, *RAW* 52*Y*40 *RAW* 53*Y*40 *RAW* 54*Y*40	*RAWL* 1 *RAWL* 2 *RAWL* 3 *RAWL* 91 *RAWL* 92

(2) Automatic welding materials which have passed the tests for each welding process given in **Table 2.2.28** are to be appended with the suffixes shown in **Table 2.2.26** at the end of their marks.

Table 2.2.26 Marks

Welding technique	Mark
Multi-run technique(1)	*M*
Two-run technique(2)	*T*
Multi-run and two-run technique	*TM*

NOTES:
(1) Multi-run technique refers to a welding process involving multiple passes.
(2) Two-run technique refers to a welding process involving a single pass on both sides.

(3) In the preceding (2), a suffix *G* will be added to the grade mark for gas shielded arc automatic welding consumables, and a suffix *N* will be added for self-shielded wire automatic welding consumables Further, the type of gas used is to be as specified in **Table 2.2.27**, and the suffix given in **Table 2.2.27** will be added after the suffix *G*. (e.g. *RAW*53 *TMG* (*M*1))

3. General provisions for tests

(1) Kinds of test, number, thickness and dimensions of test assemblies, grades and number of test specimens to be taken from each test assembly for automatic welding consumables are to be as given in **Table 2.2.28.**

(2) Steel plates to be used for test assemblies are to be as given in **Table 2.2.29,** appropriate to the kind of automatic welding consumables.

(3) For the approval of automatic welding consumables, the tests specified in the preceding (1) are to be conducted for each brand of automatic welding consumables.

(4) For gas shielded arc automatic welding consumables, the test in the preceding (3) is to be performed for each type of gas given in **Table 2.2.27.** When the manufacturer of the material recommends gas types of the group of *M*1, *M*2, *M*3 or *C* in **Table 2.2.27** and the test is satisfactorily conducted in accordance with the preceding (3) on one of the gas type, the test on the other gas types belonging to the same group is allowed to be dispensed with at the discretion of the Society.

(5) The welding conditions used such as amperage, voltage, travel speed, etc. are to be within the range recommended by the manufacturer for normal good welding practice. Where a filler metal is stated to be suitable for both alternating current (AC) and direct current (DC), AC is to be used for the preparation of the test assemblies.

Table 2.2.27 Kinds of Gas

Group	Type	Gas composition (Vol.%)			
		CO_2	O_2	H_2	Ar
*M*1	*M*11	1~5	–	1~5	Rest
	*M*12	1~5	–	–	Rest
	*M*13	–	1~3	–	Rest
	*M*14	1~5	1~3	–	Rest
*M*2	*M*21	6~25	–	–	Rest
	*M*22	–	4~10	–	Rest
	*M*23	6~25	1~8	–	Rest
*M*3	*M*31	26~50	–	–	Rest
	*M*32	–	11~15	–	Rest
	*M*33	6~50	9~15	–	Rest
C	*C*1	100	–	–	–
	*C*2	Rest	1~30	–	–
I	*I*1	–	–	–	100
E	*E*1	Except above			

4. Welding of test assemblies

(1) Deposited metal test assemblies with multi-run technique

(a) Test assemblies as shown in **Fig. 2.2.24** are to be welded in the flat position by multirun technique according to the normal practice. The direction of deposition of each run is to alternate from each end of

Table 2.2.28 Kinds of Test of Automatic Welding Consumables

Welding technique[7]	Kind of test[8]		Grade of welding consumables	Test assembly			Kinds and no. of test specimens taken from test assembly
				Number	Dimensions	Thickness(mm)[3]	
Multi-run technique	Deposited metal test		RAW1, RAW54Y40 RAW2, RAW3, RAW51, RAW52, RAWL1 RAW53, RAWL2 RAW54, RAWL3 RAW52Y40, RAWL91 RAW53Y40, RAWL92	1	**Fig. 2.2.24**	20	Tensile test specimen: 2 Impact test specimen: 3
	Butt weld test			1[4]	**Fig. 2.2.25**	20~25	Tensile test specimen: 2[4] Face bend test specimen: 2[4][6] Root bend test specimen: 2[4][6] Impact test specimen: 3
Two-run technique	Butt weld test	Submerged arc welding	RAW1, RAW51	1	**Fig. 2.2.26**	12~15	Tensile test specimen: 2 Longitudinal tensile test specimen: 1[5] Face bend test specimen: 1 Root bend test specimen: 1 Impact test specimen: 3
				1		20~25	
			RAW2, RAW52Y40 RAW3, RAW53Y40 RAW52, RAW54Y40 RAW53, RAW54,	1		20~25	Tensile test specimen: 2 Longitudinal tensile test specimen: 1[5] Face bend test specimen: 1 Root bend test specimen: 1 Impact test specimen: 1
				1		30~35	
		Gas shieled and self-shielded arc welding	RAW1, RAW2, RAW3, RAW51, RAW52 RAW53, RAW54 RAW52Y40, RAW 53Y40, RAW54Y40	1		12~15[1] 20[2] 20~25[1]	Tensile test specimen: 2 Longitudinal tensile test specimen: 1[5] Face bend test specimen: 1 Root bend test specimen: 1 Impact test specimen: 3
				1		acceptable maximum thickness	
	Butt weld test		RAWL1 RAWL2 RAWL3 RAWL91 RAWL92	1		12~15	Tensile test specimen: 2 Longitudinal tensile test specimen: 1[5] Face bend test specimen: 1 Root bend test specimen: 1 Impact test specimen: 3
				1		20 or acceptable maximum thickness	

NOTES:
(1) Thickness of test assemblies where applied maximum plate thickness is not more than 25 mm.
(2) Thickness of test assemblies where applied maximum plate thickness is more than 25 mm.
(3) Where thickness is restricted by welding process, thickness of test assemblies may be changed upon approval of the Society. In this case, the maximum test thickness is taken as the maximum applicable thickness.
(4) The number of butt weld test assemblies for multi-run gas shielded and self-shielded arc welding techniques is to be one for each welding position. However, where there is more than one welding position, the number of tensile test specimens and bend test specimens selected from the test assemblies for each welding position may be half of the specified number.
(5) Test specimens are to be selected from only the thicker of two test assemblies.
(6) The number of face bend and root bend test specimens selected from the butt weld test assemblies for RAWL 91 and FAWL92 is to be one each.
(7) Tests on both multi-run and two-run technique are to be conducted for multi-run and two-run welding respectively, and the number, dimensions and thickness of test assemblies, along with the grades and number of test specimens selected from each test assembly are to be according to each of the welding processes. However, the number of tensile test specimens in the deposited metal test for the multi-pass welding technique is to be one.
(8) The hydrogen test may be applied by request of the manufacturer.

the plate and the thickness of layer is not to be less than the diameter of wire nor less than 4 mm whichever is the greater for submerged arc automatic welding consumables. For gas shield and self-shielded are automatic welding consumables the thickness of layer is not to be less than 3 mm.

(b) After each run, the test assembly is to be left in still air until it has cooled to less

Table 2.2.29 Grades of Steel used for Test Assembly

Grade of welding consumable	Grade of steel used for test assembly(1)(2)
RAW 1	*RA*
RAW 2	*RA*, *RB* or *RD*
RAW 3	*RA*, *RB*, *RD* or *RE*
RAW 51	*RA* 32 or *RA* 36
RAW 52	*RA* 32, *RA* 36, *RD* 32 or *RD* 36
RAW 53	*RA* 32, *RA* 36, *RD* 32, *RD* 36, *RE* 32 or *RE* 36
RAW 54	*RA* 32, *RA* 36, *RD* 32, *RD* 36, *RE* 32, *RE* 36 *RF* 32 or *RF* 36
RAW 52*Y*40	*RA* 40, *RD* 40
RAW 53*Y*40	*RA* 40, *RD* 40 or *RE* 40
RAW 54*Y*40	*RA* 40, *RD* 40, *RE* 40 or *RF* 40
RAWL 1	*RE* or *RL* 24*A*
RAWL 2	*RE*, *RL* 24A, *RL* 24B, *RL* 27 or *RL* 33
RAWL 3	*RL* 27, *RL* 33 or *RL* 37
RAWL 91	*RL* 9*N* 53 or *RL* 9*N* 60
RAWL 92	*RL* 9*N* 53 or *RL* 9*N* 60

NOTES:
(1) Notwithstanding the requirements in this Table, normal strength steel or higher strength steels may be used for deposited metal test assembly In this case, test assemblies of grade *RAWL*91 and *RAWL*92 are to be appropriately buttered.
(2) The tensile strength of higher strength steels *RA*32, *RD*32, *RE*32 and *RF*32 used in butt weld test assemblies is to be greater than 490 N/mm^2.

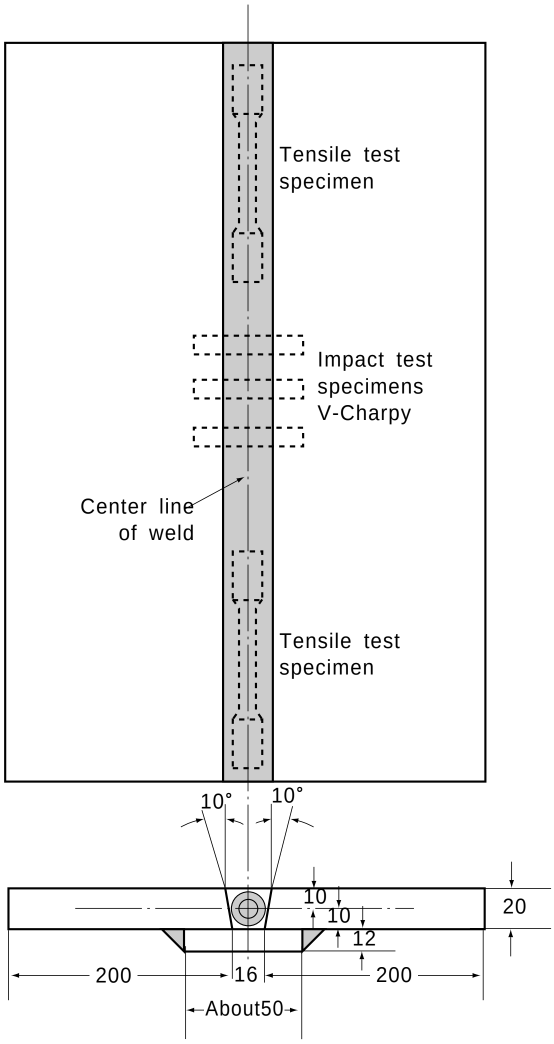


Fig. 2.2.24 Deposited Metal Test Assembly with Multi-run Technique (Automatic Welding, Unit : *mm*)

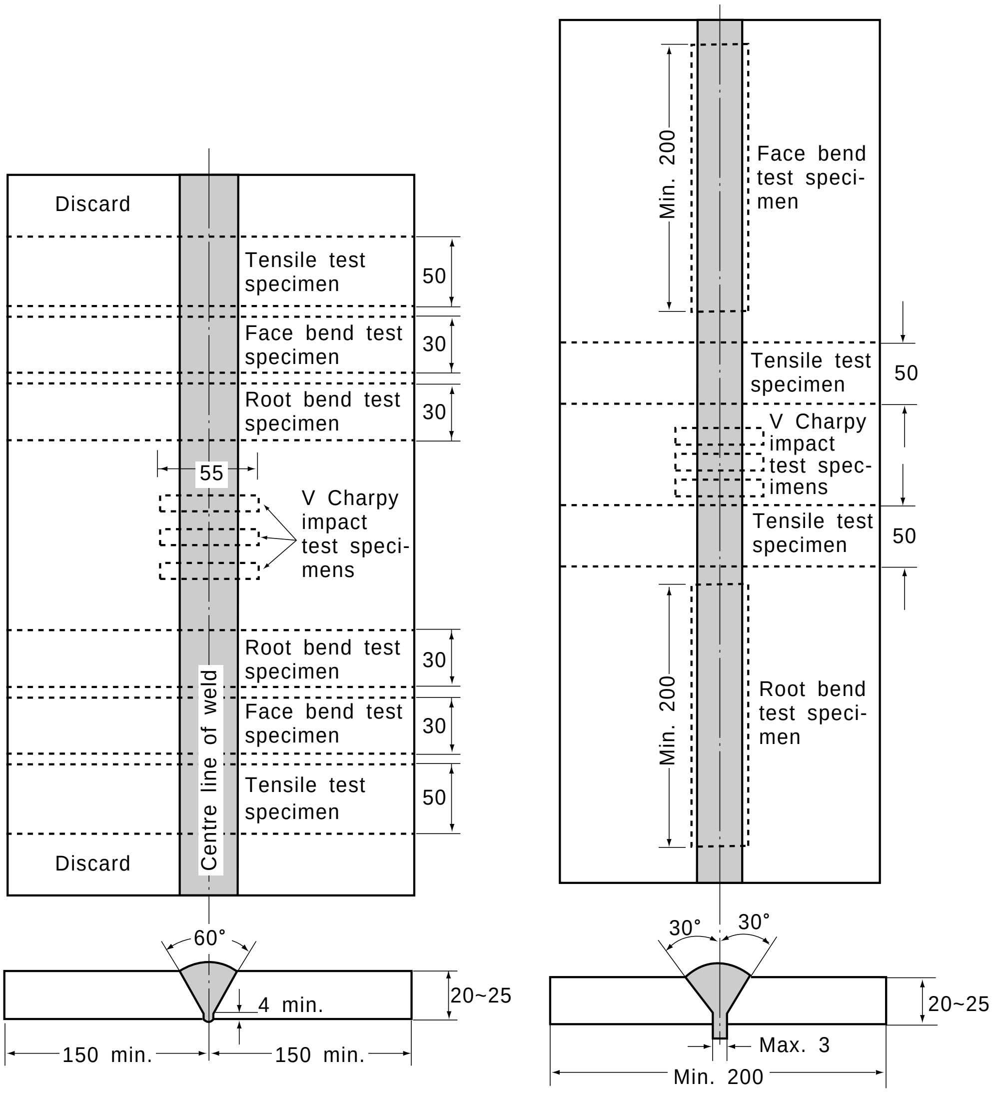
than 250°C but not below 100°C, the temperature being taken at the centre of the weld on the surface of seam.

(2) Butt weld test assemblies with multi-run technique
(a) The face side of the test assemblies as shown in **Fig. 2.2.25** is to be multi-pass welded in flat position, and the corresponding welding procedure is to follow the requirements of the preceding (1). However, for gas shield arc and self shielded arc wire automatic welding consumables, the welding position is to be as specified by the manufacturer.
(b) After completing the face welding in downhand position, back welding is performed. In this instance, back chipping may be carried out to expose sound deposited metal at the root.

(3) Butt weld test assemblies with two-run technique
(a) Test assemblies are to be prepared as shown in **Fig. 2.2.26**, and the diameter of wire and edge preparation are to be as shown in **Fig. 2.2.27**, but some deviation may be allowed where accepted by the Society.
(b) Test assemblies are to be welded according to the normal practice in downhand position by two-run technique where each run is to be started alternately from each end of the plate. After completing the first run, the assembly is to be left in still air until it has cooled to 100°C or below, the temperature being taken at the centre of weld on the surface of seam.

(4) After welding, the test assemblies are not to be subjected to any heat treatment.

(5) It is recommended that the welded assemblies be subjected to a radiographic examination to ascertain that there are any defects in the weld prior to the preparation of test specimens.



(a) For Other grades than (b)

(b) For *RAWL*91 or *RAWL*92

Fig 2.2.25 Butt Weld Test Assembly with Multi-run Technique (Automatic welding, Unit : *mm*)

5. Deposited metal tensile test with multi-run technique

(1) The tensile test specimens, two from each test assembly, are to be machined to dimensions *R*14 test specimen as shown in **Table 2.2.1**, care being taken that the longitudinal axis coincides with the centre of weld and the mid-thickness of plates.

(2) The tensile strength, yield point and elongation of each test specimen are to comply with the requirements given in **Table 2.2.30**, where the upper limit of tensile strength is exceeded, special consideration will be given to the approval of the electrode, taking into consideration of the other mechanical properties shown in the test results and the chemical composition of deposited metal.

(3) The tensile test specimens may be subjected to a temperature not exceeding 250°C for a period not exceeding 16 *hours* for hydrogen removal prior to testing.

6. Deposited metal impact test with multi-run technique

(1) One set of three impact test specimens, from each test assembly, are to be machined to dimensions *R*4 test specimen as shown in **Table 2.1.3.** The test specimen is to be cut with its longitudinal axis transverse to the direction of welding, and the test specimen is to coincide with the mid-thickness of the plate shown in **Fig. 2.2.21.**

(2) Test temperature and average absorbed energy are to comply with the requirements given in **Table 2.2.31.**

(3) The notch is to be positioned in the centre of weld and is to be cut in the face of test specimens perpendicular to the surface of plate.

