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RULES FOR THE SURVEY AND CONSTRUCTION OF INLAND WATERWAY SHIPS

GUIDANCE FOR THE SURVEY AND CONSTRUCTION OF INLAND WATERWAY SHIPS

Rules for the Survey and Construction of Inland Waterway Ships
ESTABLISHMENT

Guidance for the Survey and Construction of Inland Waterway Ships
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Rule No.70 / Notice No.51 17th September 2014
Resolved by Technical Committee on 29th July 2014
Approved by Board of Directors on 16th September 2014

ClassNK
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RULES FOR THE SURVEY AND CONSTRUCTION OF INLAND WATERWAY SHIPS

RULES

ESTABLISHMENT

Rule No.70 17th September 2014

Resolved by Technical Committee on 29th July 2014

Approved by Board of Directors on 16th September 2014

Rule No.70 17th September 2014
"Rules for the survey and construction of inland waterway ships" has been established as follows:

RULES FOR THE SURVEY AND CONSTRUCTION OF INLAND WATERWAY SHIPS

(See attached)

EFFECTIVE DATE AND APPLICATION

1. The effective date of the establishment is 17 September 2014.

RULES FOR THE SURVEY AND CONSTRUCTION OF INLAND WATERWAY SHIPS

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RULES FOR THE SURVEY AND CONSTRUCTION OF INLAND WATERWAY SHIPS

Part 1 GENERAL RULES

Chapter 1 GENERAL

1.1 General

1.1.1 Application

1 The survey, construction, installation, material, equipment and machinery, etc. of the ships mainly navigating inland waterways (hereinafter referred to as “ships” in the Rules) to be registered in accordance with the **Regulations for the Classification and Registry of Ships** are to be as prescribed in the Rules.

2 The requirements in the Rules apply to ships specified in **(1)** and **(2)**.

(1) Tugs and pushers

(2) Barges specified in **(a)** to **(c)**, not propelled by mechanical means

(a) Barges carrying dry cargoes in holds

(b) Barges carrying dry cargoes on upper decks (hereinafter referred to as “pontoon barges” in the Rules)

(c) Barges carrying liquid cargoes in bulk (hereinafter referred to as “tank barges” in the Rules)

3 Barges carrying special cargoes other than those specified in **-2(2)** above are, in general, to be in accordance with this Part with a special consideration being given depending on the kind of cargoes.

4 Additional requirements depending upon the navigating area and operating mode, etc. may be required when deemed necessary by the Society.

1.1.2 Special Cases in Application

Notwithstanding the provision in **1.1.1**, ships to which requirements in this Part, for some special reasons, are not directly applicable, are to be in accordance with the discretion of the Society.

1.1.3 Equivalency

Alternative hull construction, installation, material, equipment and machinery, etc. will be accepted by the Society, provided that the Society is satisfied that such construction, installation, material, equipment and machinery, etc. are equivalent to those required in this Part.

1.1.4 International and National Regulations

1 Ships subject to the application of international regulations are to be in accordance with the requirements specified in the international regulations.

2 In addition to the requirement in the Rules, particular attention is to be paid to complying with the requirement of national regulations of flag-government of ships and regional regulations contracted among sovereign nations around inland waterways in which ships navigate.

3 The Society may require special requirements as instructed by the flag-government of ships or the government of sovereign nation in which ships navigate.

1.1.5 Ships Carrying Dangerous Chemicals and Liquiefied Gases in Bulk

In addition to the requirements in the Rules, ships carrying dangerous chemicals or ships carrying liquiefied gases in bulk are to be in accordance with **Part S** or **Part N of the Rules for the Survey and Construction of Steel Ships** as well as the relevant requirements deemed necessary by the Society.

1.1.6 High Speed Craft

In addition to the requirements in the Rules, ships defined in **2.1.2, Part 1 of the Rules for High Speed Craft** are to be in accordance with the relevant requirements in **the Rules for High Speed Craft**.

1.1.7 Passenger Ship

Passenger ships defined in **2.1.39** are to comply with **the Rules for Survey and Construction of Passenger Ships**.

1.1.8 Stability

The requirements in the Rules are framed for ships having appropriate stability in all conceivable conditions. The Society emphasizes that the special attention is to be paid to the stability by the builders in design and construction stage and by the shipowners and ship masters while in service.

1.1.9 Means of access

Peak tanks, deep tanks, cofferdams, cargo tanks, cargo holds and other similar enclosed spaces are to be provided with means of access, *i.e.*, appropriate facilities such as ladders and steps for internal examinations in safety.

1.1.10 Gangways

Satisfactory means are to be provided on the weather decks for the protection of the crew in getting to and from their quarters and other parts.

1.1.11 Means of Embarkation and Disenbarkation

Ships are to be provided with appropriate means of embarkation on and disembarkation from ships for use in port and in port related operations, unless where a ship is engaged in voyages between designated ports where appropriate shore accommodation/embarkation ladders (platforms) are provided.

1.1.12 Protection of Openings

Openings, such as doors, ventilators, windows, manholes provided in boundaries to open space are to be commensurate with the strength and stiffness of the surrounding structure and to be of adequate watertightness or weathertightness.

1.2 Class Notations

1.2.1 General

For ships complying with additional requirements and/or those exempted from any requirements related to the subjects specified in the following paragraphs in accordance with the provisions of the Rules, an appropriate notation is affixed to the Classification Characters in accordance with the provisions of **Chapter 2 of the Regulation for the Classification and Registry of Ships** as follows:

NS* (**(1)**) (**(2)**) (**(3)**)

(1) Restricted services specified in **1.2.2**
(2) Hull constructions and equipment specified in **1.2.3**
(3) Aplication of special survey schemes specified in **1.2.4**

1.2.2 Restricted Services

For classed ships, an appropriate notation is affixed to the Classification Characters as follows.

(1) For ships which are, in general, restricted to service in inland waterways such as rivers, etc., or other areas deemed equivalent by the Society

River Service (abbreviated to *RS*)

(2) For ships which are restricted in service, other than as specified in **(1)** above, and deemed by the Society to be subject to the application of the Rules, a notation deemed appropriate by the Society may be affixed.

1.2.3 Hull Construction and Equipment

1 For tugs, the notation of “*Tug*” is affixed to the Classification Characters.

2 For pushers, the notation of “*Pusher*” (abbreviated to *P*) is affixed to the Classification Characters. In addition, for tanker convoy pushers, the notation of “*Pusher, Tanker Convoy*” (abbreviated to *PTC*) is affixed to the Classification Characters.

3 For barges, a notation corresponding to hull structure and type of cargo is affixed as follows:

(1) For barges intended for the carriage of general cargoes in cargo holds:

Barge, Dry Cargo Carrier (abbreviated to *BD*)

(2) For barges of pontoon type intended for the carriage of cargoes only on upper deck:
Barge, Pontoon Type (abbreviated to *BP*)

(3) For barges intended for the carriage of liquid cargoes in tanks integrated with the hull structures:
Barge, Tanker (abbreviated to *BT*)

However, for ships intended for the carriage of flammable liquid cargoes which comply with the appropriate requirements specified in the Rules, a notation corresponding to the flash points of the cargoes is affixed as follows:

(a) For ships intended for the carriage of liquid cargoes having a flash point on and below 60°*C* other than oils:
Barge, Tanker, flammable liquid-flash point on and below 60°C (abbreviated to *BTFLB*)

(b) For ships intended for the carriage of liquid cargoes having a flash point above 60°*C* other than oils:
Barge, Tanker, flammable liquid-flash point above 60°C (abbreviated to *BTFLA*)

(c) For ships intended for the carriage of oils having a flash point on and below 60°*C*:
Barge, Tanker, oils-flash point on and below 60°C (abbreviated to *BTOB*)

(d) For ships intended for the carriage of oils having a flash point above 60°*C*:
Barge, Tanker, oils-flash point above 60°C (abbreviated to *BTOA*)

4 For ships whose inner bottom is strengthened in accordance with the provisions of **2.3.7-2, Part 5**, the notation of "*GRAB*" is affixed to the Classification Characters.

1.2.4 Application of Special Survey Scheme

1 For ships approved for In-water Surveys in accordance with the provisions of **6.1.2, Part 2**, the notation of "*In Water Survey*" (abbreviated to *IWS*) is affixed to the Classification Characters.

2 For ships for which surveys based on the preventive maintenance system are carried out on the propeller shaft in accordance with the provisions of **8.1.3, Part 2**, the notation of "*Propeller Shaft Condition Monitoring System*" (abbreviated to *PSCM*) is affixed to the Classification Characters.

3 In consideration of the navigating area and operating mode, ships whose surveys are to be carried out in accordance with standards deemed appropriate by the Society in accordance with the provisions of **1.1.3, Part 2**, a notation deemed appropriate by the Society is affixed.

Chapter 2 DEFINITIONS

2.1 Application and Definitions

2.1.1 Application

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

2.1.2 Tugs

A "tug" is a ship primary engaged in towing barges, etc.

2.1.3 Pushers

A "pusher" is a ship that pushes barges forward with its bow.

2.1.4 Length of Ship

1 The length of tug and pusher (L) is the distance in *metres*, on the designed maximum load line defined in **2.1.12(2)**, from the fore side of the stem to the aft side of the rudder post for ships with a rudder post, or to the axis of the rudder stock for ships without a rudder post.
2 The length of barge (L) is the distance in *metres*, on the designed maximum load line defined in **2.1.12(2)**, from the inside surface of stem to the inside surface of stern.

2.1.5 Length for Freeboard

The length for freeboard (L_f) is 96% of the length in *metres* measured from the fore side of stem to the aft side of the aft end shell plate on a waterline at 85% of the least moulded depth measured from the top of the keel, or the length in *metres* measured from the fore side of the stem to the axis of the 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. For ships without a rudder stock, the length is to be taken as 96% of the waterline at 85% of the least moulded depth. The waterline on which this length is measured is to be parallel to the load line defined in **2.1.12(1)** in this Chapter.

2.1.6 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.

2.1.7 Depth of Ship

1 The depth of tug and pusher (D) is the vertical distance in *metres*, measured at the middle of L, from the top of the keel to the top of the freeboard deck beam at side. In the case where watertight 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.
2 The depth of barge (D) is the vertical distance in *metres*, measured at the middle of L, from the top of keel to the top of upper deck beam at side.

2.1.8 Depth for Strength Computation

The depth for strength computation (D_S) is the vertical distance in *metres*, measured at the middle of L, from the top of the keel to the top of the freeboard deck beam at side; or in the case where the superstructure deck is the strength deck, to the top of the superstructure deck beam at side. Where the deck does not cover the 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.

2.1.9 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 water in a loaded condition corresponding to the designed maximum load line (hereinafter referred to as “the full load condition” in the Rules).

2.1.10 Midship Part of Ship

The midship part of ship is the part 0.4*L* amidships unless otherwise specified. However, for pontoon barge and similar shaped barge, the midship part of barge is the part for 0.6*L* amidships.

2.1.11 End Parts of Ship

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

2.1.12 Load Line and Designed Maximum Load Line

Load line and designed maximum load line are to be defined as follows:

(1) Load line is the water line corresponding to each freeboard assigned in accordance with the provisions of **Part 10**.

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

2.1.13 Load Draught and Designed Maximum Load Draught

1 Load draught is the vertical distance in *metres*, measured at the middle of L_f, from the top of the keel plate to the load line.

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

2.1.14 Full Load Displacement

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

2.1.15 Block Coefficient

Block coefficient (C_b) is the coefficient given by dividing the volume corresponding to full load displacement (W) by LBd.

2.1.16 Upper Deck

The upper deck is normally the uppermost continuous deck.

2.1.17 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 For ships having a discontinuous freeboard deck (*e.g.* a stepped freeboard deck), the freeboard deck is to be determined as follows:

(1) Where a recess in the freeboard deck extends to both sides of the ship and is in excess of 1 *m* in length, 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.

(2) Where a recess in the freeboard deck does not extend to the sides of the ship or is not in excess of 1 *m* in length, the upper part of the deck is taken as the freeboard deck.

2.1.18 Bulkhead Deck

The bulkhead deck is the highest deck to which the watertight transverse bulkheads (except both peak bulkheads) extend and are made effective.

2.1.19 Strength Deck

The strength deck is the uppermost deck to which the shell plates extend at each section on the length of the ship. However, for superstructures (not including sunken superstructures) not exceeding 0.15*L* in length, the strength deck is the deck just below the superstructure deck. For design reasons, this deck may be taken as the strength deck even for superstructures exceeding 0.15*L* in length.

2.1.20 Superstructure and Forecastle

1 The superstructure is the decked structure on the freeboard deck, extending from side to side of the ship or having its side walls no further than 0.04*B* inboard from the sides of the ship.

2 The forecastle is the superstructure which extends from the forward perpendicular aft to a point which is forward of the after perpendicular. The forecastle may originate from a point forward of the forward perpendicular.

2.1.21 Enclosed Superstructure

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

(1) Access openings in the end bulkheads of the superstructure and all other openings in side or end bulkheads of the superstructure are provided with efficient weathertight means of closing.

(2) A means of access for the crew to reach machinery and other working spaces within a bridge or poop starting from any point on the uppermost complete exposed deck or higher is available at all times even when bulkhead openings are closed.

2.1.22 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 minimum value among the allowable pressures of various parts determined in accordance with the requirements in **Chapter 7** and **8, Part 7**.

2.1.23 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 or user, under which the safety valve of the superheater is to be set.

Note: Engines, pipes, etc. connected with a boiler or a pressure vessel are to be designed so as to withstand greater pressures than the nominal pressure (the approved working pressure in case of a pressure vessel or boiler without superheater).

2.1.24 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 design condition (the full load running condition for a main engine).

2.1.25 Number of Maximum Continuous Revolutions

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

2.1.26 Propeller Shaft Kind 1 and Propeller Shaft Kind 2

1 Propeller shaft Kind 1 is a propeller shaft which is effectively protected against corrosion by water with a means approved by the Society or which is made of corrosion resistant materials approved by the Society. Of these shafts which comply with the following **(1)** or **(2)** are categorized respectively in propeller shaft Kind 1*A* and propeller shaft Kind 1*B*.

(1) Propeller shaft Kind 1*A* is a propeller shaft with/without a keyed propeller attachment or with a coupling flange at the after end; to which a water-lubricated stern tube bearing (includes shaft bracket bearing for all references to the water-lubricated stern tube bearing hereinafter in this Chapter) is attached.

(2) Propeller shaft Kind 1*B* is a propeller shaft with/without a keyed propeller attachment or with a coupling flange at the after end; to which an oil-lubricated stern tube bearing is attached.

2 Propeller shaft Kind 2 is a propeller shaft other than those specified in **-1**.

2.1.27 Stern Tube Shaft

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

2.1.28 Stern Tube Shaft Kind 1 and Stern Tube Shaft Kind 2

1 Stern tube shaft Kind 1 is a stern tube shaft which is effectively protected against corrosion by water with a means approved by the Society or which is made of corrosion resistant materials approved by the Society. Of these shafts to which the water-lubricated bearing is adopted are categorized in stern tube shaft Kind 1*A* and such shafts to which the oil-lubricated bearing is adopted are categorized in stern tube shaft Kind 1*B*.

2 Stern tube shaft Kind 2 is a stern tube shaft other than those specified in **-1**.

2.1.29 Deadweight Tonnage

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

2.1.30 Light Weight

Light Weight (*LW*) 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.

2.1.31 Maximum Astern Speed

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

2.1.32 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)

2.1.33 Machinery Space

Machinery spaces are all machinery spaces of category *A* and all other spaces containing propulsion machinery and shafting systems, 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.

2.1.34 Cargo Space

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

2.1.35 Cargo Area

Cargo area is that 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 the ship over the aforementioned spaces.

2.1.36 Accommodation Space

Accommodation spaces are those spaces used for public spaces, corridors, lavatories, cabins, offices, hospitals, cinemas, games and hobby rooms, barber shops, pantries containing no cooking appliances and similar spaces.

2.1.37 Public Space

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

2.1.38 Service Space

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

2.1.39 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 persons 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.

2.1.40 Watertight

Watertight means having scantlings and arrangements capable of preventing the passage of water in any direction under the head of water that is likely to occur in intact and damaged conditions. In the damaged condition, including intermediate stages of flooding, the head of water is to be considered in the worst situation at equilibrium.

2.1.41 Weathertight

Weathertight means that in any sea conditions water will not penetrate into the ship.

2.1.42 Important System

The important system of barge is a system necessary for safety of life and barge.

2.1.43 Trusse

Trusse is a structure to connect the bottom and deck members by pillars and diagonals, having ample strength to effectively support deck loads.

Part 2 CLASS SURVEYS

Chapter 1 GENERAL

1.1 Surveys

1.1.1 Classification Surveys

1 All ships intended to be classed with the Society are to be subjected to Classification Surveys by the Surveyor in accordance with the requirements of **Chapter 2**.

2 Classification Surveys consist of the following Surveys.

(1) Classification Survey during Construction

(2) Classification Survey of Ships Not Built Under Survey

1.1.2 Class Maintenance Surveys

1 Ships classed with the Society are to be subjected to Class Maintenance Surveys by the Surveyor in accordance with the requirements of **Chapter 3** through **Chapter 9** of this Part. In addition, in cases where any modification of ship registration details is needed, the ship is to comply with **2.4** in addition to the above requirements.

2 Class Maintenance Surveys consist of Periodical Surveys, Planned Machinery Surveys and Occasional Surveys, which are as specified in the following **(1)** to **(3)**. At each of these surveys, inspections, tests or examinations are to be carried out to verify that all necessary items are in good order.

(1) Periodical Surveys

- (a) Annual Surveys

  The surveys consist of general examinations of hull, machinery, equipment, fire-fighting equipment, etc. as specified in **Chapter 3** of this Part.

- (b) Intermediate Surveys

  The surveys consist of general examinations of hull, machinery, equipment, fire-fighting equipment, etc. and detailed examinations of certain parts as specified in **Chapter 4** of this Part.

- (c) Special Surveys

  The surveys consist of detailed examinations of hull, machinery, equipment, fire-fighting equipment, etc. as specified in **Chapter 5** of this Part.

- (d) Docking Surveys

  The surveys consist of bottom inspections normally carried out in a dry dock or on a slip-way as specified in **Chapter 6** of this Part.

- (e) Boiler Surveys

  The surveys consist of open-up examinations and performance tests of boilers as specified in **Chapter 7** of this Part.

- (f) Propeller Shaft and Stern Tube Shaft Surveys

  The surveys consist of open-up examinations of propeller shafts and the stern tube shafts as specified in **Chapter 8** of this Part.

(2) Planned Machinery Survey

- (a) Continuous Machinery Survey (CMS): The Survey consists of open-up examinations of machinery and equipment specified in **Chapter 9** of this Part which are to be carried out systematically, continuously and sequentially so that each survey interval for all CMS items does not exceed the prescribed period.
- (b) Planned Machinery Maintenance Scheme (PMS): The Survey consists of open-up examinations of machinery and equipment specified in **Chapter 9** of this Part which are to be carried out according to the machinery maintenance scheme approved by the Society.

(3) Occasional Surveys

The surveys consist of examinations of the status (including damaged areas, repair work, and modifications) of hull, machinery and equipment which are carried out separately from **(1)** and **(2)** above.

3 Notwithstanding the requirements in **-1** and **-2** above, Annual Surveys are not required to be carried out for barges.

1.1.3 Intervals of Class Maintenance Surveys

1 Periodical Surveys are to be carried out in accordance with the requirements specified in **(1)** through **(6)** below. However, in consideration of the navigating area and operating mode, the intervals of Class Maintenance Surveys may be accordance mutatis mutandis with standards deemed appropriate by the Society.

(1) Annual Surveys

Annual Surveys are to be carried out within 3 *months* before or after each anniversary date.

(2) Intermediate Surveys

Intermediate Surveys are to be carried out at the time of the third Annual Survey after the Classification Survey during Construction or a Special Survey. Annual Surveys are not required to be carried out when an Intermediate Survey is carried out. Intermediate Surveys for barges are to be carried out within 3 *months* before or after of the third anniversary date.

(3) Special Surveys

Special Surveys are to be carried out as specified in **(a)** through **(c)** below.

(a) Special Surveys are to be carried out within 3 *months* before the date of expiry of the *Certificate of Classification*;

(b) Special Surveys may be commenced at or after the 5th Annual Survey and be completed within 3 *months* before the date of expiry of the *Certificate of Classification* ; or

(c) Notwithstanding **(b)**, Special Surveys may be commenced prior to the 4th Annual Survey. In this case, the Special Survey is to be completed within 15 *months* from the date of commencement of the Special Survey.

(4) Docking Surveys

(a) Docking Surveys are to be carried out concurrently with Special Surveys in cases where the ship's operating period in salt water is not more than one month per year.

(b) Docking Surveys are to be carried out as prescribed in **i)** and **ii)** below in cases where the ship's operating period in salt water is more than one month per year.

i) Concurrently with Special Surveys

ii) Concurrently with Intermediate Surveys

(5) Boiler Surveys

Boiler Surveys are to be carried out as specified in **(a)** and **(b)** below.

(a) Concurrently with Special Surveys

(b) Concurrently with Intermediate Surveys

(6) Propeller Shaft and Stern Tube Shaft Surveys

Ordinary Surveys of propeller shafts and stern tube shafts are to be carried out as specified in the following **(a)** through **(d)**:

(a) Ordinary Surveys of Propeller shafts Kind 1 or stern tube shafts Kind 1 (hereinafter referred to as "shafts Kind 1" in this chapter) are to be carried out within 6 *years* from the date of completion of the Classification Survey or the previous Ordinary Survey.

(b) Regardless of **(a)** above, Ordinary Surveys of shafts Kind 1 which have oil-lubricated stern tube bearings (hereinafter referred to as "shafts Kind 1B" in this chapter) may be postponed for no longer than 6 *years* from the date of completion of the Partial Surveys specified in **8.1.2-1** provided that the Partial Survey is carried out at the time prescribed in **(a)** above and that proper maintenance by periodical analysis for lubricating oil has been conducted.

(c) Regardless of **(a)** above, shafts Kind 1 adopting the preventive maintenance system in accordance with the requirements of **8.1.3**, need not be withdrawn at the Ordinary Surveys. The shafts are to be withdrawn for examination at the times required on the basis of the results of the preventive maintenance.

(d) Ordinary Surveys of Propeller shafts Kind 2 and stern tube shafts Kind 2 (hereinafter referred to as "shafts Kind 2" in this chapter) are to be carried out as prescribed in **i)** and **ii)**.

i) Concurrently with Special Surveys

ii) Concurrently with Intermediate Surveys

However, where the construction of the shaft in the stern tube bearing and shaft bracket corresponds to shafts Kind 1 but the construction of the shaft between the stern tube and the shaft bracket corresponds to shafts Kind 2, the shaft may be surveyed at the intervals prescribed in **(a)**, provided that examination required for the part corresponding to shafts Kind 2 is carried out at the times prescribed in **i)** and **ii)**.

2 Planned Machinery Surveys are to be carried out as specified in **(1)** and **(2)**. However, in consideration of the navigating area and operating mode, the intervals of Class Maintenance Surveys may be in accordance mutatis mutandis with standards deemed appropriate by the Society.

(1) In the Continuous Machinery Survey, survey items are to be examined at the interval not exceeding 6 *years*.

(2) In the Planned Machinery Maintenance Scheme, survey items are to be examined according to the survey schedule table specified in **9.1.3** and at the general examination (including review of maintenance records) which is 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 **(6)** below. Periodical Surveys may substitute for the Occasional Surveys where the survey items of the Occasional Surveys are inspected as a part of the Periodical Surveys.

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

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

(3) When an alteration affecting the ship's stability is made.

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

(5) When the Survey is carried out to verify that the ships already constructed are in compliance with the retroactive requirements of the Rules.

(6) Whenever the survey is considered necessary by the Society.

1.1.4 Periodical Surveys Carried out in Advance

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

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, additional Periodical Surveys are to be carried out in accordance with the provisions specified otherwise by the Society.

3 Where a 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.

(1) 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.

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

1.1.5 Postponement of Surveys

1 Special Surveys, Docking Surveys carried out at the periods specified in **1.1.3-1(4)(a)** and **(b)i)**, Boiler Surveys carried out at the periods specified in **1.1.3-1(5)** and Ordinary Surveys for Propeller shafts Kind 2 specified in **1.1.3-1(6)(d)i)** may be postponed for 3 *months* subject to the approval by the Society in advance.

2 Notwithstanding the requirement specified in **1.1.3-2**, Planned Machinery Surveys may be postponed as specified in **-1**, provided that such Surveys are carried out at the time of Special Surveys.

1.1.6 Modification of the Requirements

1 With respect to Periodical Surveys and Planned Machinery Surveys in cases where deemed appropriate by the Society, the Surveyor may modify the requirements specified in **Chapter 3** through **Chapter 9** of this Part in consideration of the size, service engaged, construction, age, history, results of previous surveys and actual condition of the ship.

2 When the results of a Periodical Survey suggest the likelihood of heavy corrosion, defects, etc., and the Surveyor considers it necessary, internal examinations, 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 **5.2.5-1**.

3 For Periodical Surveys, gauging requirements may be dispensed with at the discretion of the Surveyor in consideration of the size, service engaged, construction, age, history, results of previous surveys and actual condition of the ship

1.1.7 Laid-up Ships

1 Laid-up ships are not subject to Class Maintenance Surveys specified in **1.1.2**. However, Occasional Surveys may be carried out at the request of owners.

2 When laid-up ships are about to be re-entering service, the following surveys and surveys for specific matters which have been postponed due to being laid-up, if any, are to be carried out.

(1) If the due dates for Periodical Survey or Planned Machinery Surveys have not transpired while the ship was laid-up, then a survey equivalent to the Annual Surveys specified in **Chapter 3** is to be carried out.

(2) If the due dates for Periodical Surveys or Planned Machinery Surveys have transpired while the ship was laid-up, then these Periodical Surveys or Planned Machinery Surveys are, in principal, to be carried out. However, where two or more kinds of Periodical Surveys are due, only the superlative survey may be carried out.

3 Surveys carried out under the requirements of **-2** above are to correspond to the age of the ship.

1.1.8 Machinery Verification Runs

At the time of dry docking, a dock trial may be required at the discretion of the attending surveyor to confirm satisfactory operation of main and auxiliary machinery. If significant repairs have been carried out to main or auxiliary machinery or steering gear, the Surveyor may require a river trial.

1.2 Specialized Ships, Installations, and Apparatus

1.2.1 Incinerators of Waste Oil and Waste Substance

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

1.2.2 Surveys of Special Ships

When an application is received from the shipowner and the Society judges that it is impractical to apply the requirements in this Part to the ship due to the special nature of its design, services and operating mode, the Society may modify times, items, scope, or extent of surveys as applicable.

1.3 Definitions

1.3.1 Terms

The definitions of terms which appear in this Part are as specified in the following. Terms not define here are as defined in other parts of the Rules.

(1) "Ballast tank" is a tank which is being used solely for water ballast. For a space which is used for both cargo and water ballast, the space is treated as a Ballast Tank when substantial corrosion has been found by internal examination of that space.

(2) "Longitudinal members in the transverse section" include all longitudinal members such as plating, longitudinals and girders at the deck, side, bottom, inner bottom and longitudinal bulkheads in the considered transverse section.

(3) "Representative tanks/spaces" are those which are expected to reflect the condition of other tanks/spaces of similar types and service and with similar corrosion prevention systems. When selecting representative tanks/spaces, account is to be taken of the service and repair history on board and identifiable critical structural areas and/or suspect areas.

(4) "Suspect areas" are locations showing substantial corrosion and/or are considered by the Surveyor to be prone to rapid wastage.

(5) "Substantial corrosion" is an extent of corrosion such that assessment of corrosion pattern indicates wastage in excess of 75% of allowable margins, but within acceptable limits.

(6) "Cargo length area" is that part of the ship which includes all cargo holds and adjacent areas including fuel tanks, cofferdams, ballast tanks and void spaces.

(7) "Oil" is petroleum including crude oil, heavy fuel oil, lubricating oil, light oil, kerosene, gas oil, and others prescribed by the relevant laws and regulations.

(8) “Anniversary Date” is the day corresponding to the expiry date of the Classification Certificate, excluding the expiry date of the Classification Certificate.

1.4 Preparation for Surveys and Miscellaneous

1.4.1 Notification

When a ship is to be surveyed in accordance with the Rules, it is the responsibility of the owners to notify the Surveyor at the place where they wish to undergo the survey. The Surveyor is to be advised of the survey a reasonable time in advance so that the survey can be carried out at the proper time.

1.4.2 Preparation for Surveys

1 All such preparations as required for classification, periodical and other surveys and thickness measurements specified in this part as well as those which may be required as necessary by the Surveyor in accordance with the provisions in this Part are to be made by the Owners or their representatives at their responsibilities. The preparations are to include provisions of an easy and safe access, necessary facilities, certificates and records for the execution of the survey and thickness measurements, open-up examinations of equipment, removal of obstructions and cleaning. Inspection, measuring and test equipment, which Surveyors rely on to make decisions affecting classification are to be individually identified and calibrated to a standard deemed appropriate by the Society. However, the Surveyor may accept simple measuring equipment (*e.g.* rulers, measuring tapes, weld gauges, micrometers) without individual identification or confirmation of calibration, provided they are of standard commercial design, properly maintained and periodically compared with other similar equipment or test pieces. The Surveyor may also accept equipment fitted on board a ship and used in examination of shipboard equipment (*e.g.* pressure, temperature or rpm gauges and meters) based either on calibration records or comparison of readings with multiple instruments.

2 An applicant for survey(s) is to arrange a supervisor (hereinafter referred to as “owner’s representative”) who is well conversant with the intended survey items for the preparation of the survey in order to provide the necessary assistance to the Surveyor according to his requests during the surveys.

3 Prior to the commencement of survey and measurement, a survey planning meeting is to be held by the surveyor(s), the owner’s representative, the thickness measurement company representative, where involved, and the master of the ship or an appropriately qualified officer of the ship appointed by the master, shipowner or Company so as to ensure the safe and efficient conduct of the survey and measurement work to be carried out.

1.4.3 Suspension of Surveys

Surveys may be suspended where necessary preparations as specified in **1.4.2-1** and **-2** have not been made, any appropriate attendant in accordance with **1.4.2-3** is not present, or the Surveyor considers that the safety for execution of the survey is not ensured.

1.4.4 Disposition when Repairs are Considered Necessary as a Result of Surveys

When repairs are considered to be necessary as a result of surveys, the Surveyor notifies his findings to the survey applicant. The applicant, when he receives such notification, is to obtain the Surveyor’s verification after carrying out the necessary repairs.

1.4.5 Procedure for Tests, Wear and Tear, etc.

1 Inclining Test

An Inclining test is to be carried out at the Class Maintenance Survey, where alterations or repairs which might greatly affect the ship’s stability have been made and/or the Surveyor deems it necessary.

2 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 replaced by new ones having either the original scantlings at the time of construction or the scantlings deemed appropriate by the Society.

3 Replacement of fittings, equipment and parts, etc.

In cases where it is necessary to replace any fittings, equipment or parts, etc. used onboard, replacements are to comply with the regulations to be applied during ship construction. However, in cases where new requirements are specified or where deemed necessary by the Society, the Society may require that such replacements comply with any new requirements in effect at the time the relevant replacement work is carried out. In addition, replacements are not to use any materials which contain asbestos.

Chapter 2 CLASSIFICATION SURVEYS

2.1 Classification Survey During Construction

2.1.1 General

1 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.

2 The new installation of materials which contain asbestos is to be prohibited.

2.1.2 Submission of Plans and Documents for Approval

1 When it is intended to build a ship for classification by the Society, the following plans and documents are to be submitted for the approval by the Society before the work is commenced. The plans and documents may be submitted for examination by the Society prior to making an application for the classification of the ship as stipulated otherwise by the Society.

(1) Hull
- (a) General arrangement
- (b) Midship section
- (c) Stem, sternframe, propeller post and rudder (indicating materials and the ship's speed)
- (d) Construction profile
- (e) Deck plans (indicating arrangement and construction of hatchways, hatch beams, etc.)
- (f) Single bottoms and double bottoms
- (g) Watertight and oiltight bulkheads (indicating the highest position of tank and positions of tops of overflow pipes)
- (h) Superstructure end bulkhead (with details of closing appliances of openings on the bulkheads)
- (i) Pillars and deck girders
- (j) Shell expansion
- (k) Truss construction
- (l) Skeg construction
- (m) Construction of the joint between pusher and barge
- (n) For ships that are required to have a loading manual in accordance with the requirements of **10.2.4, Part 4** or **9.1.3, Part 5**, loading manual indicating conditions for loading, etc.
- (o) Shaft tunnels
- (p) Seatings of boilers, engines, thrust and plummer blocks, dynamos and other important auxiliary machinery (indicating horse powers, heights and weights of main engines, and arrangements of holding down bolts)
- (q) Machinery casings
- (r) Plans showing locations, sizes and details of equipment forming part of the watertight and weather-tight integrity of the ship, including piping
- (s) Pumping system (indicating capacity of each tank, water or oil)
- (t) Construction for fire protection and plans showing ventilation systems (indicating details of fire protection construction)
- (u) Plans showing means of escape (indicating details of escape routes, passage width, etc.)
- (v) Plans showing fire extinguishing arrangement (the locations, types, capacity and numbers of fire fighting systems, fire extinguishers, fire pumps, hydrants, hoses, etc. and the layout of the fire detection and alarm system). For ships equipped with inert gas systems, the locations of these systems (general layout; piping diagrams with materials, dimensions, design pressure of pipes, valves, etc.; details of each component; and diagrams of control devices including monitoring, alarm and safety devices of the systems.)
- (w) Venting systems for tankers
    - i) General arrangement of bilge systems and ventilation systems of the cargo oil pump room.

ii) General arrangement of venting systems for cargo vapours, etc.