(4) When the absorbed energy of two or more test specimens among a set of test specimens is less in value than the specified average absorbed energy or when the absorbed energy of a single test specimen is less in value

Table 2.2.30 Tensile Test Requirements for Deposited Metal

Grade of welding material	Tensile strength (N/mm^2)	Yield strength (N/mm^2)	Elongation (%)
RAW 1 RAW 2 RAW 3	400~560	305 min.	22 min.
RAW 51 RAW 52 RAW 53 RAW 54	490~660	375 min.	22 min.
RAW 52Y40 RAW 53Y40 RAW 54Y40	510~690	400 min.	22min.
RAWL 1	400~560	305 min.	22 min.
RAWL 2	440~610	345 min.	22 min.
RAWL 3	490~660	375 min.	21 min.
RAWL 91	590 min.	375 min.(1)	25 min.
RAWL 92	660 min.	410 min.(1)	25 min.

NOTE:
(1) 0.2% yield stress

Table 2.2.31 Impact Test Requirements for Deposited Metal

Grade of welding material	Test temp.(°C)	Average absorbed energy (J)
RAW 1	20	34 min.
RAW 2	0	
RAW 3	− 20	
RAW 51	20	
RAW 52	0	
RAW 53	− 20	
RAW 54	− 40	
RAW 52Y40	0	41 min.
RAW 53Y40	− 20	
RAW 54Y40	− 40	
RAWL 1	− 40	27 min.
RAWL 2	− 60	
RAWL 3	− 60	
RAWL 91	− 196	
RAWL 92	− 196	

than 70% of the specified average absorbed energy, the test is considered to have failed.

7. Butt weld tensile test with multi-run technique

(1) The tensile test specimens are to be prepared to $R2A$ specimen shown in **Table 2.2.1** and two test specimens are to be taken from each test assembly.

(2) The surface of weld is to be machined flush with the surface of plate.

(3) The tensile strength of test specimen is to comply with the requirements given in **Table 2.2.32.**

Table 2.2.32 Tensile Test Requirements for Butt Weld

Grade of welding material	Tensile strength (N/mm^2)
RAW 1, RAW 2, RAW 3	400 min.
RAW 51, RAW 52, RAW 53, RAW 54	490 min.
RAW 52Y40, RAW 53Y40 RAW 54Y40	510 min.
RAWL 1	400 min.
RAWL 2	440 min.
RAWL 3	490 min.
RAWL 91	630 min.
RAWL 92	670 min.

8. Butt weld bend test with multi-run technique

(1) The face bend and root bend test specimens are to be $RB4$ specimen shown in **Table 2.2.2**, and two test specimens are to be taken from each test assembly. However, for $RAWL91$ or $RAWL92$, the face bend and root bend specimens are to be $RB1$ specimen shown in **Table 2.2.2**, and test specimens are to be taken longitudinally from each test assembly.

(2) The test specimens are to be capable of withstanding, without crack exceeding 3 *mm* long on the outer surface of other defects, being bent through an angle of 120 *degrees* over a former having a radius of 1.5 *times* the thickness of test specimen. The radius and angle of the former for $RAWL91$ and $RAWL92$, however, are to be 2 *times* the thickness of the specimen and 180 *degrees* respectively.

9. Butt weld impact test with multi-run technique

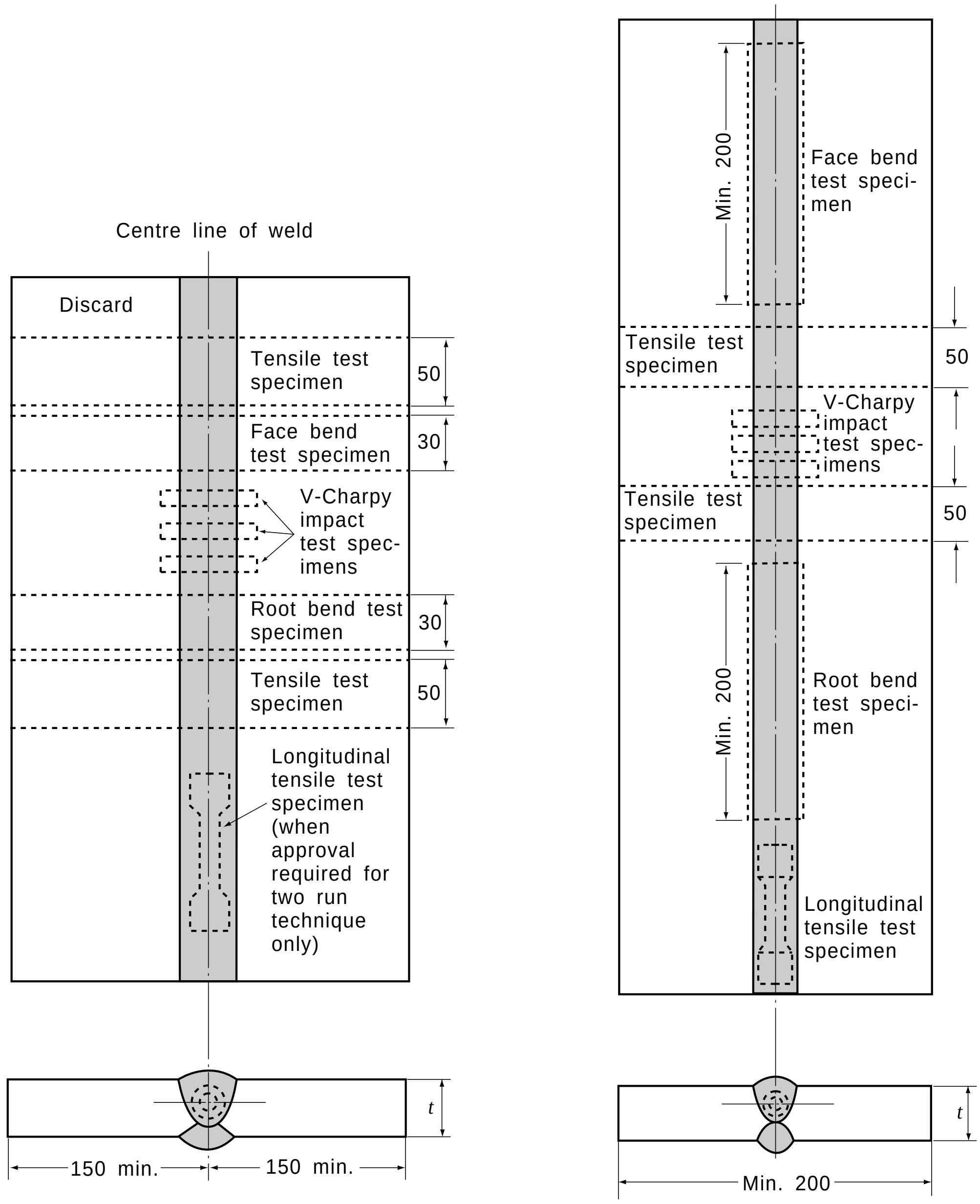
(1) One set of three impact test specimens, from each test assembly, are to be machined to dimensions $R4$ test specimens as shown in **Fig. 2.1.3.** The test specimen is to be cut with its longitudinal axis perpendicular to the direction of welding, and the test specimen is to coincide with the mid-thickness of the plate shown in **Fig. 2.2.21.**

(2) Test temperature and average absorbed energy are to comply with the requirements given in **Table 2.2.31.**

(3) The requirements in **Par 6** (3) and (4) are to correspondingly apply to this Paragraph.

10. Butt weld tensile tests with two-run technique

(1) The tensile test specimens are to be $R2A$ specimen shown in **Table 2.2.1** and two test spec-



(a) For Grades Other than (b)　　(b) For *RAWL*91 or *RAWL*92

Fig. 2.2.26 Butt Weld Test Assembly with Two-run Technique (Automatic welding, Unit : *mm*, *t* : plate thickness)

imens are to be taken from each welded assembly.

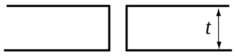
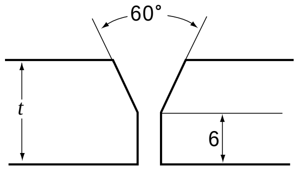
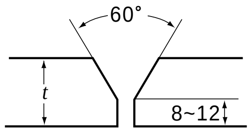
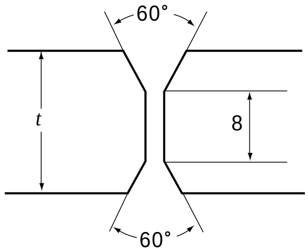
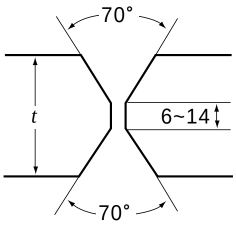
(2) The surface of weld is to be machined flush with the surface of plate.

(3) The tensile strength of test specimen is to comply with the requirements given in **Table 2.2.32.**

(4) One longitudinal tensile test specimen of *R*14 shown in **Table 2.2.1** is to be machined from the thicker of the test assembly specified in **Table 2.2.28** and the longitudinal direction of the test specimen is to be parallel to the weld line and the centre line of the test specimen is to coincide with the centre of second layer.

(5) The longitudinal tensile test specimen in the preceding (4) may be subjected to a temperature not exceeding 250°C for a period not exceeding 16 *hours* for hydrogen removal prior to testing.

(6) The requirements of tensile test specified in the preceding (4) and (5) are to be as given in **Table 2.2.30.** Where the upper limit of tensile strength is exceeded, special consideration will be given to the approval of the welding consumables, taking into consideration of the other mechanical properties shown in the test results and the chemical composition of deposited metal.

(A) Submerged arc welding consumables			(B) Gas shielded arc and self shielded arc welding consumables		
Thickness of test assembly	Edge preparation(1)	Max. dia. of core	Thickness of test assembly	Edge preparation(2)	Max. dia. of wire
12~15		5	12~15		Maximum diameter of wire used is to be reported for information by manufacturer.
20~25		6	20~25		
30~35		7			

NOTES:
(1) Root gap is not to be greater than 1.0 *mm*.
(2) For assemblies using plate over 25 *mm* in thickness, the edge preparation used is to be specified by the manufacturer and the thickness of assembly is to comply with **Table 2.2.28.** (2).

Fig. 2.2.27 Edge Preparation of Butt Weld Test Assembly with Two-run Technique (*t* : plate thickness. Unit: *mm*)

11. Butt weld bend test with two-run technique

(1) The face and root bend test specimens are to be *RB*4 or *RB*5 specimen shown in **Table 2.2.2** and test specimens are to be taken from each test assembly. However, for *RAWL*91 and *RAWL*92, the face and root bend test specimens are to be *RB*1 test specimens and test specimens shown in **Table 2.2.2** are to be taken longitudinally from each test assembly.
(2) The requirements in **Par 8** (2) are to correspondingly apply to this Paragraph.

12. Butt weld impact test with two-run technique

(1) One set of three impact test specimens, from each test assembly, are to be machined to dimensions *R*4 test specimens as shown in **Table 2.1.3**, and the longitudinal direction of the test specimen is to be perpendicular to the weld line and the surface of weld about 2 *mm* apart is to coincide with the surface of specimen as shown in **Fig. 2.2.28**.
(2) Test temperature and average absorbed energy are to comply with the requirements given in **Table 2.2.31.**
(3) The requirements in **Par 6** (3) and (4) are to correspondingly apply to this Paragraph.

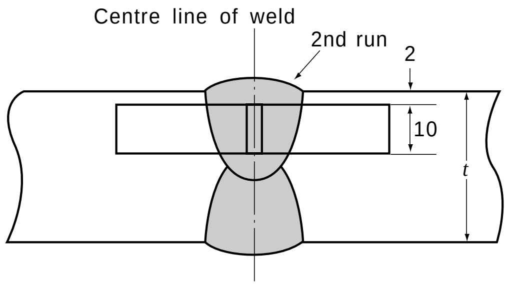


Fig. 2.2.28 Position of impact Test Specimen for Butt Weld Test Assembly with Two-Run Technique (Unit: *mm*, *t* : plate thickness)

13. Hydrogen test

The hydrogen test is left to the discretion of the Society.

14. Annual inspections

(1) In the annual inspection, tests specified in the following (2) are to be conducted for each brand of the approved consumables, and they are to be passed satisfactorily.
(2) The kinds of test, etc. involved in the annual inspections are to be as given in Table **2.2.33.**
(3) The welding procedures and requirements for test assemblies of tests specified in the preceding (2) are to be as specified in **Pars 4** through **12.**

15. Changes in grades

(1) Where changes in the grades relating to the strength or toughness of automatic welding consumables approved are to be made, tests specified in the following (2), (3) and (4) are to be carried out and satisfactorily passed in accordance with the requirements in **601.3** (3).

Table 2.2.33 Kinds of Test for Annual Inspection

<table>
<tr><th rowspan="2">Grade of welding consumables</th><th rowspan="2">Welding technique(1)</th><th rowspan="2" colspan="2">Kind of test</th><th colspan="3">Test assembly</th><th rowspan="2">Kinds and no. of test specimens taken from test assembly</th></tr>
<tr><th>Number</th><th>Dimensions</th><th>Thickness (mm)</th></tr>
<tr><td rowspan="3">RAW1, RAW2, RAWL1
RAW3, RAWL2
RAW51, RAWL3
RAW52, RAWL91
RAW53, RAWL92
RAW54
RAW52Y40
RAW53Y40
RAW54Y40</td><td>Multi-run technique</td><td colspan="2">Deposited metal test</td><td>1</td><td>Fig. 2.2.24</td><td>20</td><td>Tensile test specimen: 1
Impact test specimen: 3</td></tr>
<tr><td rowspan="2">Two-run technique</td><td rowspan="2">Butt weld test</td><td>Sub-merged arc welding</td><td>1</td><td rowspan="2">Fig. 2.2.26</td><td>20</td><td>Tensile test specimen: 1
Longitudinal tensile test specimen: 1
Face bend test specimen: 1
Root bend test specimen: 1
Impact test specimen: 3</td></tr>
<tr><td>Gas shileded and self shielded arc welding</td><td>1</td><td>20~25</td><td>Tensile test specimen: 1
Longitudinal tensile test specimen: 1
Face bend test specimen: 1
Root bend test specimen: 1
Impact test specimen: 3</td></tr>
<tr><td colspan="8">NOTE:
(1) Tests on both multi-run and two run technique are to be conducted for multi-run and two run welding respectively. However, longitudinal tensile test of two run technique are not required.</td></tr>
</table>

(2) Changes in grades relating to the strength or toughness of multi-run automatic welding consumables are to be in accordance with the requirements in the following (a) and (b).
   (a) For changes in the grades relating to strength, the butt weld tests, specified in the annual inspection of **Par 14** and in the requirements of **Par 3** (1), are to be conducted.
   (b) For changes in the grades relating to toughness, the butt weld impact tests, specified in the annual inspection of **Par 14** and in the requirements of **Par 3** (1), are to be conducted.
(3) Changes in grades relating to the strength or toughness of two-run automatic welding consumables are to be in accordance with the requirements in the following (a) and (b).
   (a) For changes in the grades relating to strength, all tests specified in **Par 3** (1) are to be conducted.
   (b) For changes in the grades relating to toughness, the butt weld impact tests, specified in the annual inspections of **Par 14** and in the requirements of the preceding (a), are to be conducted.
(4) Changes in the grades relating to the strength or toughness of automatic welding consumables for multi-run and two-run use are to be as specified in the preceding (2) and (3).