(x) Arrangement of the means of embarkation and disembarkation

(2) Machinery

(a) Arrangement of machinery in machinery space, diagram for internal communication systems

(b) Main and auxiliary engines (including their attachments):
Plans and data specified in **2.1.2, Part 7**

(c) Power transmission gears, shafting and propellers:
Plans and data specified in **3.1.2**, **4.1.2**, **5.1.2** and **6.1.2, Part 7**

(d) Boilers, incinerators and pressure vessels:
Plans and data specified in **7.1.3**, **7.4.2** and **8.1.4, Part 7**

(e) Auxiliary machinery and piping:
Plans and data specified in **11.1.2** and **15.1.2(2), Part 7**

(f) Steering gear:
Plans and data specified in**12.1.3, Part 7**

(g) Automatic and remote controls:
Plans and data specified in **14.1.3, Part 7**

(h) Electrical installations:
Plans and data specified in **1.1.6, Part 8**

(3) Plans and documents for in-water surveys specified in **6.1.2-2**

(4) Other plans and documents not specified in **(1)** through **(3)** which are deemed necessary by the Society

2 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 examination of proposed constructions.

3 A stability information booklet is to be submitted for approval by the Society, in addition to the plans and documents as listed in **-1**.

4 For ships that are required to have a loading manual in accordance with the requirements of **10.2.4, Part 4** or **9.1.3, Part 5**, the loading manual is to include conditions for loading and other necessary information and is to be submitted for approval by the Society, in addition to the plans and documents listed in **-1**.

5 Notwithstanding **-1** and **-2**, part of the plans and documents specified in **-1** and **-2** may be omitted in accordance with the requirements stipulated otherwise by the Society, in cases where a ship or machinery is built at the same place of manufacture based on plans and documents which have already been approved.

2.1.3 Submission of Other Plans and Documents

1 When it is intended to build a ship to the classification with the Society the following plans and documents are to be submitted, in addition to those required in **2.1.2**:

(1) Specifications for hull and machinery

(2) Calculation sheets for the minimum section modulus of the midship cross section

(3) Where provisions are to be made for exceptional conditions of loading, plans showing the particulars of the cargo intended to be carried and its distribution

(4) For ships that are required to have stability information documents, the following plans and documents:

(a) General arrangement

(b) Midship section

(c) Longitudinal section at centre line (showing the area of buoyancy)

(d) Construction profile

(e) Lines (including an offset table)

(f) Arrangement of openings (showing the position, size and closing devices of openings)

(g) Stability calculation sheets (showing the details of calculation of free surface effect and maximum permissible height of centre of gravity)

(h) Plans showing the arrangement, size and projected lateral area of bilge keels, if fitted.

(5) For ships complying with the requirements in **Part 10**, the following plans:

(a) General arrangement

(b) Midship section

(c) Construction profile or structural arrangement
(d) Deck plans (showing the freeboard and superstructure decks)
Where the structural arrangement plans (with details of scantlings and arrangements of members in hatchways) are submitted, the submission of the deck plans may be dispensed with.
(e) Superstructure end bulkheads
(f) Lines
(g) Hydrostatic curves (indicating the displacement and the change of displacement per cm immersion at each draught up to the freeboard deck)

(6) Capacity calculation sheet for pressure/vacuum valves and overpressure protective devices of cargo oil tanks, if any

2 Submission of other plans and documents not specified in **-1** may be required where deemed necessary by the Society

2.1.4 Presence of Surveyor

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

(1) When the tests for the equipment prescribed in **Part L of the Rules for the Survey and Construction of Steel Ships** are carried out.
(2) When the materials or parts manufactured away from the site are being applied to the ship concerned.
(3) When the tests of welding prescribed in **Part M of the Rules for the Survey and Construction of Steel Ships** are carried out.
(4) When designated by the Society during shop work or sub-assembly.
(5) When each block is assembled.
(6) When hydrostatic tests, watertight tests and non-destructive tests are carried out.
(7) When the hull is completed.
(8) When performance tests are carried out on closing appliances of openings, remote control devices, steering gears, anchoring, fire fighting systems, ventilation systems, and piping, etc.
(9) When rudder installation, keel line profiling, measurement of principal dimensions, measurement of hull deflection, etc. are carried out.
(10) When the ships are marked with the load lines in accordance with the requirements in **Part 10**.
(11) When river trials are carried out.
(12) When stability experiments are carried out.
(13) When deemed necessary by the Society.

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 of the Rules for the Survey and Construction of Steel Ships** are carried out.
(2) Main parts of machinery
(a) When the tests stipulated in either **Part 7** or **Part 8** (according to the kind of machinery) are carried out.
(b) When the materials are assembled for construction of the parts and the parts are assembled for installation on board.
(c) When machining of the main parts is finished and, if necessary, at appropriate stages 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 main parts of machinery are installed on board.
(4) When performance tests are carried out on measurement instruments, remote control devices of opening and closing appliances, remote control devices for machinery and gears, automatic control devices, steering gear, fire extinguishing equipment, piping, etc.
(5) When river trials are carried out.
(6) When deemed necessary by the Society.

3 For barge machinery, the presence of the Surveyor is required at the following stages of work notwithstanding the requirements in **-2**. Submission of the test data specified in **15.7.1-2**, **-4 of Part 7** and **5.11.1-1 of Part 8** may be required where deemed necessary by the Surveyor.

(1) When the tests prescribed in **15.7.1-1 of Part 7** for boilers and pressure vessels are carried out.

(2) When the tests prescribed in **15.7.1-3 of Part 7** for the valves and cocks attached to shell plating are carried out.
(3) When the tests prescribed in **5.11.1-3 of Part 8** for the explosion-proof type electrical equipment are carried out.
(4) When machinery is installed on the barge.
(5) When the tests and trials prescribed in **15.7.2 of Part 7** and **5.11.2 of Part 8** are carried out.
(6) When the tests prescribed in **15.7.3 of Part 7** and **5.11.3 of Part 8** are carried out.
(7) When the tests for special machinery are carried out.

4 The requirements specified in **-1**, **-2** and **-3** may be modified having regard to the actual status of facilities, technical abilities and quality control at the place of manufacture, except in the case of river trials.

5 For the tests specified in **-1**, **-2** and **-3**, the applicant is to prepare test plans for review by the Society prior to testing. Test records and/or measurement records are to be submitted to the Society, as required.

2.1.5 Hydrostatic Tests, Watertight Tests, and Relevant Tests

In the Classification Survey during construction, hydrostatic tests, watertight tests, and other relevant tests are to be carried out in accordance with the following:

(1) Hull and equipment
  (a) Hydrostatic tests or watertight tests are to be carried out after all work in connection with watertightness are completed but before painting, in accordance with the requirements specified in **Table 2.2.1**.
  (b) A part or all of the hose tests may be dispensed with at the discretion of the Society.
  (c) Watertight tests may be replaced by airtight tests at the discretion of the Society, provided that certain tanks designated by the Society are to be subjected to hydrostatic tests specified in **Table 2.2.1**, while afloat.

(2) Machinery
  Hydrostatic, leakage or airtight tests are to be carried out as specified in each Chapter of **Part 7** in relation to the kind of machinery.

2.1.6 Documents to be Maintained on Board

1 At the completion of a classification survey, the Surveyor confirms that the finished versions of the following applicable drawings, plans, manuals, lists, etc., are on board. For barges, these drawings, etc. need not be on board, however, are to be kept appropriately by the owner of barges (or the management company of barges).

(1) Documents approved by the Society or their copies
  (a) Loading manuals (**10.2.4, Part 4** or **9.1.3, Part 5**)
  (b) Stability information booklets (**1.2.1, Part 6**)
  (c) Plans and documents for in-water surveys (**6.1.2-2**)
(2) Other documents
  (a) Operation manuals for the stability computer (**1.2.2, Part 6**)
  (b) Fire Control Plans, Fire Safety Operational Booklets (**1.4.1, Part 9**)
  (c) Manuals for towing or manuals for pushing
(3) Finished plans specified in **2.1.7-1**

2 Where deemed necessary by the Society considering the purpose, characteristics, etc. of the ship, the additional documents may be required to be on board.

3 At the completion of classification surveys, Surveyors confirm that certificates showing that the following devices have passed all required examinations or tests are maintained on board.

(1) Fire pumps
(2) Fire hoses and nozzles
(3) Fire extinguishers (including spare charges)
(4) Fixed fire-extinguishing systems
(5) Power-operated closing doors
(6) Fixed fire detection and fire alarm systems
(7) Additional equipment required for ships carrying dangerous goods, etc.

2.1.7 Finished Plans

1 At the completion of a classification survey during construction, the applicant is to prepare finished plans regarding the following drawings, etc., and submit them to the Society.

(1) General arrangement

(2) Midship section, scantling plans (construction profile), deck plans, shell expansion, transverse bulkheads, plans for rudder and rudder stock
(3) Bilge, ballast and cargo piping diagrams
(4) Fire protection plans
(5) Fire-extinguishing appliances arrangement

2 Notwithstanding **-1** above, for barges, at the completion of a classification survey during construction, the applicant is to prepare finished plans regarding the following drawings, etc., and submit them to the Society.
(1) General arrangement
(2) Midship section, scantling plans (construction profile), deck plans, shell expansion, transverse bulkheads
(3) Bilge, ballast and cargo piping diagrams

3 Where deemed necessary by the Society considering the purpose, characteristics, etc. of the ship, other plans, etc. may be required to be submitted to the Society.

2.2 Classification Survey of Ships not Built Under Survey

2.2.1 General

1 In the Classification Survey of ships not built under the Society's survey, the actual scantlings of main parts of the ship are to be measured in addition to such examination of the hull and equipment, machinery, fire protection and detection, means of escape, fire fighting system, 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 For ships subject to Classification Survey of ships not built under the Society's survey, plans and documents necessary for registration to the Society are to be submitted according to the relevant requirements in **2.1.2** and **2.1.3**.

3 For ships that are required to prepare a loading manual in accordance with the requirements of **10.2.4, Part 4** or **9.1.3, Part 5**, the loading manual (including the conditions for loading and other necessary information) is to be submitted for approval by the Society.

2.2.2 Hydrostatic Tests, Watertight Tests, and Relevant Tests

In the Classification Survey prescribed in **2.2.1**, river trials are to be carried out after the following items have been completed: hydrostatic tests and watertight tests in accordance with the requirements shown below in **(1)** and **(2)**; maintenance of machinery and determination of the working pressure of the boilers; and adjustment of safety valves and accumulation tests of the boilers. Tests and trials may be dispensed with at the discretion of the Society with the exception of hydrostatic tests of boilers and pressure vessels of which important parts have been newly repaired, main steam pipes, and air tanks of which the interior can not be inspected; and tests for gas leakage of refrigerating machinery on board.
(1) Double bottoms, both peaks, tanks, cofferdams, watertight bulkheads and shaft tunnels are to be tested as specified in **Table 2 2.1**.
(2) Hydrostatic, leakage or airtight tests are to be carried out on machinery and its parts at the pressures specified in the relevant chapters of **Part 7**.

2.2.3 Documents to be Maintained on Board

At the completion of a classification survey, the Surveyor confirms that documents specified in **2.1.6** are on board the ship. However, in barges, the documents are not required to be kept on board.

2.3 River Trials and Stability Experiments

2.3.1 River Trials

1 In the Classification Survey of all ships, river trials specified in following **(1)** to **(8)** are to be carried out in full load condition, in the calmest possible water and weather condition and in deep unrestricted water. However, where river trials cannot be carried out in full load condition, river trials may be carried out in an appropriate loaded condition.
(1) Astern test
(2) Steering test and the change-over test from the main to auxiliary steering gears

(3) Confirmation of no abnormality for the operating condition of machinery and behaviour of the ship during the trials
(4) Performance test of windlasses
(5) Performance test of automatic and remote control systems for main propulsion machinery, controllable pitch propellers, boilers and electric generating sets
(6) Accumulation test of boilers
(7) Measurement of torsional vibration for the shafting systems (if required)
(8) Other tests where deemed necessary by the Society

2 The results of the tests specified in **-1** are to be submitted to the Society as river trial records.

3 In the case of classification Survey of ships not built under the Society's survey, the above tests may be dispensed with, provided that sufficient data on the previous tests are available and no alteration affecting the tests specified in **-1** have been made after the previous tests and the Society deems it appropriate.

4 Notwithstanding the requirements in **-1** through **-3**, river trials may be omitted for barges. However, for barges having unconventional construction or a special navigation system, river trials may be required where deemed necessary by the Society.

2.3.2 Stability Experiments

1 In the Classification Survey, stability experiments are to be carried out upon completion of the ship. In addition, 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 the Society, is to be provided on board. However, in barges, a stability information booklet is not required to be kept on board.

2 In the Classification Survey of ships not built under the Society's survey, stability experiments may be dispensed with, provided that sufficient information based on previous stability experiments is available and neither alteration nor repair affecting the stability has been made after the previous experiments.

3 The stability experiments of an individual ship may be dispensed with, provided that reliable stability data is obtained from the stability experiments of a sister ship or other adequate means and a special approval is given by the Society.

4 Where a computer for stability calculation is on board the ship as a supplement to the stability information booklet, an operation manual for the computer is to be provided on board. After the computer is installed on board, a functional test to ensure that it is working correctly is to be carried out.

2.4 Alterations

2.4.1 Examinations of Altered Parts

In cases where ships classified by the Society undergo repairs, alternations, modifications and outfitting related thereto (hereinafter referred to as "modifications, etc."), such ships are to continue to at least comply with any previously applicable requirements. Moreover, such ships, if constructed before the date on which any relevant amendments enter into force, are, as a rule, to comply with any requirements for ships constructed on or after that date to at least the same extent as they did before undergoing such modifications, etc. In cases where ships undergo modifications, etc. which affect main particulars, unless otherwise permitted by the Society, the concerned ship is to comply with requirements in force at the time of such modifications, etc.

Table 2.2.1 Hydrostatic Tests

No.	Applicable areas	Type of tests and their pressure/head	Notes
1	Double bottom and double side skin spaces	Hydrostatic test with a head of water up to the bulkhead deck.	The centre girder between tanks that carry the same liquid need not be tested.
2	Deep tanks	Hydrostatic test with a head of water up to the top of overflow pipe.	
3	Cargo tanks	Hydrostatic test with a head of water up to the level of 1.22 *m* above the deck at side forming the crown of the tank or the top of hatch, whichever is the greater.	
4	Forepeaks, after peaks and stern tube compartments	Hydrostatic test with a head of water up to the load waterline. For portions above load waterline, hose 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	Shell Plating	Hose test with a pressure of water not less than 0.2 *MPa* in the hose.	For shell plating of the areas listed in rows No.1 through No.4, refer to the corresponding row.
6	Watertight decks		For decks of the areas listed in rows No.2 through No.4, refer to the corresponding row.
7	Watertight bulkheads and recesses		When part of deep tanks or peak tanks, refer to the corresponding row.
8	Shaft tunnels and other watertight tunnels		
9	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*	

Note:

Tests of piping systems in each part of the ship are to be carried out as specified in **10.6** and **11.16, Part 7**.

Chapter 3 ANNUAL SURVEYS

3.1 General

3.1.1 Surveys Equivalent to Special Surveys

Surveys equivalent to Special Surveys may be required when considered necessary by the Society, based on the service and repair history of the ship or damage history of similar ship types or ships with similar tanks and spaces.

3.1.2 Annual Surveys for Barges

Annual Surveys are not required to be carried out for barges.

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

3.2.1 Examination of Plans and Documents

At Annual Surveys, the management conditions of plans and documents listed in **Table 2.3.1** are to be examined.

3.2.2 General Examination

At Annual Surveys, examinations of hull, equipment, fire-extinction and fittings listed in **Table 2.3.2** are to be carried out.

3.2.3 Performance Tests

At Annual Surveys, performance tests listed in **Table 2.3.3** are to be carried out.

3.2.4 Internal Examinations of Spaces and Tanks

At Annual Surveys, the internal examinations **(1)** and **(2)** below are to be carried out.

(1) Spaces and Tanks listed in **Table 2.3.4**

(2) Suspect areas identified at previous survey

3.2.5 Thickness Measurements

At Annual Surveys, the thickness measurements **(1)** to **(3)** below 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.

(1) Spaces and Tanks listed in **Table 2.3.5**

(2) Areas where deemed necessary by the Surveyor as a consequence of internal examination of spaces and tanks specified in **3.2.4(2)**

(3) Substantial corrosion areas identified at the previous survey

3.3 Annual Surveys for Machinery

3.3.1 General Examinations

At Annual Surveys for Machinery, general examination of all the machinery in the engine room and the following examinations **(1)** through **(4)** are to be carried out:

(1) It is to be ascertained that the main propulsion machinery, power transmission machinery, shafting systems, propellers, 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.

(2) It is to be ascertained that the engine room, boiler spaces and means of escape are placed in good order with respect to dangers of fire and explosion.