604. Semi-automatic welding consumables for normal strength steels, higher strength steels and steels for low temperature service

1. Application

Welding consumables for semi-automatic welding for normal strength steels, higher strength steels and steels for low temperature service (hereinafter referred to as “semi-automatic welding consumables”) are to be subjected to the approval test and annual inspections in accordance with the requirements in **604.**

2. Grades and marks

(1) The semi-automatic welding consumables are classified as specified in **Table 2.2.34.**
(2) A suffix *G* will be added to the grade marks for semi-automatic welding consumables which use shield gas, and a suffix *N* will be added for semi-automatic welding consumables which do not use shield gas. Further, the type of shield gas used is to be as specified in **Table 2.2.27**, and the suffix given in **Table 2.2.27** will be added after the suffix G. (e.g. *RSW*53*G* (*M*1))
(3) For low hydrogen electrodes, which have passed the hydrogen test specified in **Par 10**, the suffixes given in **Table 2.2.22** are to be added to the end of the grade marks of the said electrode. (e.g. *RSW*53*HHH*)

3. General provisions for tests

(1) Kinds of test, number, thickness and dimensions of test assemblies, diameter of wire used for welding, welding position, grades and number of test specimens to be taken from each test assembly, position for semi-automatic weld-

Table 2.2.35 Kinds of Test for Semi-automatic Welding Consumables

Kind of test[7]	Test assembly					Kinds and no. of test specimens taken from test assembly
	Welding position	Wire diameter(mm)	Number	Dimensions	Thickness(mm)	
Deposited metal test	Flat	maximum diameter	1[1]	**Fig. 2.2.18**	20	Tensile test specimen: 1 Impact test specimen: 3
		minimum diameter	1[1]			
Butt weld test	Flat	First-run: minimum diameter Remaing-run: maximum diameter	1[2]	**Fig. 2.2.19**	15~20	Tensile test specimen: 1 Face bend test specimen :1 Root bend test specimen: 1 Impact test specimen: 3[3]
	Horizontal[4]		1			
	Vertical upward		1			
	Vertical downward		1			
	Overhead		1			
Fillet weld test[5]	Horizontal vertical	One side: maximum diameter The other side: minimum diameter	1	**Fig. 2.2.20**	20	Macro test specimen: 3[6] Hardness test specimen: 2[6] Fracture test specimen: 2

NOTES:
(1) Where the core diameter to be manufactured is of single variety, the number of test assembly is to be one.
(2) Where tests are conducted solely in the Flat position. one test assembly welded with wire of different diameters is to be added.
(3) Impact tests are not required for welding in overhead position.
(4) For semi-automatic welding consumables which have passed butt weld tests in the downhand and vertical upward positions, the horizontal butt weld test may be omitted. at the discretion of the Society.
(5) This test is to be added solely against welding consumables for use in both butt and fillet weld.
(6) The test specimens used in the macro-etching test and hardness test are to be the same.
(7) For low hydrogen welding consumables, an hydrogen test may be conducted by the application of the manufacturer, and test assembly is to be as specified in **602.4.**(3).

Table 2.2.34 Grades and Marks

For normal strength steel	For higher strength steel	For steel for low temperature service
RSW 1 *RSW* 2 *RSW* 3	*RSW* 51, *RSW* 52*Y*40 *RSW* 52, *RSW* 53*Y*40 *RSW* 53, *RSW* 54*Y*40 *RSW* 54	*RSWL* 1 *RSWL* 2 *RSWL* 3 *RSWL* 91 *RSWL* 92

ing consumables used in butt welds or in both butt and fillet welds are to be as given in **Table 2.2.35.**

(2) Kinds of test, number, thickness and dimensions of test assemblies, diameter of wire used for welding, welding position, grades and number of test specimens to be taken from each test assembly for semi-automatic welding materials used in fillet welds only are to be as given in **Table 2.2.16.**

(3) Steel plates to be used for test assemblies are to be as given in **Table 2.2.36**, appropriate to the kind of semi-automatic welding consumables.

(4) For the approval of semi-automatic welding consumables, the test specified in the preceding (1) and (2) are to be conducted for each brand of semi-automatic welding consumables.

(5) For semi-automatic welding consumables, the test in the preceding (4) is to be performed for each type of gas given in **Table 2.2.27.** When the manufacturer of the material recommends gas types of the group of $M1$, $M2$, $M3$ or C in **Table 2.2.27** and the test is satisfactorily conducted in accordance with the preceding (3) on one of the gas type, the test on the other gas types belonging to the same group is allowed to be dispensed with at the discretion of the Society.

(6) The welding conditions used such as amperage, voltage, travel speed, etc. are to be within the range recommended by the manufacturer for normal good welding practice. Where a filler metal is stated to be suitable for both alternating current (AC) and direct current (DC), AC is to be used for the preparation of the test assemblies.

4. Welding of test assemblies

(1) Deposited metal test assemblies

(a) Test assembly as shown in **Fig. 2.2.18** is to be welded in the flat position according to the normal practice.

(b) Test assembly is to be welded in single or multi-run layers, and the direction of deposition of each run is to alternate from each end of the plate, each run of weld metal being not less than 2 mm but not more than 6 mm thick.

(c) After each run, the test assembly is to be

Table 2.2.36 Grades of Steel for Test Assembly

Grade of welding consumables	Grade of steel for test assembly(1)(2)
RSW 1	RA
RSW 2	RA, RB or RD
RSW 3	RA, RB, RD or RE
RSW 51	RA 32 or RA 36
RSW 52	RA 32, RA 36, RD 32 or RD 36
RSW 53	RA 32, RA 36, RD 32, RD 36, RE 32 or RE 36
RSW 54	RA 32, RA 36, RD 32, RD 36, RE 32, RE 36 RF 32 or RF 36
RSW 52Y40	RA 40 or RD 40
RSW 53Y40	RA 40, RD 40 or RE 40
RSW 54Y40	RA 40, RD 40, RE 40 or RF 40
RSWL 1	RE or RL 24A
RSWL 2	RE, RL 24A, RL 24B, RL 27 or RL 33
RSWL 3	RL 27, RL 33 or RL 37
RSWL 91	RL 9N 53 or RL 9N 60
RSWL 92	RL 9N 53 or RL 9N 60

NOTES;
(1) Notwithstanding the requirements in this Table, normal or higher strength steels may be used for deposited metal test assembly. In this case, test assemblies of grade RSWL91 and RSWL92 are to be appropriately buttered.
(2) The tensile strength of higher strength steels RA32, RD32, RE32 and RF32 used in butt weld test assemblies is to be greater than 490 N/mm^2.

left in still air until it has cooled to less than 250°C but not below 100°C, the temperature being taken at the centre of the weld on the surface of seam.

(2) Butt weld test assemblies
   (a) Test assembly as shown in **Fig. 2.2.19** is to be welded in each welding position (flat, horizontal-vertical, vertical-upward, vertical-downward and overhead) which is recommended by the manufacturer.
   (b) After each run, the test assembly is to be left in still air until it has cooled to less than 250°C but not below 100°C, the temperature being taken at the centre of the weld on the surface of seam.
(3) Fillet weld test assemblies
   The test assemblies are to be in accordance with the requirements in **602.4** (4).
(4) After welding, the test assemblies are not to be subjected to any heat treatment.
(5) It is recommended that the welded assemblies be subjected to a radiographic examination to ascertain that there are any defects in the weld prior to the preparation of test specimens.

5. Deposited metal tensile test

(1) The tensile test specimen, one from each test assembly, is to be machined to dimensions R14 test specimen as shown in **Table 2.2.1**, care being taken that the longitudinal axis coincides with the centre of weld and the mid-thickness of plates.
(2) The tensile test specimen may be subjected to a temperature not exceeding 250°C for a period not exceeding 16 *hours* for hydrogen removal prior to testing.
(3) The tensile strength, yield strength and elongation of each test specimen are to comply with the requirements given in **Table 2.2.37**, where the upper limit of tensile strength is exceeded, special consideration will be given to the approval of the electrode, taking into consideration of the other mechanical properties shown in the test results and the chemical composition of deposited metal.

6. Deposited metal impact tests

(1) One set of three impact test specimens, from each test assembly, are to be machined to dimensions R4 test specimens as shown in **Table 2.1.3.** The test specimen is to be cut with its longitudinal axis transverse to the direction of welding, and the test specimen is to coincide with the mid-thickness of the plate shown in **Fig. 2.2.21.**
(2) Test temperature and average absorbed energy are to comply with the requirements given in **Table 2.2.38.**
(3) The notch is to be positioned in the centre of

Table 2.2.37 Tensile Test Requirements for Deposited Metal

Grade of welding consumables	Tensile strength (N/mm^2)	Yield strength (N/mm^2)	Elongation (%)
RSW 1 RSW 2 RSW 3	400~560	305 min.	22 min.
RSW 51 RSW 52 RSW 53 RSW 54	490~660	375 min.	22 min.
RSW 52Y40 RSW 53Y40 RSW 54Y40	510~690	400 min.	22 min.
RSWL 1	400~560	305 min.	22 min.
RSWL 2	440~610	345 min.	22 min.
RSWL 3	490~660	375 min.	21 min.
RSWL 91	590 min.	375 min.(1)	25 min.
RSWL 92	660 min.	410 min.(1)	25 min.

NOTE:
(1) 0.2% yield stress

Table 2.2.38 Impact Test Requirements for Deposited Metal

Grade Of welding consumables	Test temp. (°C)	Average absorbed energy (J)
RSW 1	20	47 min.
RSW 2	0	
RSW 3	− 20	
RSW 51	20	
RSW 52	0	
RSW 53	− 20	
RSW 54	− 40	
RSW 52Y40	0	
RSW 53Y40	− 20	
RSW 54Y40	− 40	
$RSWL$ 1	− 40	34 min.
$RSWL$ 2	− 60	
$RSWL$ 3	− 60	
$RSWL$ 91	− 196	27 min.
$RSWL$ 92	− 196	

weld and is to be cut in the face of test specimens perpendicular to the surface of plate.

(4) When the absorbed energy of two or more test specimens among a set of test specimens is less in value than the specified average absorbed energy or when the absorbed energy of a single test specimen is less in value than 70% of the specified average absorbed energy, the test is considered to have failed.

7. Butt weld tensile tests

(1) The tensile test specimen is to be $R2A$ test specimen shown in **Table 2.2.1** and the test specimen is to be taken from each test assembly.

(2) The surface of weld is to be machined flush with the surface of plate.

(3) The tensile strength of test specimen is to comply with the requirements given in **Table 2.2.39.**

8. Butt weld bend test

(1) The face and root bend test specimens are to be $RB4$ specimen shown in **Table 2.2.2**, and test specimens are to be taken from each test assembly. However, for $RSWL$91 or $RSWL$92, the face and root bend specimens are to be $RB1$ specimen shown in **Table 2.2.2**, and test specimens are to be taken longitudinally from each test assembly.

(2) The test specimens are to be capable of withstanding, without crack exceeding 3 mm long on the outer surface of other defects, being bent through an angle of 120 $degrees$ over a former having a radius of 1.5 $times$ the thickness of test specimen. The radius and angle of the former for $RSWL$91 and $RSWL$92, however, are to be 2 $times$ the thickness of the specimen and 180 $degrees$ respectively.

Table 2.2.39 Tensile Test Requirements for Butt Weld

Grade of welding consumables	Tensile strength (N/mm^2)
RSW 1, RSW 2, RSW 3	400 min.
RSW 51, RSW 52, RSW 53, RSW 54	490 min.
RSW 52Y40, RSW 53Y40 RSW 54Y40	510 min.
$RSWL$ 1	400 min.
$RSWL$ 2	440 min.
$RSWL$ 3	490 min.
$RSWL$ 91	630 min.
$RSWL$ 92	670 min.

9. Butt weld Impact test

(1) One set of three impact test specimens, from each test assembly, are to be machined to dimensions $R4$ test specimens as shown in **Table 2.1.3.** The test specimen is to be cut with its longitudinal axis transverse to the direction of welding, and the test specimen is to coincide with the mid-thickness of the plate shown in **Fig. 2.2.21.**

(2) Test temperature and average absorbed energy are to comply with the requirements given in **Table 2.2.40.**

(3) The requirements in **Par 6** (3) and (4) are to correspondingly apply to this Paragraph.

10. Hydrogen test

The hydrogen test is left to the discretion of the Society.

11. Fillet weld macro-structure test

The macro-structure test is to be correspondingly in accordance with the requirements in **602.11.**

12. Fillet weld hardness test

The hardness test is to be correspondingly in accordance with the requirements in **602.12.**

13. Fillet weld fracture test

The fracture test is to be correspondingly in accordance with the requirements in **602.13.**

14. Annual inspections

(1) In the annual inspections, tests specified in the following (2) are to be conducted for each brand of the approved consumables, and they are to be passed satisfactorily.

(2) The kinds of test, etc. in the annual inspection are to be as given in **Table 2.2.41.**

(3) The welding procedures and requirements for

Table 2.2.40 Impact Test Requirements for Butt Weld

<table>
<tr><th rowspan="2">Grade of welding consumables</th><th rowspan="2">Test temp. (°C)</th><th colspan="2">Average absorbed energy (J)</th></tr>
<tr><th>Flat, Horizontal</th><th>Vertical upward, Vertical downward</th></tr>
<tr><td>RSW 1</td><td>20</td><td rowspan="10">47 min.</td><td rowspan="7">34 min.</td></tr>
<tr><td>RSW 2</td><td>0</td></tr>
<tr><td>RSW 3</td><td>− 20</td></tr>
<tr><td>RSW 51</td><td>20</td></tr>
<tr><td>RSW 52</td><td>0</td></tr>
<tr><td>RSW 53</td><td>− 20</td></tr>
<tr><td>RSW 54</td><td>− 40</td></tr>
<tr><td>RSW 52Y40</td><td>0</td><td rowspan="3">41 min.</td></tr>
<tr><td>RSW 53Y40</td><td>− 20</td></tr>
<tr><td>RSW 54Y40</td><td>− 40</td></tr>
<tr><td>RSWL 1</td><td>− 40</td><td rowspan="5">27 min.</td><td rowspan="5">27 min.</td></tr>
<tr><td>RSWL 2</td><td>− 60</td></tr>
<tr><td>RSWL 3</td><td>− 60</td></tr>
<tr><td>RSWL 91</td><td>− 196</td></tr>
<tr><td>RSWL 92</td><td>− 196</td></tr>
</table>

test assemblies of tests specified in the preceding (2) are to be as specified in **Pars 4** through **9.**

15. Changes in grades

(1) Where changes in the grades relating to the strength or toughness of welding consumables approved are to be made, tests specified in the following (2), (3) and (4) are to be carried out and satisfactorily passed in accordance with the requirements in **601.3** (3).

(2) For changes in the grades relating to strength, the butt weld tests, specified in the annual inspection of **Par 14** and in the requirements of **Par 3** (1), are to be conducted.

(3) For changes in the grades relating to toughness, the butt weld impact tests, specified in the annual inspection of **Par 14** and in the requirements of **Par 3** (1), are to be conducted.

605. Electro-slag and electro-gas welding consumables

1. Application

Electro-slag and electro-gas welding consumables for normal strength and higher strength steels (hereinafter referred to as “welding consumables”) are to be in accordance with the requirements in **605.**

2. Grades and marks

Welding consumables are classified as specified in **Table 2.2.42.**

Table 2.2.42 Gradas and Marks

For normal strength steel	For higher strength steel
REW 1 *REW* 2 *REW* 3	*REW* 51, *REW* 52Y40 *REW* 52, *REW* 53Y40 *REW* 53, *REW* 54Y40 *REW* 54

3. General provisions for tests

(1) Kinds of test, number, thickness and dimensions of test assemblies, grades and number of test specimens to be taken from each test assembly for welding consumables are to be as given in **Table 2.2.43.**

(2) Steel plates to be used for test assemblies are to be as given in **Table 2.2.44**, appropriate to the kind of welding consumables.

(3) For the approval of welding consumables, the tests specified in the preceding (1) are to be coducted for each brand of welding consumables.

(4) The welding conditions used such as amperage, voltage, travel speed, etc. are to be within the range recommended by the manufacturer for normal good welding practice. Where a filler metal is stated to be suitable for both alternating current (AC) and direct current (DC), AC is to be used for the preparation of the test assemblies.

4. Welding of test assemblies

(1) Butt weld test assemblies

(a) Test assemblies as shown in **Fig. 2.2.29**

Table 2.2.41 Kind of Test for Annual Inspection

<table>
<tr><th rowspan="2">Kind of test</th><th colspan="5">Test assembly</th><th rowspan="2">Kind and no. of test specimens taken from test assembly</th></tr>
<tr><th>Welding position</th><th>Diameter of wire (mm)</th><th>Number</th><th>Dimension</th><th>Thickness (mm)</th></tr>
<tr><td>Deposited metal test</td><td>Flat</td><td>(1)</td><td>1</td><td>Fig. 2.2.18</td><td>20</td><td>Tensile test specimen : 1
Impact test specimen : 3</td></tr>
<tr><td colspan="7">NOTE:
(1) The diameters of the wire are to be within the range specified by the manufacturers.</td></tr>
</table>

Table 2.2.43 Kinds of Test for Electro-Slag and Electro-Gas Welding Consumables

Kind of test	Test assembly			Kinds and no. of test specimens taken from test assembly
	Number	Dimensions	Thickness (mm)(1)	
Butt weld test	1	**Fig. 2.2.29**	20~25	Tensile test specimen: 2 Longitudinal tensile test specimen: 2 Side bend test specimen: 2 Impact test specimen: 6 Macro structure test specimen: 2
	1		35~40	

NOTE:
(1) Where thickness is restricted by welding process, thickness of test assemblies may be changed upon approval of the Society. In thls case, the maximum test thickness is to be taken as the maximum applicable thickness.

Table 2.2.44 Grades of Steel used for Test Assembly

Grade of welding material	Grade of steel used for test assembly(1)
REW 1	RA
REW 2	RA, RB or RD
REW 3	RA, RB, RD or RE
REW 51	RA 32 or RA 36
REW 52	RA 32, RA 36, RD 32 or RD 36
REW 53	RA 32, RA 36, RD 32, RD 36, RE 32 or RE 36
REW 54	RA 32, RA 36, RD 32, RD 36, RE 32, RE 36 RF 32 or RF 36
REW 52Y40	RA 40 or RD 40
REW 53Y40	RA 40, RD 40 or RE 40
REW 54Y40	RA 40, RD 40, RE 40 or RF 40

NOTE:
(1) The tensile strength of higher strength steels of RA32, RD32, RE32 and RF32 used in the test assemblies is to be greater than 490 N/mm^2.

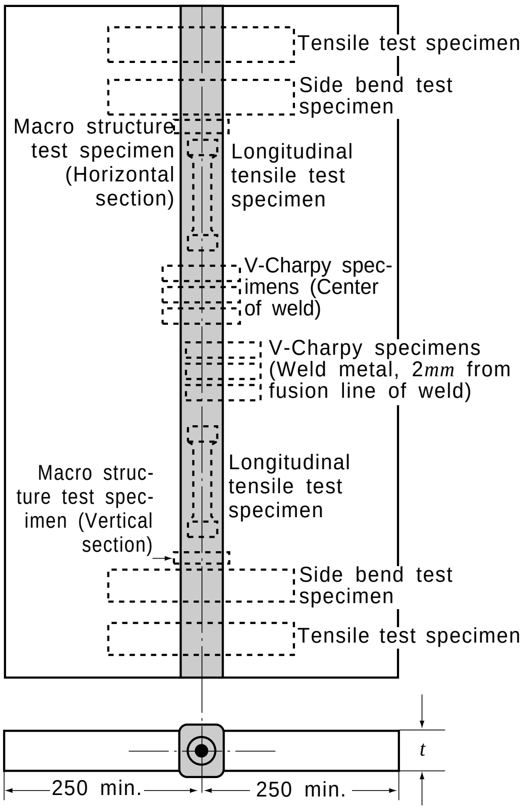


Fig. 2.2.29 Butt Weld Assembly (Electro-slag and electrod-gas welding, Unit :mm)

are to be welded upward in vertical position in one Pass.

(b) The welding conditions and edge preparation are to be within the range recommended by the manufacturer.

(2) After welding, the test assemblies are not to be subjected to any heat treatment.

(3) It is recommended that the welded assemblies be subjected to a radiographic examination to ascertain that there are any defects in the weld prior to the preparation of test specimens.

5. Tensile test

(1) Two tensile test specimens to be $R2A$ specimen and two longitudinal tensile test specimens to be $R14$ specimen as shown in **Table 2.2.1** are to be taken from each test assembly The longitudinal axis of test specimen coincides with the centre of weld and the mid-thickness of plates.

(2) The longitudinal tensile test specimens may be subjected to the heat treatment not exceeding 250°C for a period not exceeding 16 $hours$ for hydrogen removal prior to testing.

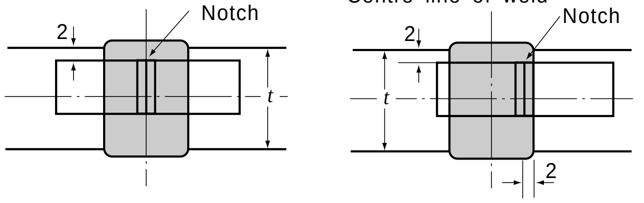
(3) Tensile strength of each test specimen $R2A$ is to comply with the requirements in **Table 2.2.45.** Tensile strength, yield strength and elongation of each longitudinal test specimen $R14$ are to comply with the requirements in **Table 2.2.46**. Where the upper limit of tensile strength is exceeded, special consideration will be given to the approval of the welding consumables,

Table 2.2.45 Tensile Test Requirements

Grade of welding consumables	Tensile strength (N/mm^2)
REW 1, REW 2, REW 3	400 min.
REW 51, REW 52, REW 53, REW 54	490 min.
REW 52Y40, REW 53Y40, REW 54Y40	510 min.

Table 2.2.46 Longitudinal Tensile Test Requirements

Grade of welding consumablesl	Tensile strength (N/mm^2)	Yield strength (N/mm^2)	Elongation (%)
REW 1 REW 2 REW 3	400~560	305 min.	22 min.
REW 51 REW 52 REW 53 REW 54	490~660	375 min.	22 min.
REW 52Y40 REW 53Y40 REW 54Y40	510~690	400 min.	22 min.



(a) Centre of weld
(b) Weld metal, 2 mm from fusion line of weld

Fig. 2.2.30 Position of Impact Specimen (Unit: mm, t = Plate thickness)

Table 2.2.47 Impact Test Requirements

Grade of welding consumables	Test temp. (°C)	Average absorbed energy (J)
REW 1	20	34 min.
REW 2	0	
REW 3	− 20	
REW 51	20	
REW 52	0	
REW 53	− 20	
REW 54	− 40	
REW 52Y40	0	41 min.
REW 53Y40	− 20	
REW 54Y40	− 40	

taking into consideration of the other mechanical properties shown in the test results and chemical composition of deposited metal.

6. Bend test

(1) Bend test specimens are to be RB6 specimens shown in **Table 2.2.2** and two side bend test specimens are to be taken from each test assembly.

(2) The test specimens are to be capable of withstanding, without crack exceeding 3 mm long on the outer surface of other defects, being bent through an angle of 180 $degrees$ over a former having a radius of two times the thickness of test specimen.

7. Impact test

(1) Two sets of six impact test specimens, from each test assembly, are to be machined to dimensions R4 test specimens as shown in **Table 2.1.3** and the longitudinal direction of the test specimen is to be perpendicular to the weld line and the surface of weld about 2 mm apart is to coincide with the surface of specimen as shown in **Fig. 2.2.30.**

(2) The position of the notch is to be in accordance with **Fig. 2.2.30** (a) and (b) respectively, and its longitudinal direction is to be perpendicular to the surface of the test assembly.

(3) Test temperature and average absorbed energy are to comply with the requirements given in **Table 2.2.47.**

(4) When the absorbed energy of two or more test specimens among a set of test specimens is less in value than the specified average absorbed energy or when the absorbed energy of a single test specimen is less in value than 70% of the specified average absorbed energy, the test is considered to have failed.

8. Macro-structure test

(1) Two macro-structure test specimens are to be taken from the position shown in **Fig. 2.2.29.** As for the surface to be tested, one is to be normal to the assembly surface and the other parallel to the assembly surface.

(2) Both the welded parts and the weld boundaries are to show complete fusion, penetration and sound metallurgical structure.

9. Annual inspections

(1) In the annual inspection, tests specified in the following (2) are to be conducted for each brand of the approved materials, and they are to be passed satisfactorily.

(2) The kinds of test, etc. in the annual inspections are to be as given in **Table 2.2.48.**

(3) The welding procedures and requirements for test assemblies of tests specified in the preceding (2) are to be as specified in **Pars 4** through **7.**

10. Changes in grades

Where changes in the grades relating to the strength or toughness of welding consumables approved are to be made, tests specified in **Par 3** (1) are to be conducted and satisfactorily passed in accordance with the requirements in **601.3** (3).

606. One side welding consumables for normal strength steels, higher strength steels and steels for low temperature service.

1. Application

(1) Welding consumables for normal strength steels, higher strength steels and steels for low temperature service given in the following (a) through (c) (hereinafter referred to as “one side automatic welding consumables”) are to be subjected to the approval tests and annual inspections in accordance with the requirements in **606.**

(a) Submerged arc one side automatic welding consumables

(b) Gas shielded arc one side automatic welding consumables (solid wire one side automatic welding consumables and flux cored wire one side automatic welding consumables with shielding gas)

(c) Self-shielded arc one side automatic welding consumables (flux cored wire one side automatic welding consumables without shielding gas)

(2) Approval tests and annual inspections of one side covered electrodes for normal strength steels, higher strength steels and steels for low temperature service, and one side semi-automatic welding consumables are to be as deemed appropriate by the Society.

(3) Approval tests and annual inspections for one side automatic welding consumables of muitiple electrodes are to be as deemed appropriate by the Society.

Table 2.2.48 Kind of Test for Annual Inspection

Kind of test	Test assembly			Kinds and no. of test specimens taken from test assembly
	Number	Dimensions	Thickness (mm)(1)	
Butt weld test	1	**Fig. 2.2.29**	20~25	Tensile test specimen: 1 Longitudinal Tensile test specimen: 1 Side bend test specimen: 2 Impact test specimen: 6(1)

NOTE:
(1) One set of three impact test specimens may be taken from the centre of welded part. where approved by the Society.

2. Grades and marks

(1) One side automatic welding consumables are classified as specified in **603.2.** Further, one side automatic welding consumables which have passed the tests for each welding procedure given in **Table 2.2.50** are to be appended with the suffixes given in **Table 2.2.49** at the end of their marks.

(2) In the preceding (1), a suffix G will be added to the grade mark for gas shielded arc one side automatic welding consumables, and a suffix N will be added for self-shielded wire one side automatic welding consumables. Further, the type of gas used is to be as specified in **Table 2.2.27** and the suffix given in **Table 2.2.27** will be added after the suffix G. (e.g.$RAW53SMRG$ ($M1$))

3. General provisions for tests

(1) Kinds of test, number, thickness and dimensions of test assemblies, grades and number of test specimens to be taken from each test assembly for one side automatic welding consumables are to be as given in **Table 2.2.50.**

(2) Steel plates to be used for test assemblies are to be as given in **Table 2.2.51.**

(3) For the approval of one side automatic welding consumables, the tests specified in the preceding (1) are to be conducted for each brand of one side automatic welding consumables.

(4) For gas shield arc one side automatic welding consumables, the test in the preceding (3) is to be performed for each type of gas given in **Table 2.2.27.** When the manufacturer of the material recommends gas types of the group of $M1$, $M2$, $M3$ or C in **Table 2.2.27** and the

Table 2.2.49 Marks

Welding technique(1)	Marks
One-run technique	SR
Multi-run technique	MR
One-run and multi-run technique	SMR

NOTE:
(1) One-run or multi-run tequnique refers to a welding process which performed in one pass or multiple passes respectively regardless of the number of electrodes.

test is satisfactorily conducted in accordance with the preceding (3) on one of the gas type, the test on the other gas types belonging to the same group is allowed to be dispensed with at the discretion of the Society.

(5) The combination of one side automatic welding materials are classified as given in **Table 2.2.52,** appropriate to the welding procedure.

(6) The welding conditions used such as amperage, voltage, travel speed, etc. are to be within the range recommended by the manufacturer for normal good welding practice. Where a filler metal is stated to be suitable for both alternating current (AC) and direct current (DC), AC is to be used for the preparation of the test assemblies.

4. Welding of test assemblies

(1) Butt weld test assemblies with one-run and multi-run technique

(a) Test assemblies are to be prepared as shown in **Fig. 2.2.31**, and the diameter of wire, root gap and edge preparation are to be within the range specified by the manufacturer.

(b) Test assemblies are to be welded in down-hand position by one-run technique or multi-run technique according to the procedures specified by the manufacturer. However, for gas shield and self-shielded arc one side automatic welding consumables, the welding position is to be specified by the manufacturer.

(c) After completing each run the test assembly is to be left in still air until it has cooled to less than 250°C but not below 100°C, the temperature being taken at the centre of weld on the surface of seam.

(2) After welding, the test assemblies are not to be subjected to any heat treatment.

(3) It is recommended that the welded assemblies be subjected to a radiographic examination to ascertain that there are any defects in the weld prior to the preparation of test specimens.

5. Butt weld tensile test with one-run and multi-run technique

(1) Tow tensile test specimens to be $R2A$ specimen and one longitudinal tensile test specimen to be $R14$ specimen as shown in **Table 2.2.1** are to be taken from each test assembly The longitudinal axis of test specimen coin-

Table 2.2.50 Kinds of Test for One-side Automatic Welding Consumables

Grade of welding consumables	Welding technique	Kind of test(4)	Test assembly			Kind and number of test specimens taken from test assembly
			Number	Thickness(mm)(1)	Dimension	
$RAW1$ $RAW2$ $RAW3$ $RAW51$ $RAW52$ $RAW53$ $RAW54$ $RAW52Y40$ $RAW53Y40$ $RAW54Y40$ $RAWL1$ $RAWL2$ $RAWL3$ $RAWL91$ $RAWL92$	One-run technique	Butt weld test	1	12~15	**Fig. 2.2.31**	Tensile test specimen: 2 Longitudinal tensile test specimen: 1 Face bend specimen: 1 Root bend specimen: 1 Impact test specimen: 6 Macro-structure test specimen: 1
			1	Maximum thickness		
	Multi-run technique		1	15~25		Tensile test specimen: 2 Longitudinal tensile test specimen: 1 Face bend specimen :1 Root bend Specimen: 1 Impact test specimen: 6 Macro-structure test specimen: 1
			1	35		
	One-run and Multi-run technique		1	Maximum thickness(2)		Tensile test specimen: 2 Longitudinal tensile test specimen: 1 Face bend specimen: 1 Root bend specimen: 1 Impact test specimen: 6 Macro-structure test specimen: 1
			1	35(3)		

NOTES:
(1) Where thickness is restricted by welding process, thickness of test assemblies may be changed upon approval of the Society. In this case, the maximum test thickness is to be taken as the maximum applicable thickness.
(2) Thickness of test assembly for one run technique.
(3) Thickness of test assembly for multi-run technique.
(4) The hydrogen test may be carried out according to the manufacturer's request.

Table 2.2.51 Grades of Steel used for Test Assembly

Grade of welding consumables	Grade of steel used for test assembly(1)
RAW 1	RA
RAW 2	RA, RB or RD
RAW 3	RA, RB, RD or RE
RAW 51	RA 32 or RA 36
RAW 52	RA 32, RA 36, RD 32 or RD 36
RAW 53	RA 32, RA 36, RD 32, RD 36, RE 32 or RE 36
RAW 54	RA 32, RA 36, RD 32, RD 36, RE 32, RE 36 RF 32 or RF 36
RAW 52Y40	RA 40 or RD 40
RAW 53Y40	RA 40, RD 40 or RE 40
RAW 54Y40	RA 40, RD 40, RE 40 or RF 40
RAWL 1	RE or RL 24A
RAWL 2	RE, RL 24A, RL 24B, RL 27 or RL 33
RAWL 3	RL 27, RL 33 or RL 37
RAWL 91	RL 9N 53 or RL 9N 60
RAWL 92	RL 9N 53 or RL 9N 60

NOTE:
(1) The tensile strength of higher strength steels RA 32, RD 32, RE 32 and RF 32 used in the test assemblies is to be greater than 490 N/mm^2.

Table 2.2.52 Combinations of One Side Automatic Welding Consumables

Welding technique	Combinations of welding consumables
Submerged one side automatic welding	Wire + Flux + Iron powder + Backing
Gas shielded arc one side automatic welding	Wire + Gas + Iron powder + Backing
Self-shielded arc one side automatic welding	Wire + Iron powder + Backing

NOTE:
Where iron powder is not used, iron powder is excluded in this **Table.**

cides with the centre of weld and the mid-thickness of plate.

(2) The longitudinal tensile test specimen may be subjected to a temperature not exceeding 250°C for a period not exceeding 16 hours for hydrogen removal prior to testing.

(3) Tensile strength of each test specimen $R2A$ is to comply with the requirements in **Table 2.2.32.** Tensile strength, yield strength and elongation of longitudinal tensile test specimens $R14$ are to comply with the requirements given in **Table 2.2.30.** Where the upper limit of tensile strength is exceeded, special consideration will be given to the approval of the welding consumables, taking into consideration of the other mechanical properties shown in the test results and chemical composition of deposited metal.

6. Butt weld bend test with one-run and multi-run technique

The bend tests are to comply with the requirements in **603.11.**

7. Butt weld impact test with one-run and multi-run technique

(1) Two sets of impact test specimens, from each test assembly, are to be machined to dimensions $R4$ test specimen as shown in **Table 2.1.3.** Longitudinal direction of the test specimen is to be perpendicular to the weld line as shown in **Fig. 2.2.32.**

(2) Test temperature and average absorbed energy are to comply with the requirements given in **Table 2.2.31.**

(3) The notch is to be positioned in the centre of weld and is to be cut in the face of test specimens perpendicular to the surface of plate.