(3) For ships adopting the survey for propeller shafts and stern tube shafts in accordance with the requirements in **1.1.3-1(6)(b)**, the records of periodical analysis for lubricating oil are to be reviewed in order to ascertain that the relevant installations have been well maintained.

(4) For ships adopting the preventive maintenance system in accordance with the requirements in **8.1.3**, the records

of the parameters monitored are to be reviewed and a general examination is to be carried out in order to ascertain that the relevant installations have been well maintained.

3.3.2 Performance Tests

At Annual Surveys for Machinery, performance tests for the systems and devices listed in **Table 2.3.6** are to be carried out in order to ascertain that they are in good working order.

Table 2.3.1 Examination of Plans and Documents

Items	Examination
1 Loading Manual	• For ships required to have the manual on board in accordance with the requirements of **10.2.4, Part 4**, confirmation that 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 Fire Control Plan	• Confirmation that the fire control plan is provided on board is to be made.

Table 2.3.2 General Examination

Items	Examination
1 Shell plating 2 Weather deck plating	• Confirmation that areas visible above the load waterline are in good condition.
3 Openings on deck and outside of the hull	• Confirmation that the following are in good condition: coamings and closing appliances of hatchways and flush deck openings on the exposed deck and within unenclosed superstructures; gangway ports, cargo ports and coal ports; and side scuttles below the freeboard or superstructure deck.
4 Casings of engine room	• Confirmation that the following are in good condition: exposed engine casings and their openings; and skylights of the engine room and boiler room and their closing appliances.
5 Ventilators	• Confirmation that coamings and closing appliances of ventilators are in good condition.
6 Air pipes	• Confirmation that the air pipes on weather deck and their closing appliances are in good condition.
7 Watertight bulkhead, superstructure end bulkhead and deckhouses	• Confirmation that penetrations and stop valves on watertight bulkheads and closing appliances of exits provided in boundaries to open spaces are in good condition.
8 Load line marks	• Confirmation that deck line and load line markings are appropriate.
9 Gangways	• Confirmation that gangways are in good condition.
10 Scuppers, inlets, other discharge pipes and valves	• Confirmation that all areas which can be examined are in good condition.
11 Anchoring arrangement	• Confirmation that the anchoring arrangements including their accessories are in good condition as far as can be seen.
12 Fire-extinguishing arrangement	• Confirmation that the fire-extinguishing arrangement is in good condition and the fixed fire extinguishing system, semi-portable and portable fire extinguishers, fireman's outfits and emergency fire pumps are maintained in good order.
13 Fire protection arrangement and means of escape	• Confirmation that no alteration has been made to these arrangements since the last survey.
14 Means of embarkation and disembarkation	• Confirmation that the means of embarkation and disembarkation are in good condition.

Note:

Examination of suspect areas identified at previous surveys is to be carried out.

Table 2.3.3 Performance Tests

Items	Tests
1 Closing appliances of exits provided in boundaries to open spaces	・ Hose tests listed in **Table 2.2.1** or equivalent tests are to be carried out. Such tests may be dispensed with at the discretion of the Surveyor.
2 Appliances related to fire protection and escape	・ Checking whether the appliances work in good order is to be carried out.
3 Fire detection system and fire alarm system including manually operated call points	・ Checking whether the systems work in good order (including proper operation of malfunction indicator) is to be made.
4 Fire pumps, piping, hydrants, hoses, nozzles etc.	・ Performance test of the fire fighting system composed of fire pump, hydrants, etc. is to be carried out.
5 Ventilation system	・ Checking whether the system works in good order is to be carried out.
6 Stability Computer	・ A performance test is to be carried out.

Table 2.3.4 Internal Examinations of Spaces and Tanks

Items	Examination
Requirements for all ships	
1 Engine room	・ An internal examination is to be carried out.
2 Ballast tanks	・ For ships over 6 *years* of age, an internal examination of the tank(s), of which an internal examination is required as a consequence of the last intermediate Survey or special survey, is to be carried out.

Table 2.3.5 Thickness Measurements

Items	Note
Requirements for all ships	
1 Structural members in ballast tanks	・ When extensive corrosion is found in the examination specified in **Table 2.3.4** which is required for ships over 6 *years* of age, thickness measurements are to be carried out to the satisfaction of the Surveyor.

Table 2.3.6 Performance Tests at Annual Surveys

Items	Examinations
1 Shut-off devices for oil tanks	Operation tests for the remote shut-off devices for fuel oil tanks and lubricating oil tanks are to be carried out.
2 Fuel oil pumps, ventilating fans and boiler draught fans	Operation tests for emergency stopping means are to be carried out.
3 Communication systems	Operation tests for the means of communication between the navigation bridge and the machinery control position and between the navigation bridge and the steering gear compartment are to be carried out.
4 Steering gears	Performance tests specified in the following **(a)** to **(d)** are to be carried out for the main and auxiliary steering gears including their associated equipment and control systems; (a) Operation test for the power units including changeover from one to another (b) Test for supply of the alternative source of power specified in **12.2, Part 7** (c) Operation test for the control system including the changeover system (d) Operation test for the alarm devices, rudder angle indicators and running indicators of power units specified in **Part 7**
5 Bilge systems	Operation tests for the valves, cocks, strainers, pumps, reach-rods and level alarms of the bilge systems are to be carried out.
6 Safety devices	Operation tests for the safety devices, etc. specified in the following **(a)** to **(d)** are to be carried out. However, the tests may be omitted at the Surveyor's discretion based on the general examination, reports of working conditions at river and inspection records taken by the ship's crew.
(a) Main propulsion machinery and auxiliary machinery	Operation tests of the following safety/alarm devices on prime movers of main propulsion machinery; electric generators; auxiliary machinery essential for propulsion; and auxiliary machinery for manoeuvring and safety are to be carried out. Where deemed necessary by the Surveyor, the maintenance records of the cooling water and lubricating oil are required to be presented for review. (i) Overspeed protective devices (ii) Automatic shut-off and alarm devices in case of loss or low pressure of the lubricating oil
(b) Boilers, thermal oil heaters and incinerators	Operation tests for the safety devices, alarm devices and pressure indicators specified in **Chapter 7, Part 7** are to be carried out. Calibration records for the pressure indicators are to be ascertained and the relieving gears of the safety valves are to be examined and tested to verify satisfactory operation. However, the relief valves provided on the exhaust gas economizers are to be tested by the Chief Engineer at river prior to the Annual Survey within the period specified in **1.1.3-1(1)**. This test is to be recorded in the logbook for review by the attending surveyor. Where deemed necessary by the Surveyor, the control records of the boiler water and thermal heater oil are required to be presented for review.
(c) Monitoring devices	Operation tests for pressure indicators, thermometers, ammeters, voltmeters and revolution meters are to be carried out.
(d) Automatic control devices or remote control devices	Operation tests for automatic and remote control devices of auxiliary machinery essential for propulsion, manoeuvring, and crew safety are to be carried out.

Chapter 4 INTERMEDIATE SURVEYS

4.1 General

4.1.1 Surveys Equivalent to Special Surveys

Surveys equivalent to Special Surveys may be required when considered necessary by the Society, based on the service and repair history of the ship or damages history of similar ship types or ships with similar tanks and spaces.

4.2 Intermediate Surveys for Hull, Equipment, Fire Extinction and Fittings

4.2.1 Examination of Plans and Documents

At Intermediate Surveys for ships other than barges, the management conditions of plans and documents specified in **3.2.1** are to be examined.

4.2.2 General Examination

1 At Intermediate Surveys, examinations of hull, equipment, fire-extinction and fittings specified in **3.2.2** are to be carried out. In addition, examinations specified in the following **(1)** and **(2)** are to be carried out.

(1) General examinations of the spare parts of extinguishing systems

(2) General examinations of coamings and closing appliances of hatchways, gangway ports and cargo ports

2 For tank barges, general examinations listed in **Table 2.4.1** are to be carried out.

4.2.3 Performance Tests

1 At Intermediate Surveys, performance tests listed in **Table 2.4.2** are to be carried out.

2 For tank barges, performance tests listed in **Table 2.4.3** are to be carried out.

4.2.4 Internal Examinations of Spaces and Tanks

At Intermediate Surveys, internal examinations of the areas listed in **Table 2.4.4** and suspect areas identified in the previous survey are to be carried out.

4.2.5 Thickness Measurements

At Intermediate Surveys, thickness measurements of the area listed in **(1)** to **(3)** below are to be carried out. As to the gauging equipment and thickness measurement report, the provisions of **5.2.5-1** are to be applied correspondingly as well.

(1) Structural members, etc. listed in **Table 2.4.5**

(2) Suspect areas identified in the previous survey where deemed necessary by the Surveyor as a consequence of internal examination of spaces and tanks specified in **4.2.4**.

(3) Substantial corrosion areas identified in the previous survey

4.2.6 Pressure Test

At Intermediate Surveys for tank barges, a pressure test for piping systems is to be carried out when deemed necessary by the Surveyor as a consequence of the general examination required in **4.2.2**.

4.3 Intermediate Surveys for Machinery

4.3.1 General Examinations

At Intermediate Surveys for Machinery, in addition to the general examinations specified in **3.3.1**, the examinations specified in **Table 2.4.6** are to be carried out.

4.3.2 Performance Tests

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

4.3.3 Intermediate Surveys for barges

For barges, notwithstanding the requirements specified in **4.3.1** and **4.3.2**, following examinations are to be carried out.

(1) Open-up inspections of auxiliary generator engines, auxiliary machinery, heat exchangers and air tanks that are used as parts of important systems are to be carried out. These open-up inspections may be dispensed with, however, where it is verified that this machinery is in satisfactory condition as a result of a general examination and investigation of the maintenance records by the Surveyor.

(2) In cases where the machinery specified in **(1)** consists of duplicate systems, surveys for either of the machinery may be carried out.

Table 2.4.1 General Examination

Items	Examinations
Additional Requirements For Tank Barges	
1 Piping	・ Confirmation that cargo piping, vent piping, purging piping, gas free piping, inert gas piping and all other piping systems cargo pump-room, cargo compressor rooms and on weather decks are in good condition.

Table 2.4.2 Performance Test

Items	Tests
1 Equipment or installations of items in **Table 2.3.3** (except item 2)	・ Tests for each item specified in **Table 2.3.3** are to be carried out.
2 Closing appliances of exits provided in boundaries to open spaces	・ Confirmation that the doors and closing appliances work in order is to be made. ・ Hose tests listed in **Table 2.2.1** or equivalent tests are to be carried out. Such tests may be dispensed with at the discretion of the Surveyor.
3 Drainage, anchoring arrangements and their accessories	・ Confirmation that the arrangements work in order is to be made. This check may be dispensed with at the discretion of the Surveyor.
4 Water spray system	・ Checking whether the system works in order is to be made by delivering water through the system. Checking of quantity of delivered water may be dispensed with.
5 Carbon dioxide extinguishing medium, etc.	・ Confirmation of quantity of media is to be made.
6 Fixed carbon dioxide fire-fighting system	・ Confirmation that piping is maintained in good condition is made by delivering air through the pipes. ・ Confirmation that system alarm works in order is to be made.
7 Fixed high expansion foam fire-fighting system	・ Confirmation that piping is maintained in good condition is to be carried out by delivering water through the pipes.
8 Fixed pressure water spraying fire-fighting system	・ Confirmation that the system works in order is to be made by delivering water through the system. ・ Confirmation that the system pump works in order is to be made.

Table 2.4.3 Additional Performance Test for Tank Barges

Items	Examinations
1 Cargo pumps, bilge pumps, ballast pumps, stripping pumps and ventilators	Operation tests for the remote control systems and shut-off devices of the pumps installed in cargo pump-rooms are to be carried out.
2 Bilge systems	Operation tests of the bilge systems installed in cargo pump-rooms are to be carried out.
3 Level indicators	Operation tests of level indicators used in cargo tanks are to be carried out.
4 Pressure indicators	Operation tests of pressure indicators installed in cargo discharge lines are to be carried out.
5 Inert gas systems	Inert gas systems installed in accordance with **3.5.6, Part 9**, are subjected to the following tests. Other inert gas systems are to be examined as deemed appropriate by the Society. (a) Operation tests of the inert gas blowers and scrubber room ventilation systems (b) Function tests of the water seals and general examinations of the non-return valves (c) Operation tests of the remotely operated or automatically controlled valves (d) Operation tests of the interlocking system between the soot blowers and the shut-off valves on gas supply line (e) Operation tests of the measuring devices, alarm devices and safety devices specified in **35.2.6** and **35.2.8** through **35.2.10, Part R for Rules for the Survey and Construction of Steel Ships**.
6 Gauging, detecting and alarming devices	Operation tests for the following are to be carried out. Where tests under actual conditions are difficult, simulation tests or other suitable means may be used to confirm functionality. (a) Fixed and portable gas detecting instruments and associated alarms (b) Gauging devices for oxygen density

Table 2.4.4 Internal Examinations of Spaces and Tanks

Items	Examinations
Requirements for all ships unless specified otherwise	
1 Engine room and boiler room	・ An internal examination is to be carried out on all aspects.
2 Ballast tanks	・ For ships over 6 *years* and up to 12 *years* of age, an internal examination of representative ballast tanks is to be carried out. Where corrosion or other defects are found in a ballast tank, the examination is to be extended to other ballast tanks of the same type. ・ For ships over 12 *years* of age, an internal examination of all ballast tanks is to be carried out. ・ If such examinations reveal no visible structural defects, the examination may be limited to a verification that the corrosion prevention system remains effective.
3 Cargo holds	・ For ships over 12 *years* of age, an internal examination of one forward cargo hold and one after cargo hold is to be carried out.
4 Void spaces	・ For pontoon barges over 12 *years* of age, an internal examination of one port side void space and one starboard side void space is to be carried out.
Requirements for Tank Barges	
1 Engine room and boiler room	・ An internal examination is to be carried out on all aspects.
2 Cargo pump rooms, other pump rooms adjacent to cargo tanks, cargo compressor rooms and cargo pipe tunnels	・ An internal examination is to be carried out after thoroughly cleaned out and gas freed. Attention is to be paid to the sealing arrangements of all penetrations of bulkheads, ventilating arrangements, foundations and gland seals of pumps and compressors.
3 Ballast tanks	・ For ships over 6 *years* and up to 12 *years* of age, an internal examination of representative ballast tanks is to be carried out. Where corrosion or other defects are found in a ballast tank, the examination is to be extended to other ballast tanks of the same type. ・ For ships over 12 *years* of age, an internal examination of all ballast tanks is to be carried out. ・ If such examinations reveal no visible structural defects, the examination may be limited to a verification that the corrosion prevention system remains effective.
4 Cargo tanks	・ For pontoon barges over 12 *years* of age, an internal examination of three cargo tanks (port, starboard and center) is to be carried out.

Note:

(1) "Representative ballast tanks" means ballast tanks which include, at least, fore and aft peak tanks and two deep tanks within the cargo length area.

Table 2.4.5 Thickness measurements

Items	Notes
Requirements for All Ships except those specified in the followings	
1 Structural members in ballast tanks	・Where corrosion found and where considered necessary by the Surveyor as a result of the survey specified in **Table 2.4.4**, thickness measurements are to be carried out at the discretion of the Surveyor.
2 Hatch coamings	・Thickness measurements of areas found to be suspect areas at previous surveys are to be carried out.
3 Structural members in cargo holds	・Where corrosion found and where considered necessary by the Surveyor as a result of the survey specified in **Table 2.4.4**, thickness measurements are to be carried out at the discretion of the Surveyor.
Requirements for Tank Barges	
1 Cargo oil, fuel oil, ballast, vent pipes including vent masts and headers, inert gas pipes and all other piping in cargo pump rooms and on weather decks	・When deemed necessary by the Surveyor as a consequence of the examination specified in **4.2.2**, thickness measurements are to be carried out.
2 Structural members in ballast tanks (for ships over 6 *years* of age)	・Where corrosion found and where considered necessary by the Surveyor as a result of the survey specified in **Table 2.4.4**, thickness measurements are to be carried out at the discretion of the Surveyor.
3 Structural members in cargo tanks	・Where corrosion found and where considered necessary by the Surveyor as a result of the survey specified in **Table 2.4.4**, thickness measurements are to be carried out at the discretion of the Surveyor.

Table 2.4.6 Additional Requirements at Intermediate Surveys

Items	Examinations
1 Electrical installations	Insulation resistance of the generators and switchboards, 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 **2.17.1**, **Part 8**. However, where a proper record of measurement is maintained and deemed appropriate by the Surveyor, consideration may be given to accepting recent readings.

Chapter 5 SPECIAL SURVEYS

5.1 General

5.1.1 Examinations to be Carried out at the Commencement or Completion of Special Surveys

1 Where the Special Survey is commenced in accordance with the requirements in **1.1.3-1(3)(b)** or **(c)**, the thickness measurements required in **5.2.5** are to be carried out at the commencement of the Survey if possible in order to facilitate planning repairs. Where the Special Survey is commenced at or prior to the time of the 5th Annual Survey, a minimum of the examinations required for Annual Surveys specified in **Chapter 3** are to be carried out.

2 Where the Special Survey is completed in accordance with the requirements in **1.1.3-1(3)(b)** or **(c)**, a minimum of the examinations required in **3.2.2**, **3.2.3**, **3.3.1** and **3.3.2** are to be carried out at the completion of the Special Survey. Where considered necessary by the Surveyor as a result of these examinations, examinations may be increased to include those which have already been carried out.

5.1.2 Survey for the Postponement of Special Surveys

Where postponement of the Special Survey for a ship is granted in accordance with the requirements in **1.1.5**, the content of the Special Survey is determined based on the original expiry date of the Classification Certificate of the ship.

5.2 Special Surveys for Hull, Equipment, Fire Extinction and Fittings

5.2.1 Examination of Plans and Documents

1 At Special Surveys for ships other than barges, the management conditions of plans and documents specified in **3.2.1** are to be examined.

5.2.2 General Examination

1 At Special Surveys, examinations of hull, equipment, fire-extinction and fittings specified in **4.2.2** are to be carried out.

2 At Special Surveys for tank barges, 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 ballast tanks and all tanks and spaces bounding cargo tanks such as pump-rooms, pipe tunnels, cofferdams, and void spaces and on weather decks are to be examined.

5.2.3 Performance Test

1 At Special Surveys, performance tests specified in **4.2.3** are to be carried out. The performance tests for anchoring arrangements specified in item 3 of **Table 2.4.2** may not be omitted.

2 In addition to **-1** above, the performance tests and operation tests specified in **(1)** to **(4)** below are to be carried out.

(1) Performance tests and operation tests for all bilge and ballast piping system

(2) The hose tests listed in **Table 2.2.1** or equivalent tests, for closing appliances of exits provided in boundaries to open spaces

(3) For oil tank barges, performance tests and operation tests of cargo and ballast piping systems within all cargo tanks, all ballast tanks and all tanks and spaces bounding cargo tanks such as pump-rooms, pipe tunnels, cofferdams and void spaces, and on the weather deck

(4) Performance test and operation test of all piping systems within cargo holds, all ballast tanks and all tanks and spaces bounding cargo holds such as pipe tunnels, cofferdams, void spaces bounding cargo holds, and those on weather decks

3 Where considered necessary by the Surveyor, an execution of the inclining test and alterations to the stability information may be required.

5.2.4 Internal Examinations of Spaces and Tanks

1 At Special Surveys, examinations of structures and fittings such as piping in tanks and spaces are to be carried out carefully paying due attention to items **(1)** through **(6)** below.

(1) Areas sensitive to corrosion (on parts such as structural members and piping) in cargo holds where cargoes highly corrosive to steel such as logs, salt, coal, and sulphide ore have been loaded

(2) Areas sensitive to deterioration by heat such as plating under boilers

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

(4) Condition of striking plates under sounding pipes

(5) Condition of deck covering (*e.g.* cement)

(6) Locations on which defects such as cracking, buckling, and corrosion have been found in similar ships or similar structures

2 At Special Surveys, internal examinations of tanks or spaces listed in **Table 2.5.1** are to be carried out paying attention to the items in **-1** above.

3 At Special Surveys for tank barges with integral tanks, in addition to **-1** and **-2** above, an internal examination of tanks and spaces listed in **Table 2.5.2** is to be carried out. Tanks and spaces identified as suspect areas at previous surveys are to be examined.

5.2.5 Thickness Measurements

1 At Special Surveys, thickness measurements are to be carried out in accordance with **(1)** through **(4)** below.

(1) Thickness measurements are to be carried out using appropriate ultra-sonic gauging machines or other approved means. The Surveyor may request that the accuracy of the equipment be demonstrated.

(2) Thickness measurements are to be carried out within 12 *months* prior to completion of the survey in question under the attendance of the Surveyor by the firm approved by the Society under the "**Rules for Approval of Manufactures and Service Suppliers**" or equivalent firm. The surveyor may request to have the measurements taken again to ensure acceptable accuracy.

(3) Additional thickness measurements are to be carried out before the completion of the survey.

(4) A thickness measurement record is to be prepared and submitted to the Society.

2 At Special Surveys, thickness measurements are to be carried out according to **-1** above for structural members listed in **Table 2.5.3**.

5.2.6 Pressure Tests

1 At Special Surveys, a pressure test of tanks is to be carried out according to **(1)** through **(3)** below.

(1) A pressure test is to be carried out under the pressure specified below:

   (a) For tanks: the pressure corresponding to the maximum head that can be experienced in service

   (b) For piping: the working pressure

(2) A pressure test of tanks may be carried out when the ship is afloat, provided that an internal examination of the bottoms of the tanks has also been carried out while afloat.

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

2 At Special Surveys, a pressure test is to be carried out according to **-1** above for tanks listed in **Table 2.5.4**.

3 At Special Surveys for tank barges with integral tanks, notwithstanding the provisions of **-2** above, a pressure test is to be carried out for tanks listed in **Table 2.5.5**. In addition, pressure tests of cargo tanks may be specially considered when deemed appropriate by the Society. For double hull tank barges with integral tanks, any testing of double bottom tanks and other watertight compartments not designed to carry liquids may be omitted, provided that satisfactory internal and/or external examinations are carried out.

5.3 Special Surveys for Machinery

5.3.1 General Examinations

At Special Surveys for Machinery, in addition to the general examination specified in **3.3.1**, the surveys specified in **Table 2.5.6** are to be carried out.

5.3.2 Performance Tests and Pressure Tests

At Special Surveys for Machinery, in addition to the performance tests specified in **3.3.2**, the performance tests specified in **Table 2.5.7** are to be carried out.

5.3.3 Special Survey for Barges

For barges, notwithstanding the requirements specified in **5.3.1** and **5.3.2,** open-up inspections of auxiliary generator engines, auxiliary machinery, heat exchangers and air tanks that are used as parts of important systems are to be carried out. These open-up inspections may be dispensed with, however, where it is verified that this machinery is in satisfactory condition as a result of a general examination and investigation of the maintenance records by the Surveyor.

Table 2.5.1 Internal examinations of tanks and spaces

Special Survey	Tanks and spaces subject to examination	Notes
Special Survey for ships up to 6 *years* of age	・ Cargo holds ・ Cofferdams ・ Ballast tanks ・ Cargo tanks ・ Peak tanks ・ Machinery spaces and other spaces	
Special Survey for ships over 6 *years* and up to 12 *years* of age	・ Tanks and spaces subject to examination carried out at Special Survey for ships up to 6 *years* of age ・ Fresh water tanks ・ Fuel oil tanks in cargo length areas	・ If fresh water tanks and fuel oil tanks have had external examinations and the Surveyor is satisfied that they are in good condition, the scope of any internal examinations may be reduced to just one selected tank respectively. Notwithstanding the above, peak tanks are to be subject to internal examinations at each Special Survey.
Special Survey for ships over 12 *years* and up to 18 *years* of age	・ Tanks and spaces subject to examination carried out at Special Survey for ships over 6 *years* and up to 12 *years* of age ・ Fuel oil tanks	・ For fuel oil tanks: (1) If fuel oil tanks in cargo areas for tank barges or in cargo length areas for other ships have had external examinations and the Surveyor is satisfied that they are in good condition, the scope of any internal examinations may be reduced to just two selected tanks. In cases where deep fuel oil tanks are provided, one or more deep tanks are to be included in this scope. (2) If fuel oil tanks other than those mentioned in (1) have had external examinations and the Surveyor is satisfied that they are in good condition, the scope of any internal examinations may be reduced to just one tank selected from those in engine rooms. Notwithstanding the above, peak tanks are to be subject to internal examinations at each Special Survey.

Table 2.5.1 Internal examinations of tanks and spaces (continued)

Special Survey	Tanks and spaces subject to examination	Notes
Special Survey for ships over 18 *years* of age	・ Tanks and spaces subject to examination carried out at Special Survey for ships over 12 *years* and up to 18 *years* of age ・ Lubricating oil tanks	・ For fuel oil tanks: (1) If fuel oil tanks in cargo areas for tankers or in cargo length areas for other ships have had external examinations and the Surveyor is satisfied that they are in good condition, the scope of any internal examinations may be reduced to half of the selected tanks, but not less than two tanks. In cases where deep fuel oil tanks are provided, one or more deep tanks are to be included in this scope. (2) If fuel oil tanks other than those mentioned in (1) have had external examinations and the Surveyor is satisfied that they are in good condition, the scope of any internal examinations may be reduced to just one tank selected from those in engine rooms. Notwithstanding the above, peak tanks are to be subject to internal examinations at each Special Survey. ・ If lubricating oil tanks have had external examinations and the Surveyor is satisfied that they are in good condition, the scope of any internal examinations may be reduced to just one selected tank. Notwithstanding the above, peak tanks are to be subject to internal examinations at each Special Survey.

Table 2.5.2 Additional requirements of internal examinations for tank barges

Special Survey	Tanks and spaces subject to examination	Notes
All Special Surveys	1 All cargo tanks	・ 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. ・ Condition of the inner surface of the bottom plating of the tank is to be examined carefully in order to ascertain that the there is no excessive pitting of the plating. ・ Bell mouths of the cargo suction pipes are to be removed and the bottom plating of the tank and bulkheads in that vicinity are to be examined as considered necessary by the Surveyor.
	2 All ballast tanks, and all tanks and spaces adjacent to cargo tanks (pump rooms, pipe tunnels, cofferdams and void spaces)	・ An internal examination of the pump room is to be carried out carefully paying attention to condition of mounting of pumps, gland seals, all penetrations of bulkheads and ventilating arrangement.

Table 2.5.3 Requirements for Thickness Measurements

Special Survey	Structural members subject to thickness measurement
Special Survey for ships up to 6 *years* of age	1. Suspect areas
Special Survey for ships over 6 *years* and up to 12 *years* of age	1. Suspect areas
Special Survey for ships over 12 *years* and up to 18 *years* of age	1. Suspect areas 2. Each plate and member in two transverse sections within 0.5*L* amidships. (in way of two different cargo spaces, if applicable). When the selected section is a transversely framed section, adjacent frames and their end connections in way of the transverse section are to be included. 3. Internals in fore and aft. peak tank 4. Both ends and middle part of each hatch side and end coaming (plating and stiffeners)
Special Survey for ships over 18 *years* and up to 24 *years* of age	1. Suspect areas 2. Following portions of structural members: (1) All exposed main deck plates, full length (2) Each plate, girder and member in three transverse sections of cargo areas within 0.5*L* amidships. When the selected section is a transversely framed section, adjacent frames and their end connections in way of the transverse section are to be included. (3) All wind and water strakes, port and starboard, full length 3. Representative exposed superstructure deck plating (poop, bridge and forecastle deck) 4. All keel plates, full length, and an appropriate number of bottom plates in way of cofferdams, machinery spaces and aft end of tanks 5. In all cargo holds, all lowest strakes and strakes in way of tween decks of all watertight transverse bulkheads in cargo spaces together with internals in way 6. Structural members specified in 3. and 4. of Special Survey for ships over 12 *years* and up to 18 *years* of age
Special Survey for ships over 24 *years* of age	1. Suspect areas 2. Structural members specified in 2. to 6. of Special Survey for ships over 18 *years* and up to 24 *years* of age

Table 2.5.4 Requirements of Pressure Tests

Special Survey	Tanks subject to pressure tests
All Special Survey	1. All water tanks including cargo holds used for ballast and all cargo tanks Pressure tests of fresh water tanks may be specially considered when deemed appropriate by the Society. 2. All fuel oil tanks Pressure tests may be specially considered when deemed appropriate by the Society. 3. All lubrication oil tanks Pressure tests may be specially considered when deemed appropriate by the Society.

Table 2.5.5 Requirements of Pressure Tests for Tank Barges

Special Survey	Tanks subject to pressure tests
Special Survey for ships up to 6 *years* of age	1. Cargo tank boundaries facing ballast tanks, void spaces, pipe tunnels, fuel oil tanks, pump rooms and cofferdams 2. All water tanks Pressure tests of fresh water tanks may be specially considered when deemed appropriate by the Society. 3. All fuel oil tanks Pressure tests may be specially considered when deemed appropriate by the Society. 4. All lubrication oil tanks Pressure tests may be specially considered when deemed appropriate by the Society.
Special Survey for ships over 6 *years* and up to 12 *years* of age	1. Tanks specified in 1. to 4. of Special Survey for ships up to 6 *years* of age
Special Survey for ships over 12 *years* of age	1. All cargo tank bulkheads 2. Tanks specified in 2. to 4. of Special Survey for ships up to 6 *years* of age

Table 2.5.6 Additional Requirements at Special Surveys for Machinery

Items	Examinations
1 Diesel engines (main propulsion machinery and auxiliary machinery for propulsion, manoeuvring and personnel 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, detuners, balancers, and compensators are to be generally examined. (d) The crankshaft alignment is to be checked and if necessary, adjusted.
2 Electrical installations	(a) The switchboards, distribution boards, cables, etc. are, as far as practicable, to be generally examined. (b) Insulation resistance of the generators and switchboards, 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 **2.17.1**, **Part 8**. However, where a proper record of measurement is maintained and deemed appropriate by the Surveyor, consideration may be given to accepting recent readings.

Table 2.5.7 Additional Requirements at Special Surveys

Items	Examinations
1 Speed governors, generator circuit breakers and associated relays	Performance tests are to be carried out with all generators operating under loaded condition, either separately or in parallel, as far as practicable.
2 All other piped machinery and parts	Pressure tests are to be handled in accordance with the requirements of **2.2.2(2)** where deemed necessary by the Surveyor.
3 Lighting systems, communication and signalling systems, ventilating systems, and other electrical equipment	Performance tests (including operation tests) of interlocking devices used to ensure safe operation are to be carried out where deemed necessary by the Surveyor.

Chapter 6 DOCKING SURVEYS

6.1 Docking Surveys

6.1.1 Surveys in Dry Dock or on Slipway

At Docking Surveys, examinations listed in **Table 2.6.1** are to be carried out in the dry dock or on the slipway after cleaning the outer shell.

6.1.2 In-water Surveys

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

2 The following plans and documents are to be included as part of a submission to the Society for approval for conducting In-water Surveys, which is to be obtained prior to commencement.

(1) Plans of shell plating below the waterline showing details of the location and sizes of shell openings, location of bottom plugs, location of bilge keels, location of water- and oil-tight bulkheads, location of welded seams and butts and location of anodes

(2) Detailed information or drawings of constructions and arrangements indicated in **-3** below, together with their colour photographs, and detailed instructions for inspection of such constructions and arrangements

(3) Documents showing the procedure which enables the Surveyor to confirm the clearance of the rudder bearing or the condition of the stern tube bearing based on a review of the operating history, on board testing or analysis of stern oil sample

Where the bearing is found to be satisfactory, special consideration may be given to the requirements in **-3(1)** or **-3(4)** below.

(4) Other data which may serve the inspections

3 Ships intended to be subjected to the In-water Survey are to comply with the following. Where the documents specified in **-2(3)** above are submitted, special consideration may be given to **(1)** or **(4)** below.

(1) A means of measuring the clearance of the rudder in way of each pintle is provided

(2) Rope-guard ring plates are of such construction as to facilitate the inspection of the shafting between propeller hubs and stern frame boss

(3) For water lubricating type stern tube bearings, a means of measuring the clearance between the propeller shafts and their bearings is provided

(4) For oil lubricating type stern tube bearings, a suitable means of ascertaining the performance of the stern tube bearings including oil sealing devices is provided

(5) A suitable means of ascertaining the position and identity of each blade of the propellers is provided

(6) Hinged gratings are installed on all sea chests and constructed so as to facilitate opening and closing by the diver

(7) Markings indicating the position of longitudinal and transverse bulkheads and the names of interior spaces on the hull below the load water line, so that the diver is able to orient his/her position relative to the ship

4 The Surveyor may require internal examinations or dry dock surveys where deemed necessary as a result of the In-water Survey.