(4) When the absorbed energy of two or more test specimens among a set of test specimens is less in value than the specified average absorbed energy or when the absorbed energy of a single test specimen is less in value than 70% of the specified average absorbed energy, the test is considered to have failed.

8. Butt weld macro-structure test with one-run and multirun technique

(1) Macro-structure test specimens are to be taken from the position shown in **Fig. 2.2.31.** The surface to be tested is to be perpendicular to the surface of the test assembly.

(2) Both the welded parts and the weld boundaries are to show complete fusion, penetration and sound metallurgical structure.

9. Hydrogen test

The hydrogen test is left to the discretion of the Society.

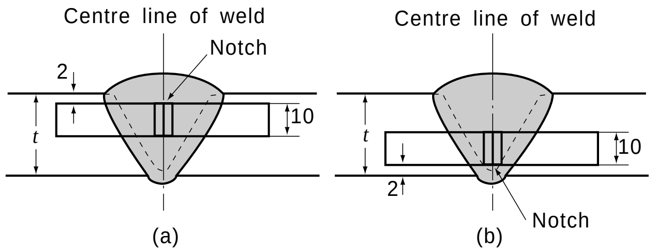


Fig. 2.2.32 Position of Impact Test Specimen for Butt Weld with One-run and Multi-run Technique
(Unit: mm, t = Plate thickness)

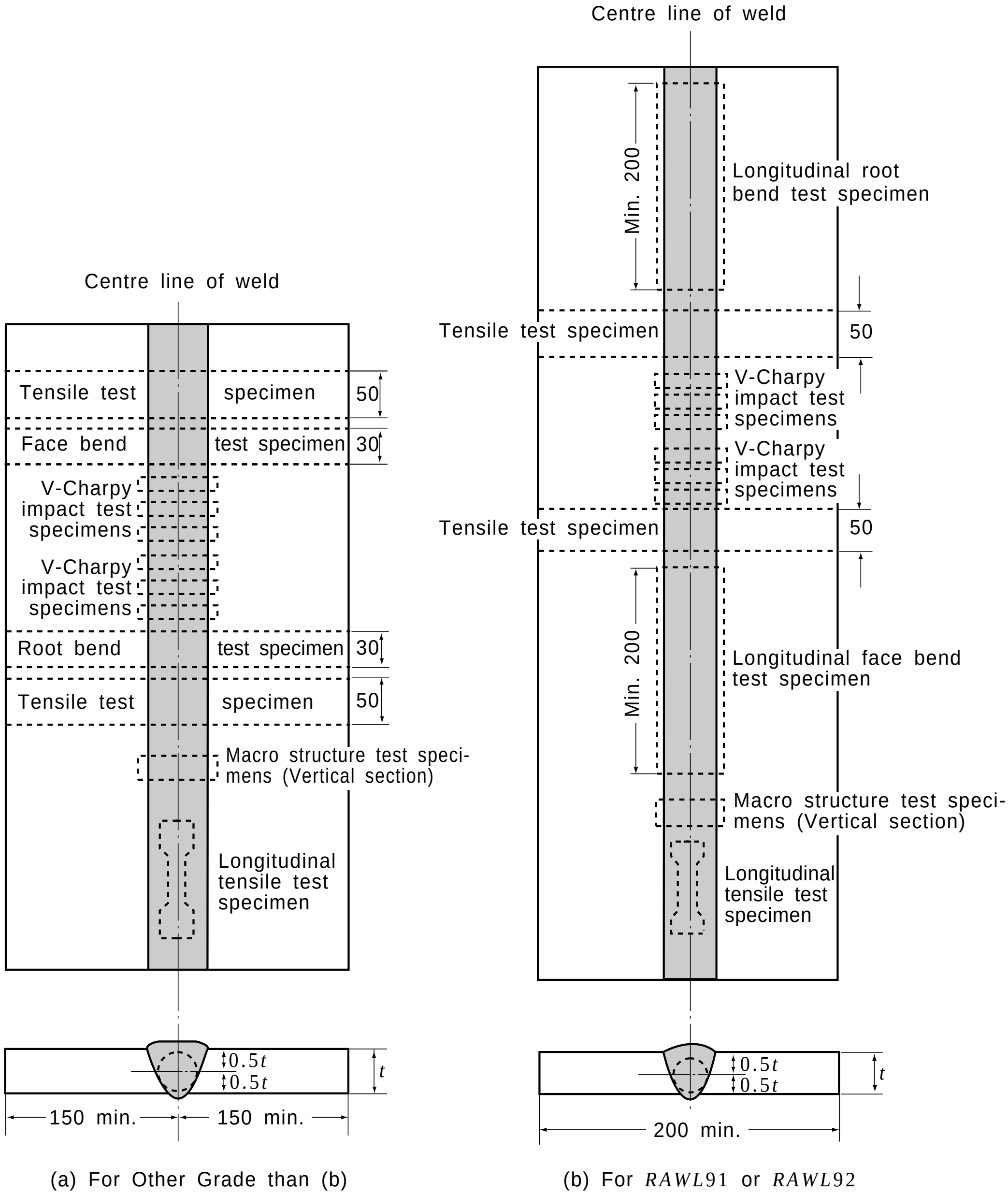


Fig. 2.2.31 Butt Weld Test Assembly with One-run and Multi-run Technique (Unit : mm, t = Plate thickness)

10. Annual inspections

(1) In the annual inspection, tests specified in the following (2) are to be conducted for each brand of the approved consumables, and they are to be passed satisfactorily.

(2) The kinds of test, etc. in the annual inspection are to be as given in **Table 2.2.53.**

(3) The welding procedures and requirements of test assemblies for tests in the preceding (2) are to be as specified in **Pars 4** through **7.**

11. Changes in grades

Where changes in the grades relating to the strength or toughness of one side automatic welding consumables approved are to be made, all the tests specified in **Par 3** (1) are to be carried out and satisfactorily passed in accordance with the requirements in **601.3** (3).

607. Welding consumables for stainless steel

1. Application

Welding consumables for stainless steels specified in **Ch 1, Sec 3** (hereinafter referred to as "welding consumables") are to be subjected to the approval tests and annual inspections in accordance with the requirements in **607.**

2. Grades and marks

(1) Welding consumables are classified as specified in **Table 2.2.54.**

Table 2.2.53 Kinds of Test for Annual Inspection

Grade of welding consumables	Welding technique	Kind of test	Test assembly			Kind and number of test specimens taken from test assembly
			Number	Dimension	Thickness(mm)(1)	
$RAW1$ $RAW2$ $RAW3$ $RAW51$ $RAW52$ $RAW53$ $RAW54$ $RAW52Y40$ $RAW53Y40$ $RAW54Y40$ $RAWL1$ $RAWL2$ $RAWL3$ $RAWL91$ $RAWL92$	One-run technique	Butt weld test(2)	1	**Fig. 2.2.31**	20	Tensile test specimen: 1 Longitudinal tensile test specimen: 1 Face bend specimen: 1 Root bend specimen: 1 Impact test specimen: 3(3)
	Multi-run technique		1		20~25	Tensile test specimen: 1 Longitudinal tensile test specimen: 1 Face bend specimen: 1 Root bend specimen: 1 Impact test specimen: 3(3)
	One-run and Multi-run technique		1		20~25	Tensile test specimen: 1 Longitudinal tensile test specimen: 1 Face bend specimen: 1 Root bend specimen: 1 Impact test Specimen: 3(3)

NOTES:
(1) Where the thickness of test assemblies is changed according to Note (1) of **Table 2.2.50**, the maximum test thickness for approval test is to be applied.
(2) The butt weld tests for one-run and multi-run technique are to be carried out by one-run technique.
(3) The positions of notch and selection of impact test specimens are to be as given in **Fig.2.2.32** (b).

Table 2.2.54 Grades and Marks of Welding Consumables

Electrode for manual arc welding	Material for TIG and MIG welding	Flux cored wire semi-automatic welding	Consumables for submerged welding
$RD308$	$RY308$	$RW308$	$RU308$
$RD308L$	$RY308L$	$RW308L$	$RU308L$
$RD309$	$RY309$	$RW309$	$RU309$
$RD309L$	$RY309L$	$RW309L$	–
$RD309Mo$	$RY309Mo$	$RW309Mo$	$RU309Mo$
$RD309MoL$	–	$RW309MoL$	–
$RD310$	$RY310$	$RW310$	$RU310$
–	$RY310S$	–	–
$RD310Mo$	–	–	–
$RD316$	$RY316$	$RW316$	$RU316$
$RD316L$	$RY316L$	$RW316L$	$RU316L$
$RD317$	$RY317$	$RW317$	$RU317$
$RD317L$	$RY317L$	$RW317L$	$RU317L$
–	$RY321$	–	–
$RD347$	$RY347$	$RW347$	$RU347$

Table 2.2.55 Marks

Welding technique	Marks
Multi-run technique	M
Two-run technique	T
Multi-run and Two-run technique	TM

(2) Submerged arc welding consumables which have passed the tests for each welding process given in **Table 2.2.56** are to be appended with the suffixes shown in **Table 2.2.55** at the end of their marks.

(3) For flux cored wire semi-automatic welding consumables in the preceding (1), a suffix G will be added to the grade mark for welding consumables which use shield gas, and a suffix N will be added to the grade markes for welding consumables which do not used shield gas. Further, the type of shield gas used is to be as specified in **Table 2.2.27** and the suffix given in **Table 2.2.27** will be added after the suffix G. (e.g. $RW308G$ (C))

3. General provisions for tests

(1) Kinds of test, number, thickness and dimensions of test assemblies, diameter of wire used for welding, grades and number of test specimens to be taken from each test assembly in each welding position for welding consumables are to be as given in **Table 2.2.56.** However, additional tests appropriate to steels, such as test on corrosion-resistance test, impact test, macro etching test, etc., except the test given in **Table 2.2.56** may be required where deemed necessary by the Society.

(2) Steel plates to be used for test assemblies are to be as given in **Table 2.2.57** according to the grades of welding consumables.

Table 2.2.56 Kinds of Test of Welding Consumables for Stainless Steel

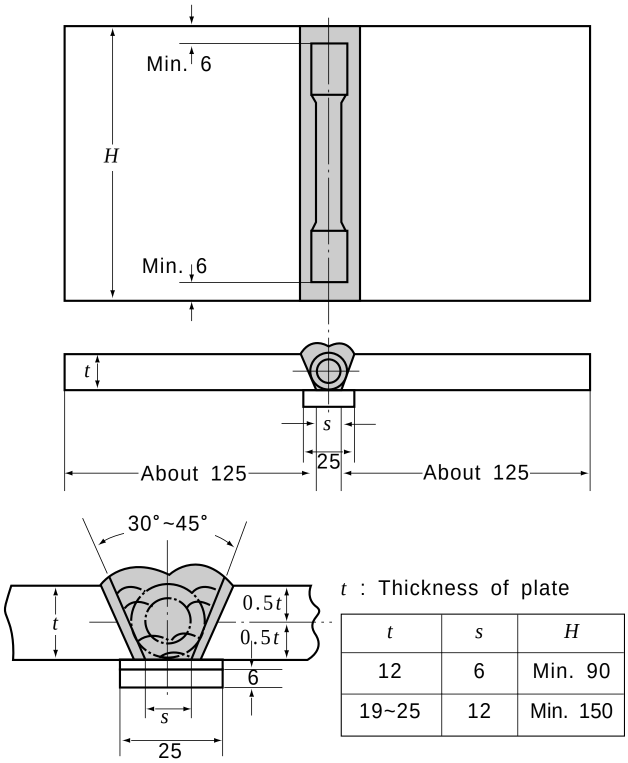
Kind of welding consumables		Kind of test	Test assembly: Thickness (mm)	Test assembly: Number	Test assembly: Welding position	Test assembly: Dia. of electrode or wire(1) (mm)	Test assembly: Dimension	Kind and number of test specimens taken from test assembly
Electrode for manual arc welding		Deposited metal test	12	1	Flat	3.2	**Fig. 2.2.33**	Tensile test specimen: 1
			19	1		4.0		
		Butt weld test	9~12	1	Flat	3.2 or 4.0	**Fig. 2.2.34**	Tensile test specimen: 1 Face bend Specimen: 1 Root bend specimen: 1
				1	Horizontal			
				1	Vertical upward			
				1	Vertical downward			
				1	Overhead			
Consumables for TIG welding		Deposited metal test	12	1	Flat	2.4	**Fig. 2.2.33**	Tensile test specimen: 1
			19	1		3.2		
		Butt weld test	9~12	1	Flat	2.0~3.2	**Fig. 2.2.34**	Tensile test specimen: 1 Face bend specimen: 1 Root bend specimen: 1
				1	Horizontal			
				1	Vertical upward			
				1	Vertical downward			
				1	Overhead			
Consumables for MIG welding		Deposited metal test	12	1	Flat	1.2	**Fig. 2.2.33**	Tensile test specimen: 1
			19	1	Flat	1.6		
		Butt weld test	9~12	1	horizontal Vertical upward Vertical downward Overhead	1.2~2.0	**Fig. 2.2.34**	Tensile test specimen: 1 Face bend specimen: 1 Root bend specimen: 1
Flux cored wire for semi-automatic welding		Deposited metal test	12	1	Flat	1.2~2.4	**Fig. 2.2.33**	Tensile test specimen: 1
			19	1	Flat	3.2 or max. dia		
		Butt weld test	9~12	1	horizontal Vertical upward Vertical downward Overhead	1.2~3.2	**Fig. 2.2.34**	Tensile test specimen: 1 Face bend specimen: 1 Root bend sper imen: 1
Consumables for submerged arc welding(2)	Multi-run technique	Deposited metal test	19~25	1	Flat	1.2~4.0	**Fig. 2.2.33**	Tensile test specimen: 1
		Butt weld test	19	1	Flat	1.2~4.0	**Fig. 2.2.35** (a)	Tensile test specimen: 1 Face bend spscimen: 1 Root bend specimen: 1
	Two-run technique	Butt weld test	12	1	Flat	1.2~2.4	**Fig. 2.2.35** (b)	Tensile test specimen: 1 Face bend specimen: 1 Root bend specimen: 1
			19	1	Flat	4.0		Tensile test specimen: 1 Longitudinal tensile test specimen: 1 Face bend specimen: 1 Root bend specimen: 1

NOTES:
(1) Where approved by the Society, the diameter of electrodes or wires may be changed.
(2) Tests on both multi-run and two run technique are to be conducted for multi-run and two run welding respectively and the number, dimensions and thickness of test assemblies, along with the grades and number of test specimens seclected from each test assembly are to be according to each of the welding processes. However, longitudinal tensile test of two run technique are not required.

Table 2.2.57 Grades of Steel for Test Assernbly

Grade of welding consumables	Grade of steel for test assembly(1)
*RD*308, *RY*308, *RW*308, *RU*308	*RSUS*304
*RD*308*L*, *RY*308*L*, *RW*308*L*, *RU*308*L*	*RSUS*304*L*
*RD*309, *RY*309, *RW*309, *RU*309	*RSUS*309*S*
*RD*309*L*, *RY*309*L*, *RW*309*L*	
*RD*309*Mo*, *RY*309*Mo*, *RW*309*Mo*, *RU*309*Mo*	
*RD*309*MoL*, *RW*309*MoL*	
*RD*310, *RY*310, *RW*310, *RU*310	*RSUS*310*S*
*RY*310*S*	
*RD*310*Mo*	
*RD*316, *RY*316, *RW*316, *RU*316	*RSUS*316
*RD*316*L*, *RY*316*L*, *RW*316*L*, *RU*316*L*	*RSUS*316*L*
*RD*317, *RY*317, *RW*317, *RU*317	*RSUS*317
*RD*317*L*, *RY*317*L*, *RW*317*L*, *RU*317*L*	*RSUS*317, *RSUS*317*L*
*RY*321	*RSUS*321
*RD*347, *RY*347, *RW*347, *RU*347	*RSUS*321, *RSUS*347

NOTE:
(1) Notwithstanding the requirements in this table, mild steel or higher strength steel may be used for deposited metal test assembly. In this case, test assemblies are to be appropriately buttered.



t	*s*	*H*
12	6	Min. 90
19~25	12	Min. 150

Fig. 2.2.33 Deposited Metal Test Assembly for Stainless Steel (Unit : *mm*)

(3) For the approval of welding consumables, the tests specified in the preceding (1) are to be conducted for each brand of welding consumables.