6.1.3 Other Surveys

For each ship adopting the preventive maintenance system for propulsion shafting system in accordance with the requirements in **8.1.3**, general examination 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 2.6.1 Requirements for Docking Surveys

Items	Examinations
1 Shell plating including keel plate, stem and stern frame	・Discontinuous structures, structural parts liable to excessive corrosion and openings in the shell are to be examined carefully. Grillage covers are to be removed where deemed necessary by the Surveyor.
2 Rudder	・The rudder is to be lifted or removed and visible parts of the rudder, rudder pintles, gudgeons, rudder stocks and couplings and stern frame are to be examined. Where applicable, a pressure test of the rudder according to **Table 2.2.2** may be required as deemed necessary by the Surveyor. The rudder bearing clearance is to be measured. The rudder may not require lifting or removal provided the Surveyor is satisfied with the condition of the rudder by measurement of the clearance.
3 Scupper, overboard discharges and river water inlets including distance pieces below freeboard deck, and valves and cocks on shell plating, sea chest or distance piece	・The main parts of valves and cocks are to be opened up and examined. The bolts or studs fastening these mountings to the hull are to be examined. The valves and cocks may not require open-up examination at the discretion of the Surveyor provided they were opened up and found to be in good order at the last Docking Survey. ・In cases where consecutive In-water Surveys in lieu of Docking Surveys conducted in dry dock or on slipway may be applied with Administration approval, the open-up examination of valves and cocks required may be exempted at the discretion of the Society provided they were examined (including visual inspection by diver) and found to be in good order.
4 After end of stern bush	・The wear down of the bearing is to be measured; or the clearance between the propeller shaft or stern tube shaft and the after bearing of the stern tube or the shaft bracket bearing.
5 Sealing devices for stern tube and shaft bracket bearing	・The efficiency of the oil gland is to be checked.
6 Propeller	・Propellers are to be examined. Where a controllable pitch propeller is fitted, the pitch control device is to be examined without dismantling.
7 Anchor, anchor chain, ropes, hose pipe, chain locker and cable clenches	・At the Docking Surveys carried out at the times specified in **1.1.3-1(4)(a)**, anchor and anchor chains are to be ranged and all chains and chain related equipment are to be verified and externally examined. In cases where In-water Surveys in lieu of Docking Surveys conducted in dry dock or on slipway may be applied at the times specified in **1.1.3-1(4)(a)**, anchors and anchor chains may not be required to be ranged and examined at the discretion of the Society provided they were examined (including visual inspection by diver) and found to be in good order. In such cases, anchors and anchor chains should be ranged and all chains and chain related equipment should be verified and externally examined at the next Docking Surveys conducted in dry dock or on slipway. At Special Survey No.2 and subsequent Special Surveys, the diameter of the 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 specified in **16.1, Part 4 or 14.1, Part 5**, it is to be renewed.
8 Tanks and spaces	・The internal examination and thickness measurements (if applicable and not already carried out) are to be carried out as stipulated below. At Docking Surveys in the dry dock, at least the portions below the light ballast water line of the cargo holds/tanks and water ballast tanks
9 Installations for In-water Surveys	・With regard to ships having the approval for conducting In-water Surveys based on the requirements in **6.1.2**, Surveyors are to confirm that the means and installations specified in **6.1.2-3** are in good condition.

Chapter 7 BOILER SURVEYS

7.1 Boiler Surveys

7.1.1 Surveys of Boilers and Thermal Oil Heaters

At Boiler Surveys, examinations specified in **Table 2.7.1** are to be carried out for boilers and thermal oil heaters.

7.1.2 Surveys of Steam Generators

Steam generators and other pressure vessels with steam accumulated in them are to be handled in accordance with the requirements for boilers.

Table 2.7.1 Requirements of Boiler Survey

Items	Examinations
1 Pressure parts of boilers	To be internally examined with the manholes, cleaning holes and inspection holes dismantled. Where considered to be necessary for external examination by the Surveyor, the parts are to be examined to the Surveyor's satisfaction with the insulation around the parts removed.
2 Superheaters, economizers and exhaust gas economizers	To be examined internally and externally. For exhaust gas economizers of the shell type, all accessible welded joints are to be subject to a visual examination for cracking and non-destructive testing may be requested where deemed necessary by the Surveyor.
3 Combustion parts of boilers and thermal oil heaters(1), etc.	The furnaces, combustion chambers, combustion gas chambers are internally examined with their doors opened.
4 Valves and cocks mounted to boilers	The principal mountings and their fastening bolts or studs are to be opened up and examined.
5 Thickness of plates and tubes, size of stays for boiler and thickness of thermal oil heating pipes	To be measured where deemed necessary by the Surveyor.
6 Safety valves and relevant parts of boilers, superheaters and thermal oil heaters(1)	The safety valves are to be adjusted under steam to a pressure not more than 103 % the approved working pressure after the open-up examination. The pressure gauge used for this adjustment is to be calibrated properly. The relieving gears of the valves are to be examined and tested to verify satisfactory operation. However, for exhaust gas economizers, if steam cannot be raised at port, the relief valves may be set by the chief engineer at river, and the results recorded in the logbook for review by the Surveyor. The general conditions of relief pipes for thermal oil heaters are to be examined. The popping pressure of safety valves fitted on thermal oil heaters is to be ascertained.
7 Safety devices, alarm devices and automatic combustion control devices	These devices are to be tested in accordance with the requirements in **Chapter 7, Part 7** of the Rules in order to ascertain that they are in good working conditions after the above examinations.
8 Review of the records of the logbook	Review of the following records since last boiler survey is to be carried out. (1) Operation (2) Maintenance (3) Repair history (4) Quality control of the feed water or thermal oil

Note:

(1) Only applies to thermal oil heaters heated by fire, combustion gas or exhaust gas from machinery.

Chapter 8 PROPELLER SHAFT AND STERN TUBE SHAFT SURVEYS

8.1 Propeller Shaft and Stern Tube Shaft Surveys

8.1.1 Ordinary Surveys

At Ordinary Surveys of a propeller and stern tube shafts, the shaft is to be withdrawn for examinations specified in **Table 2.8.1**.

8.1.2 Partial Surveys

At Partial Surveys for propeller shafts Kind 1 of oil lubricated stern tube bearings, the examinations specified in the following **(1)** through **(3)** are to be carried out.

(1) A visual examination of the parts of the propeller shafts exposed in the engine room

(2) Confirmation that the shaft is not operated in the barred speed range for torsional vibration

(3) Examinations specified in 1, 4, 5, 6, 9 and 10 in **Table 2.8.1**

However, the requirements of 1, 5 and 6 in **Table 2.8.1** may be omitted for shafts having keyless propeller attachments or coupling flanges at their aft end, if general examinations are proved satisfactory.

8.1.3 Preventive Maintenance System

Notwithstanding the requirements in **8.1.1** above, where the ship is equipped with oil lubricated stern tube bearings and appropriate stern tube oil sealing devices as approved by the Society, and at least the following **(1)** through **(4)** are properly monitored and recorded for diagnosing the lubricating conditions of the shafting system and maintaining the system preventively based on the results of the diagnoses subject to approval of the Society; the survey items of -2, -3 and -5 in **Table 2.8.1** may be replaced with a general examination of the shafting system provided that all condition monitoring data taken according to the approved preventive maintenance system is found to be within permissible limits. For a ship of which the preventive maintenance system has been approved by the Society, the notation "*Propeller Shaft Condition Monitoring System*" (abbreviated to *PSCM*) is affixed to the ship's classification character and the propeller shaft may be examined as a propeller shaft Kind 1*B* for the remaining requirements except -2, -3 and -5 in **Table 2.8.1**. The examination required by survey item -6 in **Table 2.8.1** may be partly dispensed with where deemed appropriate by the Society.

(1) Lubricating oil sampling and analysis is to be carried out regularly at intervals not exceeding 6 *months* and each analysis is to include the following **(a)** through **(d)** at least:

  (a) Water contents

  (b) Chlorides contents

  (c) Contents of shaft metal and bearing metal particles

  (d) Oxidation of oil

(2) Lubricating oil consumption rate

(3) Bearing temperature

(4) The value specified in item -4 of **Table 2.8.1**

Table 2.8.1 Ordinary Surveys of Propeller Shaft and Stern Tube Shaft

Items	Examinations
1 Propeller connection	
(1) Shafts having keyed propeller attachments	The aft shaft taper is to be examined from the end of the cylindrical part of the shaft (or from the aft edge of the liner, if any) for one-third of the length of the shaft taper by an efficient crack detection method.
(2) Shafts having keyless propeller attachments	The forward portion of the aft shaft taper is to be examined by an efficient crack detection method. When the propeller is force fitted to the shaft, it is to be ascertained that the pull-up length is within the upper and lower limits given in **5.3.1-1, Part 7**.
(3) Shafts having coupling flange at the after end	The flange fillet and coupling bolts are to be examined by an efficient crack detection method. However, the crack detection examination may be dispensed with, provided that the Surveyor is satisfied with the condition after an external examination.
2 Propeller shaft, stern tube shaft, and coupling bolts	The sleeves, the fillet of the coupling flange to the intermediate shaft or to the stern tube shaft and the coupling bolts are to be examined with the shaft drawn from the stern tube bearings. However, coupling bolts are to be examined by an efficient crack detection method, in cases where Surveyors, based on the results of external examinations, deem such addition testing to be necessary. In addition, anti-corrosion covers are to be removed for shafts of Kind 2.
3 Stern tube bearing	The stern tube bearings are to be examined.
4 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.
5 Sealing device	Major parts of the stern tube sealing devices (including shaft bracket sealing devices, if any, hereinafter referred to as the same in this Chapter.) are to be opened and examined.
6 Propeller boss	The propeller boss bore in way of the propeller shaft taper section is to be examined.
7 Controllable pitch propeller	The pitch control gear and working parts are to be examined and the propeller blade fixing bolts are to be examined by an efficient crack detection method.
8 Water lubrication line	Where water-lubricated stern tube bearings are adopted, the river water piping for lubrication is to be examined.
9 Oil lubrication line	Where oil-lubricated stern tube bearings are adopted, the low oil level alarms of the lubricating oil tanks, oil temperature measuring devices and oil circulation pumps are to be examined.
10 Lubrication oil	Where oil-lubricated stern tube bearings are adopted, the lubricating oil record book is to be examined.

Chapter 9 PLANNED MACHINERY SURVEYS

9.1 Planned Machinery Surveys

9.1.1 Application

In a Planned Machinery Survey, surveys in accordance with the applicable requirements prescribed in **9.1.2** and **9.1.3** are to be carried out.

9.1.2 Continuous Machinery Survey

In a Continuous Machinery Survey (hereinafter referred to as "CMS" in this Chapter), every item specified in **Table 2.9.1** is to be surveyed systematically, continuously and sequentially in accordance with the survey schedule table approved by the Society so that each survey interval for all CMS items may not exceed 6 *years*. During the CMS, when any defect or damage is found, similar machinery and equipment, or a part of them, may be required to be opened up for further examination as deemed necessary by the Surveyor, and all the defective items or failures found are to be repaired to the Surveyor's satisfaction. Survey items deemed appropriate by the Society may be delegated to overhaul inspections by the shipowner (or the ship management company). In this case, the records of the overhaul inspections of the machinery and equipment concerned are to be ascertained as soon as possible. When it is regarded that satisfactory maintenance has not been carried out, an open-up examination in the presence of the Surveyor may be required.

9.1.3 Planned Machinery Maintenance Scheme

A shipowner (or ship management company) that has an established maintenance system may apply to adopt the planned maintenance method in which the shipowner is permitted to carry out planned overhaul inspections and maintenance as specified in **(1)** in place of the open-up surveys specified in **Table 2.9.1**. In addition to **(1)**, the shipowner (or ship management company) may apply to adopt the condition monitoring maintenance method as specified in **(2)** which is based on the results of condition monitoring and diagnoses for the machinery and equipment.

(1) The planned maintenance method is to be implemented in accordance with the machinery maintenance scheme approved by the Society. The Society will perform a general examination yearly on every item including review of the maintenance records in order to ascertain that the machinery and equipment covered are placed in good order. Where it is regarded that satisfactory maintenance has not been carried out for any of the machinery and equipment, an open-up examination of the item in the presence of the Surveyor may be required. For machinery and equipment deemed necessary by the Society, open-up examinations in the presence of the Surveyor are to be performed according to the survey schedule table based on the machinery maintenance scheme.

(2) The condition monitoring maintenance method is to be implemented in accordance with the machinery maintenance scheme approved by the Society. When any abnormalities are found through the condition monitoring data or diagnoses, the shipowner (or ship management company) is to request an examination in the presence of the Surveyor as soon as possible in accordance with the survey schedule table based on the machinery maintenance scheme. The Society will perform a general examination yearly on every item including review of the condition monitoring data and the maintenance records in order to ascertain that the machinery and equipment covered are placed in good order. Where it is regarded that satisfactory maintenance has not been carried out for any of the machinery and equipment, an open-up examination of the item in the presence of the Surveyor may be required. The planned overhaul inspections and maintenance method is to be required where the condition monitoring maintenance method is not applied.

9.1.4 Periodical Surveys

In place of the Planned Machinery Surveys prescribed in **9.1.2** and **9.1.3**, the surveys specified in the following **(1)** and **(2)** may be carried out at Intermediate Surveys and Special Surveys prescribed in **1.1.3.** In addition, the Surveyor is to examine as needed any machinery and equipment for which an open up survey was carried out for maintenance, etc. at the discretion of the shipowner at times other than during Intermediate Surveys and Special

Surveys.

(1) During the Intermediate Survey, the surveys specified in **Table 2.9.2** are to be carried out to ascertain that all the machinery is placed in good order. However, in cases where the machinery consists of duplicate systems, surveys for either of the machinery may be carried out.

(2) During the Special Survey, the surveys specified in **Table 2.9.1** are to be carried out to ascertain that all the machinery is placed in good order. However, at Special Surveys of ships equipped with two or more propeller shafting systems driven by identical main engines, surveys of the main engine components that were examined in accordance with the requirements for Special Surveys after the Classification Survey during Construction or the previous Special Survey may be omitted where deemed appropriate by the Surveyor, considering the time the engines were examined, the service history of the engines, the present condition and whether or not they were subject to a Classification Survey during Construction.

Table 2.9.1 Open-up Surveys of Machinery and Equipment

Items	Examinations
1 Diesel engines (main engine)	Cylinder covers, cylinder liners, pistons (including piston pins and piston rods), crosshead pins and bearings, connecting rods, crank pins and their bearings, crank journals and their bearings, camshafts and their driving gears, turbo chargers, scavenge air pumps or blowers, air intercoolers, attached essential pumps (bilge, lubricating oil, fuel oil, cooling water) are to be opened up.
2 Power transmission systems and shafting systems	・Reduction gears, reversing gears and clutch gears are to be opened up to the Surveyor’s satisfaction, and the gears, shafts, bearings and couplings are to be examined. ・The essential parts of flexible couplings are to be opened up. ・Thrust shafts, intermediate shafts and their bearings (excluding stern tube bearings and shaft bracket bearings) are to be examined by removing the upper bearing halves or their bearing metals and thrust pads and turning the shaft. ・The essential parts of other power transmission gears are to be subjected to open-up examinations to the Surveyor’s satisfaction.
3 Auxiliary engines	Generators, auxiliary engines driving auxiliary machinery essential for main propulsion and auxiliary machinery for manoeuvring and personnel safety are to be handled in accordance with the requirements applicable to main engines.
4 Auxiliary machinery	The essential parts of the following auxiliary machinery are to be subjected to open-up examinations. (a) Air compressors, blowers (b) Cooling pumps (c) Fuel oil pumps (d) Lubricating oil pumps (e) Feed pumps, condensing pumps, drain pumps (f) Bilge pumps, ballast pumps, fire pumps (excluding those for emergency use) (g) Condensers, feed water heaters (h) Coolers (i) Oil heaters (j) Fuel oil tanks (k) Air reservoirs (including those for main, auxiliary, control and general service) (l) Deck machinery (m) Other items considered to be applicable under the Planned Machinery Survey by the Society

Table 2.9.2 Surveys of Machinery and Equipment in place of the Planned Machinery Surveys

Items	Examinations
1 Diesel engines (main engine)	・Inside of cylinders and inside and outside of cylinder covers are to be examined. However, pistons need not to be removed unless deemed necessary by the surveyor. ・Crank pin bearings in the number of one third of cylinders are to be removed and examined by turning the crank shaft. ・Blades and bearings for turbo chargers are to be examined.
2 Power transmission systems and shafting systems	・For reduction gears, gears are to be examined from inspection holes. ・Thrust shafts, intermediate shafts and their bearings (excluding stern tube bearings and shaft bracket bearings) are to be examined by removing the upper bearing halves or their bearing metals and thrust pads and turning the shaft.
3 Auxiliary engines	Generators, auxiliary engines driving auxiliary machinery essential for main propulsion and auxiliary machinery for manoeuvring and personnel safety are to be handled in accordance with the requirements applicable to main engines.
4 Auxiliary machinery	Auxiliary machinery are to be examined in accordance with item 4 of **Table 2.9.1**

Part 3 MATERIALS AND WELDING

Chapter 1 HULL STRUCTURAL MATERIALS

1.1 Hull Structural Materials

1.1.1 General

Rolled steels intended to be used for hull structure are to be at the discretion of the Society.

Chapter 2 WELDING

2.1 Welding

2.1.1 General

Welding of rolled steels for hull is to comply with the requirements in **Part C** and **Part M of the Rules for the Survey and Construction of Steel Ships**.

Part 4 HULL CONSTRUCTION AND EQUIPMENT OF TUGS AND PUSHERS

Chapter 1 GENERAL

1.1 Application

1.1.1 Application

1 This part applies to hull construction and equipment of tug and pusher of less than 90*m* in length mainly navigating inland waterways.

2 In ships of not less than 90*m* in length, the requirements concerning hull construction, equipment, arrangement and scantlings will be decided individually basing upon the general principle of this Part instead of the requirements in this Part.

1.1.2 Special Cases in Application

Notwithstanding the provisions in **1.1.1**, the requirements for hull construction, equipment, arrangement and scantlings of ships less than 30*m* in length or that do not comply with the requirements in this Part for some special reason are to be at the Society's discretion.