(4) For flux cored wire semi-automatic welding materials, which use shield gas, the test in the preceding (3) is to be performed for each type of gas given in **Table 2.2.27.** When the manufacturer of the consumables recommends gas types of the group of *M*1, *M*2, *M*3 or *C* in **Table 2.2.27** and the test is satisfactorily conducted in accordance with the preceding (3) on one of the gas type, the test on the other gas types belonging to the same group is allowed to be dispensed with at the discretion of the Society.

(5) The welding conditions used such as amperage, voltage, travel speed, etc. are to be within the range recommended by the manufacturer for normal good welding practice. Where a filler metal is stated to be suitable for both alternating current (AC) and direct current (DC), AC is to be used for the preparation of the test assemblies.

4. Welding of test assemblies

(1) Deposited metal test assemblies
  (a) Test assemblies as shown in **Fig. 2.2.33** are to be welded in the flat position according to the welding procedure recommended by the manufacturer.
  (b) After each run, the test assembly is to be left in still air until it has cooled to less than 150°C but not below 15°C, the temperature being taken at the centre of the weld on the surface of seam.

(2) Butt weld test assemblies
  (a) Test assemblies as shown in **Figs. 2.2.34** and **2.2.35** are to be welded in each welding position (flat, horizontal, vertical upward, vertical downward and overhead) which is recommended by the manufacturer.
  (b) After each run, the test assembly is to be left in still air until it has cooled to less than 150°C but not below 15°C, the temperature being taken at the centre of the weld on the surface of seam.

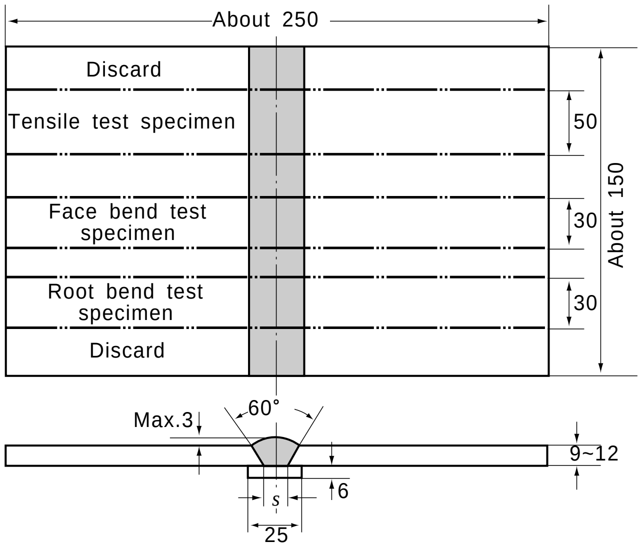
(3) After welding, the test assemblies are not to be subjected to any heat treatment.

(4) It is recommended that the welded assemblies be subjected to a radiographic examination to ascertain that there are any defects in the weld prior to the preparation of test specimens.

5. Chemical composition

(1) Deposited metals of electrodes for manual arc welding and of welding consumables for flux cored wire semi-automatic welding and submerged arc welding are to have the chemical composition given in **Tables 2.2.58, 2.2.60** and **2.2.61** respectively.

(2) TIG and MIG welding consumables are to have the chemical composition of ladle analysis value



Kind of welding consum-ables	Electrode for manual arc welding	Elec-trode for TIG welding	Wire for MIG welding	Flux cored wire for semi-auto-matic welding
$s(mm)$	Max. dia. of electrode	Max.5	Max.5	Max.6

Fig. 2.2.34 Butt Weld Test Assembly for Stainless Steel (Except for Submerged arc welding, Unit : mm)

complied with the requirements as given in **Table 2.2.59.**

6. Deposited metal tensile test

(1) One tensile test specimens to be $R10$ shown in **Table 2.2.1** is to be taken from each test assembly. Further, where approved by the Society, one $R14$ tensile test specimen may be taken, the longitudinal axis of test speci-men coincides with the centre of weld and the mid-thickness of plate.

(2) The tensile test specimens may be subjected to a temperature not exceeding 250°C for a period not exceeding 16 *hours* for hydrogen removal prior to testing.

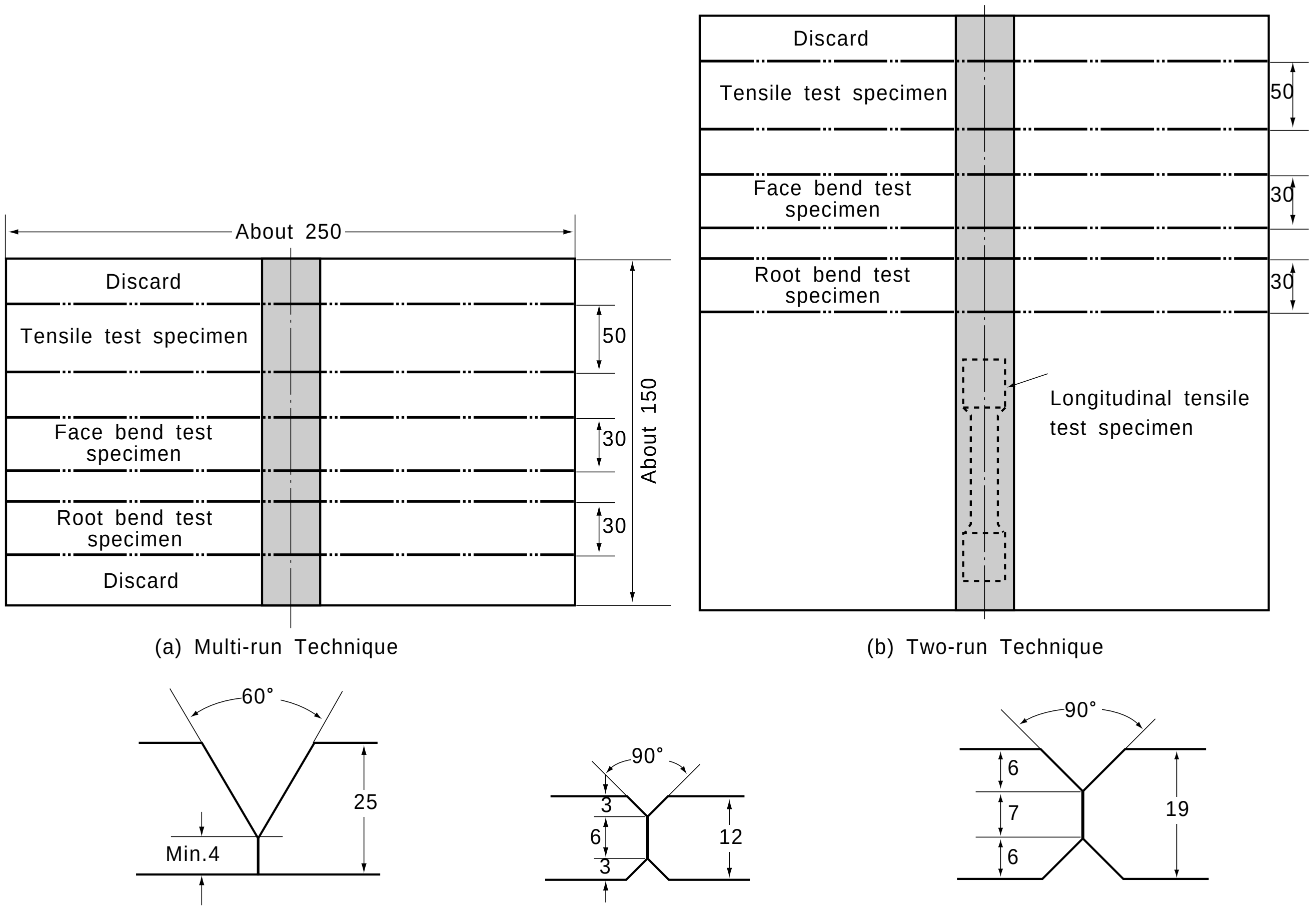
(3) Deposited metal tensile tests are to comply with the requirements in **Table 2.2.62.**

7. Butt weld tensile test

(1) One tensile test specimens to be $R2A$ shown in **Table 2.2.1** is to be taken from each test assemly.

(2) The tensile strength of each test specimen is to comply with the requirements given in **Table 2.2.63.**

(3) Submerged arc welding materials used only in the two-run technique are to be selected as



(a) Multi-run Technique (b) Two-run Technique

(1) For Multi-run Technique (2) For Two-run Technique, Thickness = 12mm (3) For Two-run Technique, Thickness = 19mm

Fig. 2.2.35 Butt Weld Test Assembly for Stainless Steel (Submerged arc welding, Unit : mm)

Table 2.2.58 Chemical Composition of Deposited Metal for Electrodes

Grade	Chemical composition (%)								
	C(max.)	Si(max.)	Mn(max.)	P(max.)	S(max.)	Ni	Cr	Mo	Others
*RD*308	0.08	0.90	2.50	0.04	0.03	9.0~11.0	18.0~21.0	–	–
*RD*308*L*	0.04	0.90	2.50	0.04	0.03	9.0~12.0	18.0~21.0	–	–
*RD*309	0.15	0.90	2.50	0.04	0.03	12.0~14.0	22.0~25.0	–	–
*RD*309*L*	0.04	0.90	2.50	0.04	0.03	12.0~16.0	22.0~25.0	–	–
*RD*309*Mo*	0.12	0.90	2.50	0.04	0.03	12.0~14.0	22.0~25.0	2.0~3.0	–
*RD*309*MoL*	0.04	0.90	2.50	0.04	0.03	12.0~14.0	22.0~25.0	2.0~3.0	–
*RD*310	0.20	0.75	2.50	0.03	0.03	20.0~22.0	25.0~28.0	–	–
*RD*310*Mo*	0.12	0.75	2.50	0.03	0.03	20.0~22.0	25.0~28.0	2.0~3.0	–
*RD*316	0.08	0.90	2.50	0.04	0.03	11.0~14.0	17.0~20.0	2.0~2.75	–
*RD*316*L*	0.04	0.90	2.50	0.04	0.03	11.0~16.0	17.0~20.0	2.0~2.75	–
*RD*317	0.08	0.90	2.50	0.04	0.03	12.0~14.0	18.0~21.0	3.0~4.0	–
*RD*317*L*	0.04	0.90	2.50	0.04	0.03	12.0~16.0	18.0~21.0	3.0~4.0	–
*RD*347	0.08	0.90	2.50	0.04	0.03	9.0~11.0	18.0~21.0	–	Nb8 × C(%)~1.0

Table 2.2.59 Chemical Composition of Deposited Metal for TIG Electrodes or Mig Wires

Grade	Chemical composition (%)								
	C(max.)	Si(max.)	Mn	P(max.)	S(max.)	Ni	Cr	Mo	Others
*RY*308	0.08	0.65	1.0~2.5	0.03	0.03	9.0~11.0	19.0~22.0	–	–
*RY*308*L*	0.03	0.65	1.0~2.5	0.03	0.03	9.0~11.0	19.0~22.0	–	–
*RY*309	0.12	0.65	1.0~2.5	0.03	0.03	12.0~14.0	23.0~25.0	–	–
*RY*309*L*	0.03	0.65	1.0~2.5	0.03	0.03	12.0~14.0	23.0~25.0	–	–
*RY*309*Mo*	0.12	0.65	1.0~2.5	0.03	0.03	12.0~14.0	23.0~25.0	2.0~3.0	–
*RY*310	0.15	0.65	1.0~2.5	0.03	0.03	20.0~22.5	25.0~28.0	–	–
*RY*310*S*	0.08	0.65	1.0~2.5	0.03	0.03	20.0~22.5	25.0~28.0	–	–
*RY*316	0.08	0.65	1.0~2.5	0.03	0.03	11.0~14.0	18.0~20.0	2.0~3.0	–
*RY*316*L*	0.03	0.65	1.0~2.5	0.03	0.03	11.0~14.0	18.0~20.0	2.0~3.0	–
*RY*317	0.08	0.65	1.0~2.5	0.03	0.03	13.0~15.0	18.5~20.5	3.0~4.0	–
*RY*317*L*	0.03	0.65	1.0~2.5	0.03	0.03	13.0~15.0	18.5~20.5	3.0~4.0	–
*RY*321	0.08	0.65	1.0~2.5	0.03	0.03	9.0~10.5	18.5~20.5	–	Ti9 × C(%)~1.0
*RY*347	0.08	0.65	1.0~2.5	0.03	0.03	9.0~11.0	19.0~21.5	–	Nb10 × C(%)~1.0

one *R*14 tensile test specimen of **Table 2.2.1**, such that the longitudinal centre line of the test specimen coincides with the weld centre line of the test assemblies and centre of thickness.

(4) The longitudinal tensile test specimens specified in the preceding (3) may be subjected to the heat treatment not exceeding 250°C for a period not exceeding 16 *hours* for hydrogen removal prior to testing.

(5) The tensile strength, yield point and elongation of the test specimens specified in the preceding (3) and (4) are to comply with the requirements given in **Table 2.2.62.**

8. Butt weld bend test

(1) The face and root bend test specimens are to be *RB*4 specimen shown in **Table 2.2.2**, and test specimens are to be taken from each test assembly.

(2) The test specimens are to be capable of withstanding, without crack exceeding 3 *mm* long on the outer surface of the specimen or other defects, being bent through an angle of 120 *degrees* over a former having a radius of 1.5 *times* the thickness of test specimen.

9. Annual inspections

(1) In the annual inspections, tests specified in the following (2) are to be conducted for each

Table 2.2.60 Chemical Composition of Deposited Metal for Flux Cored Wire Semi-automatic Welding

(a) With Gas

Grade	Chemical composition (%)								
	C(max.)	Si(max.)	Mn	P(max.)	S(max.)	Ni	Cr	Mo	Others
RW308	0.08	1.0	0.5~2.5	0.04	0.03	9.0~11.0	18.0~21.0	–	–
RW308L	0.04	1.0	0.5~2.5	0.04	0.03	9.0~12.0	18.0~21.0	–	–
RW309	0.10	1.0	0.5~2.5	0.04	0.03	12.0~14.0	22.0~25.0	–	–
RW309L	0.04	1.0	0.5~2.5	0.04	0.03	12.0~14.0	22.0~25.0	–	–
RW309Mo	0.12	1.0	0.5~2.5	0.04	0.03	12.0~14.0	22.0~25.0	2.0~3.0	–
RW309MoL	0.04	1.0	0.5~2.5	0.04	0.03	12.0~14.0	22.0~25.0	2.0~3.0	–
RW310	0.20	1.0	0.5~2.5	0.04	0.03	20.0~22.0	25.0~28.0	–	–
RW316	0.08	1.0	0.5~2.5	0.04	0.03	11.0~14.0	17.0~20.0	2.0~3.0	–
RW316L	0.04	1.0	0.5~2.5	0.04	0.03	11.0~14.0	17.0~20.0	2.0~3.0	–
RW317	0.08	1.0	0.5~2.5	0.04	0.03	12.0~14.0	18.0~21.0	3.0~4.0	–
RW317L	0.04	1.0	0.5~2.5	0.04	0.03	12.0~16.0	18.0~21.0	3.0~4.0	–
RW347	0.08	1.0	0.5~2.5	0.04	0.03	9.0~11.0	18.0~21.0	–	Nb8 × C(%)~1.0

(b) Without Gas

Grade	Chemical composition (%)								
	C(max.)	Si(max.)	Mn	P(max.)	S(max.)	Ni	Cr	Mo	Others
RW308	0.08	1.0	0.5~2.5	0.04	0.03	9.0~11.0	19.5~22.0	–	–
RW308L	0.04	1.0	0.5~2.5	0.04	0.03	9.0~12.0	19.5~22.0	–	–
RW309	0.10	1.0	0.5~2.5	0.04	0.03	12.0~14.0	23.0~25.5	–	–
RW309L	0.04	1.0	0.5~2.5	0.04	0.03	12.0~14.0	23.0~25.5	–	–
RW309Mo	0.12	1.0	0.5~2.5	0.04	0.03	12.0~14.0	22.0~25.0	2.0~3.0	–
RW309MoL	0.04	1.0	0.5~2.5	0.04	0.03	12.0~14.0	22.0~25.0	2.0~3.0	–
RW310	0.20	1.0	0.5~2.5	0.04	0.03	20.0~22.0	25.0~28.0	–	–
RW316	0.08	1.0	0.5~2.5	0.04	0.03	11.0~14.0	18.0~20.5	2.0~3.0	–
RW316L	0.04	1.0	0.5~2.5	0.04	0.03	11.0~14.0	18.0~20.5	2.0~3.0	–
RW317	0.08	1.0	0.5~2.5	0.04	0.03	13.0~15.0	18.5~21.0	3.0~4.0	–
RW317L	0.04	1.0	0.5~2.5	0.04	0.03	13.0~15.0	18.5~21.0	3.0~4.0	–
RW347	0.08	1.0	0.5~2.5	0.04	0.03	9.0~11.0	19.0~21.5	–	Nb8 × C(%)~1.0