1.1.3 Ships of Unusual Form or Proportion, or Intended for Carriage of Special Cargoes

In ships of unusual form or proportion, the requirements concerning hull construction, equipment, arrangement and scantlings will be decided individually basing upon the general principle of this Part instead of the requirements in this Part.

1.2 General

1.2.1 Direct Calculations

1 Where approved by the Society, direct calculations may be used to determine the scantlings of structural members and structural details for joints and discontinuities of structural members. In this case, if the scantlings which are determined by the reference of results of the direct calculations are not less than the scantlings of each provision in this chapter, the scantlings are not to be less than the scantlings which are determined by the reference of results of the direct calculations.

2 In case of utilizing the direct calculations, the data necessary for the calculation are to be submitted to the Society.

1.3 General for Materials, Construction, etc.

1.3.1 Application of Steels

Application of steels used for hull structures is to be at the Society's discretion.

1.3.2 Strength of Contact Parts with Other Ships

The construction of parts where the ships come into contact with other ships for navigation and/or operation purposes, such as the bow parts of ships, is to be designed to ensure sufficient strength.

1.3.3 Special Requirements for Tugs

Tugs engaged in towing operations are to comply with the following **(1)** to **(7)**.

(1) Scantlings of parts of propeller posts are to be suitably increased from that given by the formula and figures in **Fig.4.2.5**.

(2) The diameter of rudder stocks of ships is not to be less than 1.1 *times* that required in **Chapter 2**, **Part 4**.

(3) In principle, towing equipment is to be located on longitudinals, beams or girders, which are parts of the deck construction.
(4) In cases where towing equipment cannot be located as specified in **(3)** above, towing equipment is to be arranged on reinforced members.
(5) The supporting structures of towing equipment are to be designed to ensure sufficient strength.
(6) The design load on towing equipment and its supporting structures is to take into account all acting loads.
(7) The design loads for the supporting structures of towing equipment are to be not less than the breaking strength of the towline system.

1.3.4 Special Requirements for Pushers

In cases where pushers are equipped with coupling devices for connection to other vessels, etc., construction in way of such coupling devices is to be designed to ensure sufficient strength.

1.3.5 Scantlings

1 The scantlings of hull structural members are framed for the case where mild steel is used. Where material other than mild steel is used for hull structural members, the scantling of which are to be in accordance with the discretion of the Society.

2 Section moduli specified by the Rules include the steel plates with an effective breadth of 0.1*l* on either side of the members, unless specified otherwise. However, the 0.1*l* steel plates are not to exceed one-half of the distance to the next member. *l* is the length of the member specified in the relevant Chapters.

3 Where flat bars, 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 proportion to the section modulus specified in these Rules.

4 The inside radius of flanged plates is not to be less than twice but not more than 3 *times* the thickness of steel plates.

5 The thickness of face plates composing girders and transverses is not to be less than that of web plates and the full width is not to be less than that obtained from the following formula:

$$85.4\sqrt{d_0 l} \quad (mm)$$

d_0 : Depth (m) of girders and transverses specified in the relevant Chapter

l : Distance (m) between supports of girders and transverses specified in the relevant Chapters
However, where effective tripping brackets are provided, they may be taken as supports.

6 Scantlings of stiffeners based on requirements in this Part may be decided based on the concept of grouping designated sequentially placed stiffeners of equal scantlings. The scantling of the group is to be taken as the greater of the values obtained from the following requirements **(1)** and **(2)**.
(1) the average of the required scantling of all stiffeners within a group
(2) 90% of the maximum scantling required for any one stiffener within the group

1.3.6 Connection of Ends of Stiffeners, Girders and Frames

1 Where the ends of girders are connected to structures such as bulkheads and tank tops, the end connections are to be balanced by effective supporting members on the opposite side of these structures.

2 The length of the frame-side arm of brackets connected to the frames or stiffeners of structures such as bulkheads or deep tanks is not to be less than one-eighth of *l* specified in the relevant Chapter, unless specified otherwise.

1.3.7 Brackets

1 The size of brackets is to be determined by **Table 4.1.1** according to the length of longer arm.

2 The thickness of brackets is to be suitably increased where the depth of the brackets at the throat is less than two-thirds of the longer arm of the bracket.

3 Where the length of the longer arm exceeds 800*mm*, the free edges of the brackets are to be stiffened by flanging or by other means, except where tripping brackets or the like are provided.

Table 4.1.1 Brackets

(Unit: *mm*)

Length of longer arm	Thickness		Breadth of flange	Length of longer arm	Thickness		Breadth of flange
	Plane	Flanged			Plane	Flanged	
150	6.5	-	-	700	14.0	9.5	70
200	7.0	6.5	30	750	14.5	10.0	70
250	8.0	6.5	30	800	-	10.5	80
300	8.5	7.0	40	850	-	11.0	85
350	9.0	7.0	40	900	-	11.0	90
400	10.0	8.0	50	950	-	11.5	90
450	10.5	8.0	50	1,000	-	11.5	95
500	11.0	8.5	55	1,050	-	12.0	100
550	12.0	8.5	55	1,100	-	12.5	105
600	12.5	9.0	65	1,150	-	12.5	110
650	13.0	9.0	65	-	-	-	-

1.3.8 Modification of Span (*l*) for Thicker Brackets

Where brackets are not thinner than the girder plates, the value of *l* specified in **Chapter 6** to **9** may be modified in accordance with the following:

(1) Where the sectional area of the face plate of the bracket is not less than one-half that of the girder and the face plate of the girder is carried to the bulkhead, deck, tank top, etc., *l* may be measured to a point 0.15*m* inside the toe of the bracket.

(2) Where the sectional area of the face plate of the bracket is less than one-half that of the girder and the face plate of the girder is carried on to the bulkhead, deck, tank top, etc., *l* may be measured to a point where the sum of sectional areas of the bracket and its face plate outside the line of the girder is equal to the sectional area of the face plate of the girder, or to a point 0.15*m* inside the toe of the bracket, whichever is the greater.

(3) Where brackets are provided and the face plates of girders extend along the free edge of brackets to the bulkhead, deck, tank top, etc., even if the free edge of brackets is curved, *l* is to be measured to the toe of the bracket.

(4) Brackets are not to be considered effective beyond the point where the arm along the girder is 1.5 *times* the length of the arm on the bulkhead, deck, tank top, etc.

(5) In no case is the modification of *l* at either end to exceed one-quarter of the overall length of the girder including the parts of end connection.

1.3.9 Equipment

Mooring and anchoring arrangements, towing apparatus and other fittings for which there are no particular requirements in this Part are to be of appropriate construction and arrangement suitable for their respective purposes; and tests are to be carried out to the satisfaction of the Surveyor, where deemed necessary.

1.3.10 Carriage of Oil or Other Flammable Liquid Substances

1 The requirements for construction and arrangement of ships for the carriage of fuel oils specified in this Part apply to ships carrying fuel oils having a flashpoint not less than 60°*C* determined by a closed cup test.

2 The construction and arrangement of ships for the carriage of fuel oils having a flashpoint less than 60°*C* determined by a closed cup test, are to be in accordance with the requirements provided in this Chapter, as well as other requirements deemed necessary by the Society.

3 In ships of not less than 400 *gross tonnage*, oils or other flammable liquid substances are not to be carried in compartments forward of the collision bulkhead.

1.3.11 Lightening Holes

Sizes of lightening holes of girders are to be as follows:

Girder with slot: $d \leq \dfrac{d_G}{4}$

Girder without slot: $d \leq \frac{d_G}{3}$

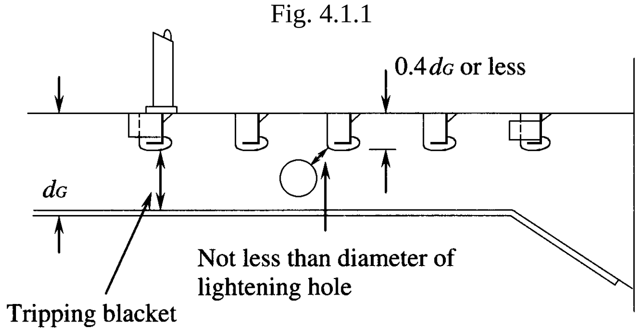
Where:

d_G : Depth of girder

d : Diameter of lightening hole

No lightening hole is to be provided near the toes of brackets or under pillars where shearing force is augmented. The distance between the lightening hole and slot is not to be less than the diameter of the lightening hole. (*See* **Fig. 4.1.1**)

Fig. 4.1.1



Chapter 2 RUDDERS AND STERN FRAMES

2.1 Rudders

2.1.1 Application

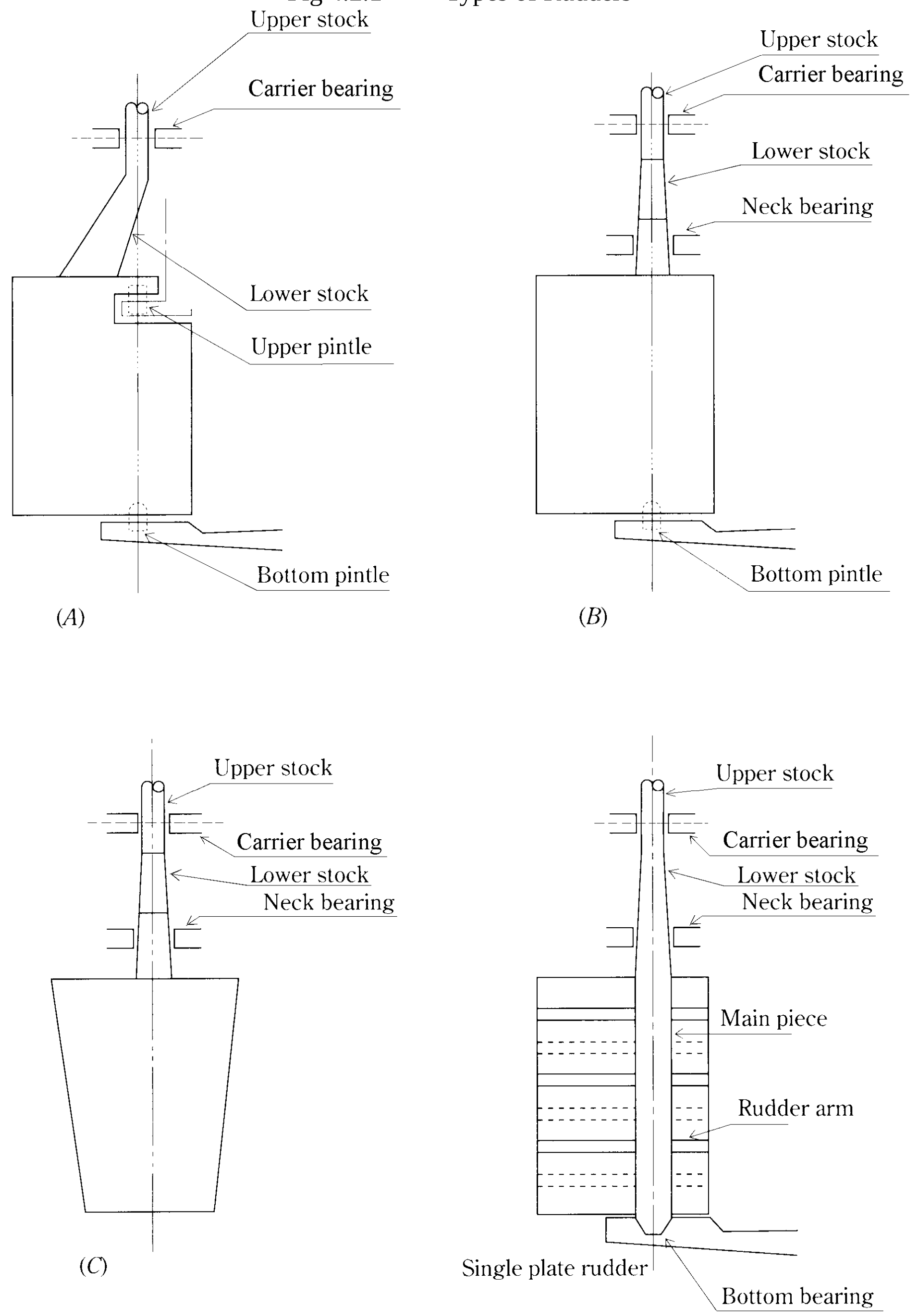
1 The requirements in this Chapter apply to double plate rudders of stream line section and ordinary shape, being divided into the following types, and single plate rudders.

(1) Type *A*: Rudders with upper and bottom pintles (*See* **Fig. 4.2.1** (*A*))

(2) Type *B*: Rudders with neck bearing and bottom pintle (*See* **Fig. 4.2.1** (*B*))

(3) Type *C*: Rudders having no bearing below the neck bearing (*See* **Fig. 4.2.1** (*C*))

Fig 4.2.1 Types of Rudders



2 The construction of rudders having three or more pintles and of those having special shape or sectional form will be specially considered by the Society.

3 The construction of rudders designed to move more than 35 *degrees* on each side will be specially considered by the Society.

2.1.2 Materials

1 For rudder stocks, pintles, coupling bolts, keys, and edge bars, the minimum yield stress is not to be less than 200 N/mm^2. The requirements in this Chapter are for materials with a yield stress of 235 N/mm^2. If materials having a yield stress differing from 235 N/mm^2 are used, the material factor K is to be determined by the following formula.

$$K = \left[\frac{235}{\sigma_Y}\right]^e$$

Where:

e : 0.75 for $\sigma_Y > 235$ N/mm^2

e : 1.00 for $\sigma_Y \le 235$ N/mm^2

Where:

σ_Y : Yield stress (N/mm^2) of material used, and is not to be taken as greater than $0.7\sigma_B$ or 450 N/mm^2, whichever is the smaller

σ_B : Tensile strength (N/mm^2) of material used

2 When the rudder stock diameter is reduced because of using 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 the edge of bearings.

2.1.3 Sleeves and bushes

Bearings located up to well above the designed maximum load line are to be provided with sleeves and bushes.

2.1.4 Rudder Force

The rudder force F_R is used to determine the rudder scantlings and is obtained from the following formula, for ahead and astern conditions. 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)

When the speed is less than 10 *knots*, V is to be replaced by V_{min} determined 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.

$$V_a = 0.5V \quad (kt)$$

Where:

K_1 : Factor depending on the aspect ratio Λ of the rudder area obtained from the following formula.

$$K_1 = \frac{\Lambda + 2}{3}$$

Where:

Λ : As obtained from the following formula

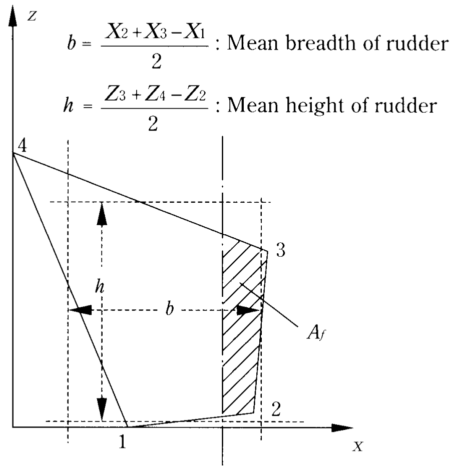
However, Λ is not required to be greater than 2.

$$\Lambda = \frac{h^2}{A_t}$$

Where:

h : Mean height of rudder (m), which is determined according to the coordinate system in **Fig. 4.2.2**

Fig. 4.2.2 Coordinate system of rudders



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 type of rudder profile (*See* **Table 4.2.1**)

Table 4.2.1 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

K_3 : Factor depending on the location of rudder, as specified below:

For rudders outside the propeller jet … 0.8

For rudders behind a fixed propeller nozzle … 1.15

Otherwise … 1.0

2.1.5 Rudder Torque

1 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.

$T_R = F_R r$ (*N-m*)

Where:

F_R : As specified in **2.1.4**

r : Distance (*m*) from the centre of the rudder force on the rudder to the centreline of the rudder stock, determined by the following formula

$r = b(\alpha - e)$

For the ahead condition, r is not to be less than r_{min} obtained from the following formula.