Table 2.2.61 Chemical Composition of Deposited Metal for Submerged Arc Welding

Grade	Chemical composition (%)								
	C(max.)	Si(max.)	Mn(max.)	P(max.)	S(max.)	Ni	Cr	Mo	기 타
RU308	0.08	1.0	2.5	0.04	0.03	9.0~11.0	18.0~21.0	–	–
RU308L	0.04	1.0	2.5	0.04	0.03	9.0~12.0	18.0~21.0	–	–
RU309	0.15	1.0	2.5	0.04	0.03	12.0~14.0	22.0~25.0	–	–
RU309Mo	0.12	1.0	2.5	0.04	0.03	12.0~14.0	22.0~25.0	2.0~3.0	–
RU310	0.20	1.0	2.5	0.04	0.03	20.0~22.0	25.0~28.0	–	–
RU316	0.08	1.0	2.5	0.04	0.03	11.0~14.0	17.0~20.0	2.0~2.75	–
RU316L	0.04	1.0	2.5	0.04	0.03	11.0~16.0	17.0~20.0	2.0~2.75	–
RU317	0.08	1.0	2.5	0.04	0.03	12.0~14.0	18.0~21.0	3.0~4.0	–
RU317L	0.04	1.0	2.5	0.04	0.03	12.0~16.0	18.0~21.0	3.0~4.0	–
RU347	0.08	1.0	2.5	0.04	0.03	9.0~11.0	18.0~21.0	–	Nb8 × C(%)~1.0

Table 2.2.62 Tensile Test Requirements for Deposited Metal

Electrode for manual arc welding	Consumables for TIG and MIG welding	Flux cored wire for semi-automatic welding	Consumablesl for submerged arc welding	Tensile strength (N/mm^2)	Yield strength (N/mm^2)	Elongation (%)
$RD308$	$RY308$	$RW308$	$RU308$	550 min.	225 min.	35 min.
$RD308L$	$RY308L$	$RW308L$	$RU308L$	510 min.	205 min.	35 min.
$RD309$	$RY309$	$RW309$	$RU309$	550 min.	225 min.	30 min.
$RD309L$	$RY309L$	$RW309L$	–	510 min.	205 min.	30 min.
$RD309Mo$	$RY309Mo$	$RW309Mo$	$RU309Mo$	550 min.	225 min.	30 min.
$RD309MoL$	–	$RW309MoL$	–	510 min.	205 min.	30 min.(1)
$RD310$	$RY310$	$RW310$	$RU310$	550 min.	225 min.	30 min.
–	$RY310S$	–	–	550 min.	225 min.	30 min.
$RD310Mo$	–	–	–	550 min.	225 min.	30 min.
$RD316$	$RY316$	$RW316$	$RU316$	550 min.	225 min.	30 min.
$RD316L$	$RY316L$	$RW316L$	$RU316L$	510 min.	205 min.	35 min.
$RD317$	$RY317$	$RW317$	$RU317$	550 min.	225 min.	30 min.
$RD317L$	$RY317L$	$RW317L$	$RU317L$	510 min.	205 min.	30 min.
–	$RY321$	–	–	550 min.	225 min.	30 min.
$RD347$	$RY347$	$RW347$	$RU347$	550 min.	225 min.	30 min.

NOTE:
(1) Elongation of $RW309MoL$ is to be not less than 20 (%).

Table 2.2.63 Tensile Test Requirements for Butt Weld

Electrode for manual arc welding	Consumables for TIG and MIG welding	Flux cored wire for semi-automatic welding	Consumables for submerged arc welding	Tensile strength (N/mm^2)
$RD308$	$RY308$	$RW308$	$RU308$	520 min.
$RD308L$	$RY308L$	$RW308L$	$RU308L$	480 min.
$RD309$	$RY309$	$RW309$	$RU309$	520 min.
$RD309L$	$RY309L$	$RW309L$	–	520 min.
$RD309Mo$	$RY309Mo$	$RW309Mo$	$RU309Mo$	520 min.
$RD309MoL$	–	$RW309MoL$	–	520 min.
$RD310$	$RY310$	$RW310$	$RU310$	520 min.
–	$RY310S$	–	–	520 min.
$RD310Mo$	–	–	–	520 min.
$RD316$	$RY316$	$RW316$	$RU316$	520 min.
$RD316L$	$RY316L$	$RW316L$	$RU316L$	480 min.
$RD317$	$RY317$	$RW317$	$RU317$	520 min.(1)
$RD317L$	$RY317L$	$RW317L$	$RU317L$	520 min.(1)
–	$RY321$	–	–	520 min.
$RD347$	$RY347$	$RW347$	$RU347$	520 min.

NOTE:
(1) Where the test assembly is made of $RSUS317L$, the tensile strength is not to be less than 480 N/mm^2.

Table 2.2.64 Kinds of Test at Annual Inspection

<table>
<tr><th rowspan="2" colspan="2">Kind of welding consumables</th><th rowspan="2">Kind of test</th><th colspan="5">Welding proudure for test assembly</th><th rowspan="2">Kind and number of test specimens taken from test assembly</th></tr>
<tr><th>Welding position</th><th>Dia. of electrode or wire (mm)</th><th>Number</th><th>Dimension</th><th>Thickness (mm)</th></tr>
<tr><td colspan="2">Electrode for manual arc welding</td><td rowspan="4">Deposited metal test</td><td rowspan="4">Flat</td><td>3.2~4.0</td><td rowspan="4">1</td><td rowspan="4">Fig. 2.2.33</td><td rowspan="4">12~19</td><td rowspan="4">Tensile test specimen: 1</td></tr>
<tr><td colspan="2">Consumables for TIG welding</td><td>2.4~3.2</td></tr>
<tr><td colspan="2">Consumables for MIG welding</td><td>1.2~1.6</td></tr>
<tr><td colspan="2">Flux cored wire for semi-automatic welding</td><td>1.2~3.2</td></tr>
<tr><td rowspan="2">Consumables for sub-merged arc welding[(1)]</td><td>Multi-urn technique</td><td>Deposited metal test</td><td>Flat</td><td>1.2~4.0</td><td>1</td><td>Fig. 2.2.33</td><td>19~25</td><td>Tensile test specimen: 1</td></tr>
<tr><td>Two-run technique</td><td>Butt weld test</td><td>Flat</td><td>2.4~4.0</td><td>1</td><td>Fig. 2.2.35 (b)</td><td>12~19</td><td>Tensile test specimen: 1
Longitudinal tensile test specimen: 1
Face bend specimen: 1
Root bend specimen: 1</td></tr>
<tr><td colspan="9">NOTE:
(1) Tests on both multi-run and two run techinque are to be conducted for multi-run and two run welding respectively and the number, dimensions and thickness of test assemblies, along with the grades and number of test specimens selected from each test assembly are to be according to each of the welding processes. However, longitudinal tensile test of two run technique are not required.</td></tr>
</table>

brand of approved consumables, and they are to be passed satisfactorily.

(2) The kinds of test, etc. in the annual inspections are to be as given in **Table 2.2.64.**

(3) The welding procedures and requirements of test assemblies for tests in the preceding (2) are to be as specified in **Pars 4** through **8.**

608. Welding consumables for aluminium alloys

1. Application

Welding consumables used for aluminium alloys mentioned in the following (1) and (2)(hereinafter referred to as "welding consumables") are to be subjected to the approval tests and annual inspections in accordance with these requirements.

(1) Rod-gas combinations for tungsten inert gas arc welding (TIG welding) or plasma arc welding

(2) Wire electrode and wire-gas combinations for metal arc inert gas welding (MIG welding), tungsten inert gas arc welding(TIG welding) or plasma arc welding

2. Grades and marks of welding consumables

(1) Grades and marks of welding consumables are classified as given in **Table 2.2.65.**

(2) Welding consumables using a specific shielding gas are to be suffixed with "G" at the end of the mark. Kinds of the shielding gases are classified as shown in **Table 2.2.66** and the kind is to be suffixed following to the mark "G". (e.g. *RAlRBG*(*I*-3))

Table 2.2.65 Grades and Marks

Kind of welding consumables	Grade and Mark
Electrode	*RAlRA, RAlRB, RAlRC, RAlRD*
Wire	*RAlWA, RAlWB, RAlWC, RAlWD*

Table 2.2.66 Kind of Gas

Group	Kinds	Gas composition(%)	
		He	Ar
I	I-1	-	100
	I-2	100	-
	I-3	1 - 33	Rest
	I-4	34 - 66	Rest
	I-5	67 - 95	Rest
E	E-1	Others	

3. Approval test

(1) For the approval of welding consumables, the tests specified in 4. (1) are to be successfully conducted for each brand of welding consumables.

(2) For welding consumables using a shielding gas, the tests specified in (1) are to be conducted for each kind of gas designated among **Table 2.2.66** by the manufacturer. However, where the manufacturer designates several kinds of gas which are classified into the group I in **Table 2.2.66** and the tests specified in (1) are

Table 2.2.67 Kinds of Test for Welding Consumables

Kinds of test	Test assembly				Kinds and number of test specimens taken from test assembly
	Welding position	Number	Dimension	Thickness (mm)	
Deposited metal test (Chemical composition test)	Flat	1	**Fig. 2.2.36**	-	-
Butt weld test	Flat	1	**Fig.2.2.37**	10～12	Tensile test specimen : 2 Face bend test specimen : 2 Root bend test specimen : 2 Macro structure test specimen : 1
	Horizontal	1(1)			
	Vertical upward	1			
	Overhead	1			
	Flat	1	**Fig.2.2.38**	20～25	Tensile test specimen : 2 Face bend test specimen : 2 Root bend test specimen : 2 Macro structure test specimen : 1

Note
(1) Welding consumables satisfying the requirements for flat and vertical upward positions may be dispensed with the tests for horizontal position subject to the approval of the Society.

Table 2.2.68 Grade of Aluminium Alloys used for Test Assembly

Grade of welding consumables	Grade of aluminium alloys used for test assembly	
RAIRA, RAIWA	5000 series	5754*P-O*
RAIRB, RAIWB		5086*P-O*
RAIRC, RAIWC		5083*P-O*
RAIRD, RAIWD	6000 series	6082*S*(1)

Note
(1) Other rolled aluminium alloys of 6000 series with minimum tensile strength 260 N/mm^2 may be used.

to be conducted for any one kind of gas, the tests for the other kind of gas may be dispensed with subject to the approval of the Society.

(3) When the manufacturer designated the gas classified into the group E in the tests specified in (2), the composition of the shielding gas is to be reported to the Society.

4. General provisions of tests

(1) Kinds of test, number, thickness and dimensions of test assemblies, kind and number of test specimen taken from each test assembly for welding consumables are to be as given in **Table 2.2.67**.

(2) The aluminium alloys used in preparation for test assembly corresponding to welding consumables are to be as given in **Table 2.2.68**.

5. Welding of test assemblies

(1) Deposited weld metal test assembly

(A) The test assemblies as shown in **Fig. 2.2.36** are to be welded in flat position in accordance with the welding process designated by the manufacturer.

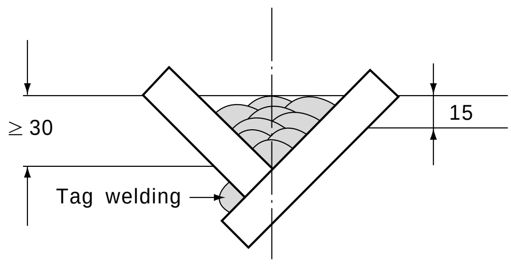
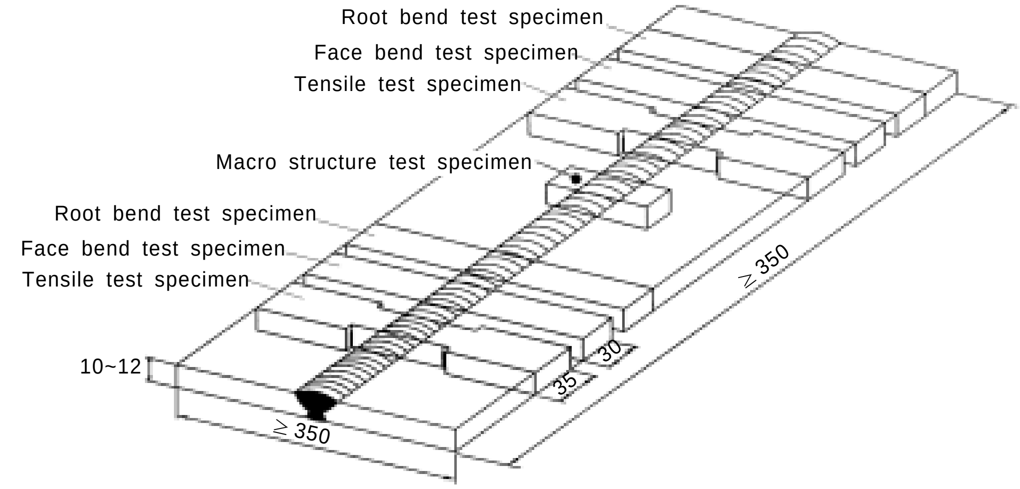


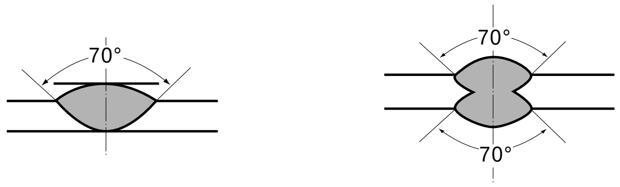
Fig. 2.2.36 Deposited Weld Metal Test Assembly
(Unit : mm)

(B) The size of test assembly corresponding to the welding consumables and welding process is to be taken a sufficient amount of pure weld metal for chemical analysis.

(2) Butt weld test assemblies

(A) The test assemblies as shown in **Fig. 2.2.37** are to be welded in each welding position designated by the manufacturer (downhand,

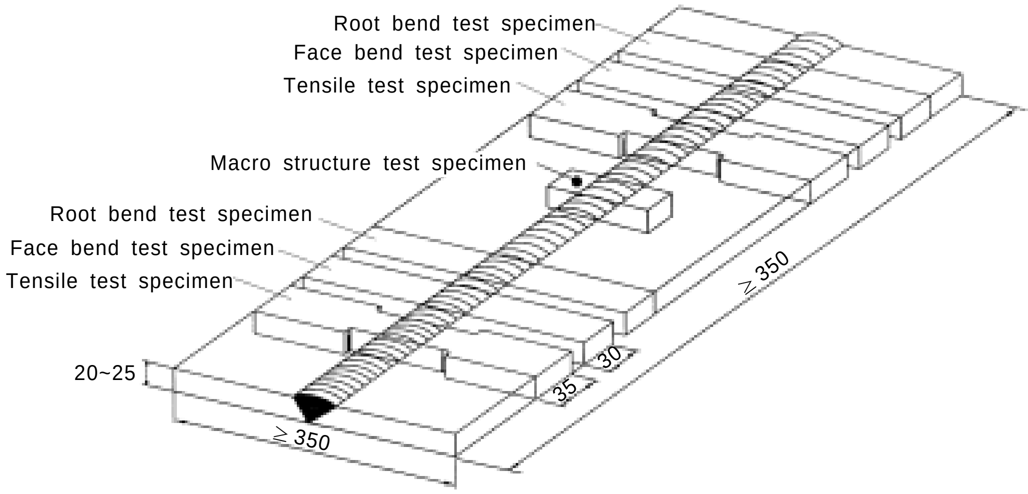


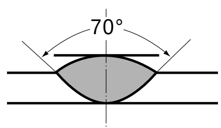


<One side welding> <Double side welding>

(Note)
(1) Back sealing runs are allowed in single V weld assembly.
(2) In case of double V assembly both sides are to be welded in the same welding position.

Fig.2.2.37 Butt Weld Test Assembly for Aluminium Alloys
(A thickness of 10 to 12, unit : *mm*)





(NOTE)
(1) Back sealing runs are allowed.

Fig. 2.2.38 Butt Weld Test Assembly for Aluminium Alloys
(A thickness of 20 to 25, unit : *mm*)

horizontal, vertical-upward and overhead). The test assembly as shown by **Fig. 2.2.38** is to be welded in the downhand position.

(B) On completion of each run, the test assemblies are to be allowed to cool naturally in air until the temperature measured at the surface of the centre of the welding joint is ambient temperature. However, the test assemblies for *RAIRD* and *RAIWD* are to be allowed to naturally ageing for a minimum period of 72 hours from the completion of welding before testing.

(3) After welding, the test assemblies are not to be subjected to any heat treatment or peening.

(4) It is recommended that the welded assemblies be subjected to a radiographic examination to ascertain that there are any defects in the weld prior to the preparation of test specimens.

6. Chemical composition

The chemical composition of the welding consumables is to be determined by the analysis of the deposited weld metal specified in **Fig. 2.2.36** and the results of the analysis are to comply with the limit value specified by the manufacturer.

7. Butt weld tensile test

(1) The tensile test specimens are to be *R2A* specimen shown in **Table 2.2.1** and two test specimens are to be taken from each test assembly.

(2) The tensile strength is to comply with the requirements as given in **Table 2.2.69.**

8. Butt Weld Bend Test

(1) The face bend and root bend test specimens are to be RB4 specimen shown in **Table 2.2.2** and two test specimens are to be taken from each assembly.

(2) The test specimens are to sustain the face and root bend tests over 180° using a former having a diameter in accordance with **Table 2.2.70**, without cracks exceeding 3 *mm* in length and other any defects on the outer surface.

9. Butt weld macro structure test

(1) One macro structure test specimen as shown in **Fig. 2.2.37** and **Fig.2.2.38** is to be taken from the butt weld test assembly.

(2) The macro structure test specimen is to be examined that there are not any imperfections such as lack of fusion, poor penetration or cracks.

10. Annual inspections

(1) In the annual inspections, every approved welding consumables are to be subjected to the tests provided in (2) and are to be successfully examined.

(2) Kinds of tests in the annual inspections are to be as given in **Table 2.2.71**.

(3) The welding procedure and requirements for test assemblies specified in (2) are to be in accordance with the requirements in **5.** to **9**.

609. Welding consumables for extra high strength steels for structures

1. Application

Welding consumables for extra high strength steels for structures, which are given in following (1) through (3) (hereinafter referred to as “welding consumables” in **609.**) the approval test and annual inspections are to be in accordance with the requirements specified in **609.**

(1) Electrodes for manual arc welding(specified in **602. 1.** (1) and (2))

Table 2.2.69 Tensile Test Requirements

Grade of welding consumables	Tensile strength(N/mm^2)
RAIRA, RAIWA	190 min.
RAIRB, RAIWB	240 min.
RAIRC, RAIWC	275 min.
RAIRD, RAIWD	170 min.

Table 2.2.70 Former Diameter of Bend Test

Grade of welding consumables	Former diameter(mm)(1)
RAIRA, RAIWA	3 *t*
RAIRB, RAIWB	6 *t*
RAIRC, RAIWC	
RAIRD, RAIWD	
Note (1) *t* : Thickness of the test specimen	

Table 2.2.71 Kinds of Tests in Annual Inspections

Kinds of test	Test assembly				Kind and number of test specimens taken from test assembly
	Welding position	Number	Dimensions	Thickness(mm)	
Deposited weld metal test (Chemical composition Analysis)	Flat	1	**Fig. 2.2.36**	-	-
Butt weld test	Flat	1	**Fig. 2.2.37**	10 - 12	Tensile test specimen : 2 Face bend test specimen : 2 Root bend test specimen : 2 Macro structure test specimen : 1

Table 2.2.72 Grades and Marks

Extra high strength steels		
Electrode for manual arc welding	Welding consumables for semi-automatic welding	Welding consumables for automatic welding
RMW2Y42, RMW2Y46, RMW2Y50, RMW2Y55, RMW2Y62, RMW2Y69	*RSW2Y42, RSW2Y46, RSW2Y50, RSW2Y55, RSW2Y62, RSW2Y69*	*RAW2Y42, RAW2Y46, RAW2Y50, RAW2Y55, RAW2Y62, RAW2Y69*
RMW3Y42, RMW3Y46, RMW3Y50, RMW3Y55, RMW3Y62, RMW3Y69	*RSW3Y42, RSW3Y46, RSW3Y50, RSW3Y55, RSW3Y62, RSW3Y69*	*RAW3Y42, RAW3Y46, RAW3Y50, RAW3Y55, RAW3Y62, RAW3Y69*
RMW4Y42, RMW4Y46, RMW4Y50, RMW4Y55, RMW4Y62, RMW4Y69	*RSW4Y42, RSW4Y46, RSW4Y50, RSW4Y55, RSW4Y62, RSW4Y69*	*RAW4Y42, RAW4Y46, RAW4Y50, RAW4Y55, RAW4Y62, RAW4Y69*
RMW5Y42, RMW5Y46, RMW5Y50, RMW5Y55, RMW5Y62, RMW5Y69	*RSW5Y42, RSW5Y46, RSW5Y50, RSW5Y55, RSW5Y62, RSW5Y69*	*RAW5Y42, RAW5Y46, RAW5Y50, RAW5Y55, RAW5Y62, RAW5Y69*

Table 2.2.73 Grade of Steels for Test Assembly

Grade of welding consumables	Grade of steel for assembly
RMW2Y42~69 *RSW2Y42~69* *RAW2Y42~69*	*RA43~RA70*
RMW3Y42~69 *RSW3Y42~69* *RAW3Y42~69*	*RA43~RA70, RD43~RD70*
RMW4Y42~69 *RSW4Y42~69* *RAW4Y42~69*	*RA43~RA70, RD43~RD70, RE43~RE70*
RMW5Y42~69 *RSW5Y42~69* *RAW5Y42~69*	*RA43~RA70, RD43~RD70,* *RE43~RE70* *RF43~RF70*

NOTES:
Notwithstanding the requirements in this table, normal and higher strength steels may be used for deposited metal test assembly. In this case, appropriate buttering is to be carried out.

(2) Automatic welding consumables(specified in **603. 1.** (1) and (2). However, in this case, used only for multi-run technique in principle.)
(3) Semi-automatic welding consumables

2. Grade and marks of welding consumables

(1) Grades and marks of welding consumables are classified as given in **Table 2.2.72.**
(2) Where the welding consumables have passed the test specified in **3,** the suffixes are to be added to the grade marks with the same methods as specified in **603. 2.** (2) and (3) or **604. 2.** (2) according to the grade of welding consumables.
(3) For low hydrogen electrodes which have passed the hydrogen test specified in 11 the suffixes given in **Table 2.2.77** are to be added to the grade marks(after the suffixes in the case of the preces said electrodes.(Example : RMW3Y46H5)

3. Approval test

For the approval of welding consumables, the tests specified in **602., 603.** or **604.** are to be conducted for each brand of welding consumables.

4. General provisions for tests

(1) Kinds of test, number, thickness, and dimensions of test assembles, diameters of electrodes or wires used for welding and welding positions, together with kinds and number of test specimens taken from each test assembly for welding consumables are to be in accordance with the requirements specified in **602. 3., 603. 3.** or **604. 3.** However, note (4) of **Table 2.2.15** and note (4) of **Table 2.2.35** are not to be required. Provisions for automatic welding consumables are to be the requirements specified in multi run technique.
(2) The grades of steels used for tests are to be those given in **Table 2.2.73** corresponding to the grades of welding consumables, or those which are considered equivalent by the Society.

5. Welding sequence or test assemblies

Welding sequence of test assemblies are to be in accordance with the requirements specified in **602. 4, 603. 4** or **604. 4** appropriate to the grade of the welding consumables.

6. Deposited metal tensile test

(1) Kinds, numbers and selection methods of the deposited metal tensile test specimens being taken from each test assembly are to comply with the requirements specified in **602. 5.** (1), **603. 5.** (1) or **604. 5.** (1) according to the grade of the welding consumables.
(2) The tensile strength, yield strength and elongation of each test specimen are to comply with the requirements specified in **Table 2.2.74** according to the grade of the welding con-

Table 2.2.74 Test Requirements for Deposited Metal

Grade of welding consumables	Tensile test			Impact test	
	Tensile strength (N/mm^2)	Yield strength (N/mm^2)	Elongation (%)	Test temper-ature (°C)	Minimum mean absorbed energy (J)
RMW2Y42 RSW2Y42 RAW2Y42	530 ~ 680	420 min.	20 min.	0	47 min.
RMW3Y42 RSW3Y42 RAW3Y42				-20	
RMW4Y42 RSW4Y42 RAW4Y42				-40	
RMW5Y42 RSW5Y42 RAW5Y42				-60	
RMW2Y46 RSW2Y46 RAW2Y46	570 ~ 720	460 min.	20 min.	0	
RMW3Y46 RSW3Y46 RAW3Y46				-20	
RMW4Y46 RSW4Y46 RAW4Y46				-40	
RMW5Y46 RSW5Y46 RAW5Y46				-60	
RMW2Y50 RSW2Y50 RAW2Y50	610 ~ 770	500 min.	18 min.	0	50 min.
RMW3Y50 RSW3Y50 RAW3Y50				-20	
RMW4Y50 RSW4Y50 RAW4Y50				-40	
RMW5Y50 RSW5Y50 RAW5Y50				-60	
RMW2Y55 RSW2Y55 RAW2Y55	670 ~ 830	550 min.	18 min.	0	55 min.
RMW3Y55 RSW3Y55 RAW3Y55				-20	
RMW4Y55 RSW4Y55 RAW4Y55				-40	
RMW5Y55 RSW5Y55 RAW5Y55				-60	
RMW2Y62 RSW2Y62 RAW2Y62	720 ~ 890	620 min.	18 min.	0	62 min.
RMW3Y62 RSW3Y62 RAW3Y62				-20	
RMW4Y62 RSW4Y62 RAW4Y62				-40	
RMW5Y62 RSW5Y62 RAW5Y62				-60	
RMW2Y69 RSW2Y69 RAW2Y69	770 ~ 940	690 min.	17 min.	0	69 min.
RMW3Y69 RSW3Y69 RAW3Y69				-20	
RMW4Y69 RSW4Y69 RAW4Y69				-40	
RMW5Y69 RSW5Y69 RAW5Y69				-60	
NOTE : Tensile strength specified in the table may be alerted where deemed appropriate by the Society.					

sumables.

(3) The provisions specified in the preceding **602. 5.** (2) may be applied to the tensile test specimens.

7. Deposited metal impact test

(1) Kinds, numbers and selection methods of the deposited metal impact test specimens being taken from each test assembly are to comply with the requirements specified in **602. 6.** (1), **603. 6.** (1) or **604. 6.** (1) according to the grade of the welding consumables.

(2) The test temperature and minimum mean absorbed energy are to comply with the requirements specified given in **Table 2.2.74** according to the grade of the welding consumables.

(3) The requirements specified in the preceding **602. 6.** (2) and (4) are to be applied to this test.

8. Butt weld tensile test

(1) Kinds and numbers of the butt weld tensile test specimens being taken from each test assembly are to comply with the requirements specified in **602. 7.** (1), **603. 7.** (1) or **604. 7.** (1) according to the grade of the welding consumables.

(2) The tensile strength of each test specimen is to meet the requirements given in **Table 2.2.75** according to the grade of the welding consumables.

9. Butt weld bend test

(1) Kinds and numbers of the butt weld face bend and root bend test specimens being taken hom each test assembly are to comply with the requirements specified in **602. 8.** (1), **603. 8.**

Table 2.2.75 Impact Test Requirements for Deposited Metal

Grade of welding consumables	Tensile strength (N/mm^2)
RMW2Y42 RSW2Y42 RAW2Y42 RMW3Y42 RSW3Y42 RAW3Y42 RMW4Y42 RSW4Y42 RAW4Y42 RMW5Y42 RSW5Y42 RAW5Y42	530 min.
RMW2Y46 RSW2Y46 RAW2Y46 RMW3Y46 RSW3Y46 RAW3Y46 RMW4Y46 RSW4Y46 RAW4Y46 RMW5Y46 RSW5Y46 RAW5Y46	570 min.
RMW2Y50 RSW2Y50 RAW2Y50 RMW3Y50 RSW3Y50 RAW3Y50 RMW4Y50 RSW4Y50 RAW4Y50 RMW5Y50 RSW5Y50 RAW5Y50	610 min.
RMW2Y55 RSW2Y55 RAW2Y55 RMW3Y55 RSW3Y55 RAW3Y55 RMW4Y55 RSW4Y55 RAW4Y55 RMW5Y55 RSW5Y55 RAW5Y55	670 min.
RMW2Y62 RSW2Y62 RAW2Y62 RMW3Y62 RSW3Y62 RAW3Y62 RMW4Y62 RSW4Y62 RAW4Y62 RMW5Y62 RSW5Y62 RAW5Y62	720 min.
RMW2Y69 RSW2Y69 RAW2Y69 RMW3Y69 RSW3Y69 RAW3Y69 RMW4Y69 RSW4Y69 RAW4Y69 RMW5Y69 RSW5Y69 RAW5Y69	770 min.

Table 2.2.76 Butt Weld Bend Test for the Bend Radius

Grade of welding consumable	Radius of plunger
RMW2Y42~50 RSW2Y42~50 RAW2Y42~50 RMW3Y42~50 RSW3Y42~50 RAW3Y42~50 RMW4Y42~50 RSW4Y42~50 RAW4Y42~50 RMW5Y42~50 RSW5Y42~50 RAW5Y42~50	2.0 t
RMW2Y55~69 RSW2Y55~69 RAW2Y55~69 RMW3Y55~69 RSW3Y55~69 RAW3Y55~69 RMW4Y55~69 RSW4Y55~69 RAW4Y55~69 RMW5Y55~69 RSW5Y55~69 RAW5Y55~69	2.5 t

Table 2.2.77 Requirements for hydrogen Contents

Grade of welding consumable	Suffixes	Requrrements for Hydrogen Contents (cm^3/g)		
		Glycerine method	Mercury method	Gas chromatographic method
RMW2Y42~50, RMW3Y42~50, RMW4Y42~50, RMW5Y42~50	H 10	0.05 max.	0.10 max.	0.10 max.
RSW2Y42~50, RSW3Y42~50, RSW4Y42~50, RSW5Y42~50				
RAW2Y42~50, RAW3Y42~50, RAW4Y42~50, RAW5Y42~50				
RMW2Y55~69, RMW3Y55~69, RMW4Y55~69, RMW5Y55~69	H 5	-	0.05 max.	0.05 max.
RSW2Y55~69, RSW3Y55~69, RSW4Y55~69, RSW5Y55~69				
RAW2Y55~69, RAW3Y55~69, RAW4Y55~69, RAW5Y55~69				

(1) or **604. 8.** (1) according to the grade of the welding consumables.

(2) The test specimens are to be subjected to face bend and root bend tests by using former having a radius given in **Table 2.2.76.** Outer surface of the specimens is to be free from any cracks exceeding 3mm long or other defects when they are bent to the angle of 120 degrees.

10. Butt weld impact test

(1) Kinds, numbers and selection method of the butt weld impact test specimens being taken from each test assembly are to comply with the requirements specified in **602. 9.** (1), **603. 9.** (1) or **604. 9.** (1) according to the grade of the welding consumables.

(2) Testing temperature and minimum mean absorbed energy are to comply with the requirements specified in **Table 2.2.74** according to the grade of the welding consumables.

(3) The requirements specified in the preceding **602. 6.** (2) and (4) are to be applied to these tests.

11. Hydrogen test

(1) Hydrogen Test is to be carried out for welding consumables except gas shielded arc solid wire by the glycerine method, mercury method, gas chromatographic method or other methods deemed appropriate by the Society.

(2) The average volume of hydrogen is to comply with the requirements specified in **Table 2.2.77** according to the test procedures specified in preceding (1) or the type of suffixes to be added to the grade marks.

12. Fillet weld macro-structure test

The fillet weld macro-structure test is to be in accordance with the requirements specified in **602. 11.**

13. Fillet weld hardness test

The fillet weld hardness test is to be in accordance with the requirements specified in **602. 12.**

14. Fillet weld fracture test

The fillet weld fracture test is to be in accordance with the requirements specified in **602. 13.**

15. Annual inspections

Annual inspections are to comply with the requirements specified in **602. 14, 603. 14** or **604. 14** according to the grade of the welding consumables. However, in general, annual inspections for automatic welding consumables are to comply with the requirements specified for multi run tenchnique.

16. Change in grades

The changes in grades relating to the strength or toughness of approved welding consumables are to comply with the requirements specified in **602. 15, 603. 15** or **604. 15** according to the grade of the welding consumables. ⚓