$r_{min} = 0.1b$ (m)

Where:

b : Mean breadth (*m*) of rudder determined by the coordinate system in **Fig. 4.2.2**

α : To be as follows:

For ahead condition: 0.33

For astern condition: 0.66

e : Balance factor of the rudder obtained from the following formula.

$$e = \frac{A_f}{A}$$

Where:

A_f : Portion of the rudder plate area (m^2) situated ahead of the centreline of the rudder stock

A : As specified in **2.1.4**

2 The rudder torque T_R of Type A rudders is to be obtained for the ahead and astern condition, respectively, according to the following formula:

$$T_R = T_{R1} + T_{R2} \quad (N\text{-}m)$$

For the ahead condition, T_R is not to be less than T_{Rmin} obtained from the following formula:

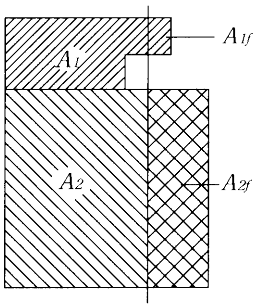
$$T_{Rmin} = 0.1 F_R \frac{A_1 b_1 + A_2 b_2}{A} \quad (N\text{-}m)$$

Where:

T_{R1} and T_{R2} : Rudder torque (N-m) of portions A_1 and A_2, respectively

A_1 and A_2 : Areas of respective rectangles (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. 4.2.3**

Fig. 4.2.3 Division of rudder



b_1 and b_2 : Mean breadth (m) of portions A_1 and A_2 respectively determined by applying **Fig. 4.2.3**

F_R and A : As specified in **2.1.4**

T_{R1} and T_{R2}, the rudder torque of portions A_1 and A_2 respectively, are to be obtained from the following formulae.

$$T_{R1} = F_{R1} r_1 \quad (N\text{-}m)$$

$$T_{R2} = F_{R2} r_2 \quad (N\text{-}m)$$

F_{R1} and F_{R2}, the rudder force of portions A_1 and A_2, are to be obtained from the following formulae.

$$F_{R1} = F_R \frac{A_1}{A} \quad (N)$$

$$F_{R2} = F_R \frac{A_2}{A} \quad (N)$$

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, are to be determined from the following formulae.

$$r_1 = b_1(\alpha - e_1) \quad (m)$$

$$r_2 = b_2(\alpha - e_2) \quad (m)$$

e_1 and e_2, the balance factors of portions A_1 and A_2 respectively, are to be determined from the following formulae.

$$e_1 = \frac{A_{1f}}{A_1}, \quad e_2 = \frac{A_{2f}}{A_2}$$

α is to be as follows:

For parts of a rudder not behind a fixed structure such as the rudder horn:

For ahead condition: 0.33

For astern condition: 0.66

For parts of a rudder behind a fixed structure such as the rudder horn:

For ahead condition: 0.25

For astern condition: 0.55

2.1.6 Rudder Strength Calculation

1 The rudder strength is to be sufficient to withstand the rudder force and rudder torque as given in **2.1.4** and **2.1.5**. 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 direct calculation or by a simplified approximation method as deemed appropriate by the Society.

2.1.7 Upper Stocks

The diameter d_u of the upper stock, which is the stock above the bearing centre of the rudder carrier required for the transmission of the rudder torque, is to be determined such that torsional stress does not exceed 68 (N/mm^2).

Considering this, the diameter of the upper stock may be determined by the following formula:

$$d_u = 4.2\sqrt[3]{T_R K_S} \quad (mm)$$

Where:

T_R : As specified in **2.1.5**

K_S : Material factor for rudder stock, as given in **2.1.2**

2.1.8 Lower Stocks

The diameter d_l of the lower stock, which is the stock below the bearing centre of the rudder carrier subject to the combined forces of torque and bending moment, is to be determined such that the equivalent stress in the rudder stock does not exceed 118 (N/mm^2).

The equivalent stress σ_e is to be obtained from the following formula.

$$\sigma_e = \sqrt{\sigma_b{}^2 + 3\tau_t{}^2} \quad (N/mm^2)$$

The bending stress and torsional stress acting on the lower stock are to be determined as follows:

Bending stress: $\sigma_b = \dfrac{10.2M}{d_l{}^3} \times 10^3 \quad (N/mm^2)$

Torsional stress: $\tau_t = \dfrac{5.1T_R}{d_l{}^3} \times 10^3 \quad (N/mm^2)$

Where:

M : Bending moment (N-m) at the section of rudder stock considered

T_R : As specified in **2.1.5**

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 : Diameter of upper stock (mm) as given in **2.1.7**

2.1.9 Rudder Plates, Rudder Frames and Rudder Main Pieces of Double Plate Rudders

1 The rudder plate thickness t is not to be less than that obtained from the following formula:

$$t = 5.5S\beta\sqrt{\left(d + \frac{F_R \times 10^{-4}}{A}\right)K_{p1}} + 2.5 \quad (mm)$$

Where:

A and F_R : As specified in **2.1.4**

K_{p1} : Material factor for rudder plate as given in **2.1.2**

β : To be obtained from the following formula:

$$\beta = \sqrt{1.1 - 0.5\left(\frac{S}{a}\right)^2} \quad \mathit{maximum}\ 1.0\ \left(\frac{a}{S} \geq 2.5\right)$$

Where:

S : Spacing (m) of horizontal or vertical rudder frames, whichever is smaller

a : Spacing (m) of horizontal or vertical rudder frames, whichever is greater

2 The rudder body is to be stiffened by horizontal and vertical rudder frames enabling it to withstand bending like a girder.

3 The standard spacing of horizontal rudder frames is to be obtained from the following formula:

$$0.2\left(\frac{L}{100}\right) + 0.4 \quad (m)$$

4 The standard distance from the vertical rudder frame forming the rudder main piece to the adjacent vertical frame is to be 1.5 *times* the spacing of horizontal rudder frames.

5 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 **-1** above, whichever is greater.

6 Vertical rudder frames forming the rudder main piece are to be arranged forward and afterward of the centreline of the rudder stock at a distance approximately equal to the thickness of the rudder if the main piece consists of two rudder frames, or at the centreline of the rudder stock if the main piece consists of one rudder frame.

7 The section modulus of the main piece is to be calculated in conjunction with the vertical rudder frames specified in **-1** above and the rudder plates attached thereto. The breadth of the rudder plates normally taken for the calculation is to be as follows:

(1) Where the main piece consists of two rudder frames, the breadth is 0.2 *times* the length of the main piece.

(2) Where the main piece consists of one rudder frame, the breadth 0.16 *times* the length of the main piece.

8 The section modulus and the web area of a horizontal section of the main piece are to be determined so that bending stress, shear stress and equivalent stress should not exceed the following stresses, respectively.

Bending stress: $\sigma_b = \frac{110}{K_m} \quad (N/mm^2)$

Shear stress: $\tau = \frac{50}{K_m} \quad (N/mm^2)$

Equivalent stress: $\sigma_e = \sqrt{\sigma_b^2 + 3\tau^2} = \frac{120}{K_m} \quad (N/mm^2)$

In the case of a Type *A* rudder, however, the section modulus and the web area of a horizontal section of the main piece in way of cut-outs are to be determined so that bending stress, shear stress and equivalent stress should not exceed the following stresses, respectively.

Bending stress: $\sigma_b = \frac{75}{K_m} \quad (N/mm^2)$

Shear stress: $\tau = \frac{50}{K_m} \quad (N/mm^2)$

Equivalent stress: $\sigma_e = \sqrt{\sigma_b^2 + 3\tau^2} = \frac{100}{K_m} \quad (N/mm^2)$

Where:

K_m : Material factor for the rudder main piece as given in **2.1.2**

9 The upper part of the main piece is to be so constructed as to avoid structural discontinuity.

10 The maintenance openings and the rudder plate cut-out of Type *A* rudders are to be rounded off properly.

11 Rudder plates are to be effectively connected to rudder frames, free from defects, with due attention paid to the workmanship.

12 The internal surfaces of rudders are to be coated with effective paint, and a means for draining is to be provided at the bottom of the rudders.

2.1.10 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:

$$t = 1.5SV\sqrt{K_{p1}} + 2.5 \quad (mm)$$

Where:

S : Spacing (m) of rudder arms, not to exceed 1 (m)

V : Ship speed (kt) as specified in **2.1.4**

K_{p1} : Material factor for rudder plate as given in **2.1.2**

2 The thickness of rudder arms is not to be less than that of rudder plates.

3 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.

$$0.5SC_1^2V^2K_a \quad (cm^3)$$

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 **2.1.2**

S and V : As specified in **-1** above

4 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, 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.

2.1.11 Couplings between Rudder Stocks and Main Pieces

1 When a rudder stock is connected with a main piece by horizontal flange coupling, the following requirements are to be complied with.

(1) Coupling bolts are to be reamer bolts, and at least 6 reamer bolts are to be provided in each coupling.

(2) The diameter of coupling bolts d_b is not to be less than the dimension obtained from the following formula:

$$d_b = 0.62\sqrt{\frac{d^3K_b}{ne_mK_S}} \quad (mm)$$

Where:

d : Stock diameter (mm), the greater of the diameters d_u or d_l according to **2.1.7** and **2.1.8**

n : Total number of bolts

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 **2.1.2**

K_b : Material factor for the bolts as given in **2.1.2**

(3) The nuts of the coupling bolts are to be provided with efficient locking devices.

(4) The thickness of the coupling flanges t_f is not to be less than that determined by the following formula, provided that the thickness is not less than $0.9d_b$ (mm).

$$t_f = d_b\sqrt{\frac{K_f}{K_b}} \quad (mm)$$

Where:

K_f : Material factor for flange as given in **2.1.2**

K_b : As specified in **(2)**

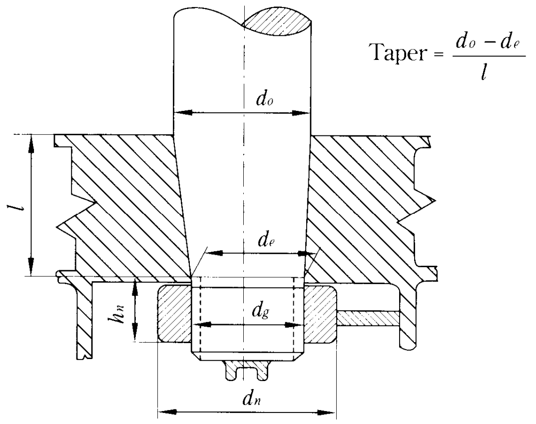
d_b : Bolt diameter (mm), according to **(2)**, determined by a number of bolts not exceeding 8

(5) The width of material outside the bolt holes of the coupling flanges is not to be less than $0.67d_b$ (mm).

2 When a rudder stock is connected with a main piece by cone coupling, the following requirements are to be complied with.

(1) Cone couplings that are mounted or dismounted without hydraulic arrangements (*e.g.* oil injection and hydraulic nut) are to be tapered 1:8 ~ 1:12 of the diameter (*See* **Fig. 4.2.4**). For rudder stocks fitted into the rudder plate and secured by the slugging nut, the taper length l is generally not to be less than 1.5 *times* the rudder stock diameter d_0 at the top of the rudder. In this case, for couplings between stock and rudder, a key is to be provided. The scantling of the key is to be to the discretion of the Society.

Fig. 4.2.4 Cone coupling



(2) The dimensions of the slugging nut as specified in **(1)** are to be as follows (*See* **Fig. 4.2.4**):

External thread diameter: $d_g \geq 0.65 d_0$ (mm)

Length of nut: $h_n \geq 0.6 d_g$ (mm)

Outside diameter of nut: $d_n \geq 1.2 d_e$ or $1.5 d_g$ (mm), whichever is greater

(3) Notwithstanding the provisions in **(1)** above, where a key is fitted to couplings between stocks and rudders, and it is considered that rudder torque is transmitted by friction at the couplings, the scantlings of the key as well as push-up force and push-up length are to be at the discretion of the Society .

(4) Cone couplings that are mounted or dismounted with hydraulic arrangements (*e.g.* oil injection and hydraulic nut) are to have a taper on the diameter of 1:12 to 1:20 (*See* **Fig. 4.2.4**).

The push-up force and the push-up length are to be to the discretion of the Society.

(5) The nuts fixing the rudder stocks are to be provided with efficient locking devices.

(6) Couplings of rudder stocks are to be properly protected from corrosion.

3 When a rudder stock is connected with a main piece by vertical flange coupling, the following requirements are to be complied with.

(1) Coupling bolts are to be reamer bolts, and at least 8 reamer bolts are to be used in each coupling.

(2) The diameter of the coupling bolts d_b is not to be less than the dimension obtained from the following formula.

$$d_b = \frac{0.81 d}{\sqrt{n}} \sqrt{\frac{K_b}{K_S}} \quad (mm)$$

Where:

d : Stock diameter (mm), the greater of the diameters d_u or d_l according to **2.1.7** and **2.1.8**

n : Number of bolts

K_b : Material factor for bolts as given in **2.1.2**

K_S : Material factor for the rudder stock as given in **2.1.2**

(3) The nuts of the coupling bolts are to be provided with efficient locking devices.

(4) The first moment of area M of the bolts about the centreline of the coupling flange is not to be less than the value obtained from the following formula:

$$M = 0.00043 d^3 \quad (cm^3)$$

(5) The thickness of the coupling flanges is not to be less than the bolt diameter.

(6) The width of the flange material outside the bolt holes is not to be less than $0.67 d_b$ (mm).

2.1.12 Pintles

1 The diameter of pintles d_p is not to be less than the dimension obtained from the following formula.

$$d_p = 0.35 \sqrt{B K_p} \quad (mm)$$

Where:

B : Reaction force in bearing (N)

K_p : Material factor for pintles as given in **2.1.2**

2 Pintles are to be constructed as taper bolts with a taper on the diameter not exceeding the following values, and capable of being fitted to the cast parts of the rudders. The nuts fixing the pintles are to be provided with efficient locking devices.

(1) For pintles to be assembled and locked with slugging nuts: 1:8 to 1:12

(2) For pintles mounted with hydraulic arrangements (*e.g.* oil injection and hydraulic nut): 1:12 to 1:20

3 The minimum dimensions of the threads and the nuts of pintles are to be determined by applying the requirements in **2.1.11-2(2)** correspondingly.

4 The taper length of the pintle is not to be less than the maximum actual diameter of the pintle.

5 Pintles are to be properly protected from corrosion.

2.1.13 Bearings of Rudder Stocks and Pintles

1 The bearing surface A_b (defined as the projected area: *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 **2.1.12**

q_a : Allowable surface pressure (N/mm^2)

The allowable surface pressure for the various bearing combinations is to be taken from **Table 4.2.2**. When verified by tests, however, values different from those in this Table may be taken.

Table 4.2.2 Allowable surface pressure q_a

Bearing material	q_a (N/mm^2)
Lignum vitae	2.5
White metal(oil-lubricated)	4.5
Synthetic material with hardness between 60 and 70, Shore *D* (Note 1)	5.5
Steel (Note 2), bronze and hot-pressed bronze-graphite materials	7.0

Notes:

1. Indentation hardness test at the temperature of 23°*C* and the humidity of 50%, according to a recognized standard. Synthetic bearings are to be of the type as deemed appropriate by the Society.
2. Stainless and wear-resistant steel in an approved combination with a stock liner.

2 The length/diameter ratio of the bearing surface is not to be less than 1.0. However, the ratio is not to be greater than 1.2 unless specially approved by the Society.

3 With metal bearings, the diameter of clearances (*mm*) is not to be less than the dimension obtained from the formula below.

If non-metallic bearing material is used, the bearing clearance is to be specially determined considering the material’s swelling and thermal expansion properties. This clearance is not to be taken as less than 1.5 *mm* on the bearing diameter unless a smaller clearance is supported by the manufacturer’s recommendation and there is documented evidence of satisfactory service history with a reduced clearance.

$$d_{bs}/1000 + 1.0 \quad (mm)$$

d_{bs} is the internal diameter of the bush (*mm*)

2.1.14 Rudder Accessories

1 Suitable rudder carriers are to be provided according to the form and the weight of the rudder, and care is to be taken to provide efficient lubrication at the support.

2 A suitable arrangement is to be provided to prevent the rudder from jumping.

2.2 Stern Frames

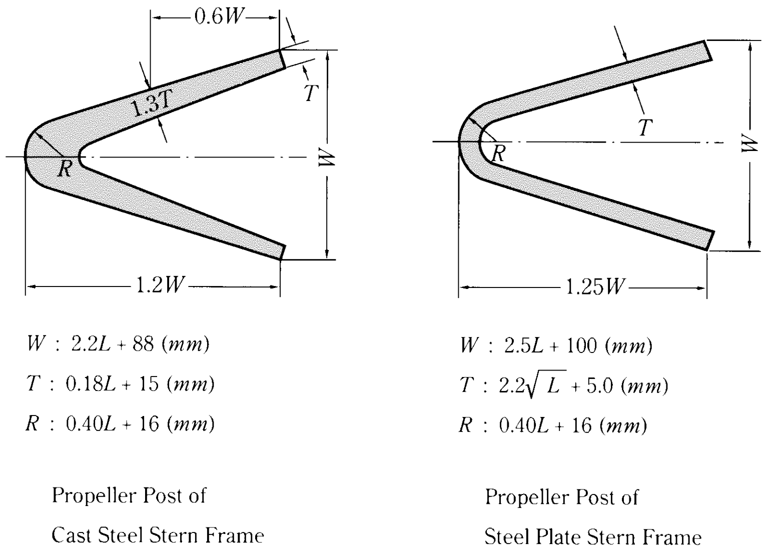
2.2.1 Application

The requirements in **2.2** apply only to stern frames without rudder post.

2.2.2 Propeller Posts

1 Propeller posts of cast steel stern frames and those of steel plate stern frames are to be of a shape suitable for the stream line at the after part of the hull, and the standard scantlings are given by the formulae and figures in **Fig. 4.2.5**. Below the propeller boss, the breadth and thickness of the propeller post are to be gradually increased in order to provide sufficient strength and stiffness in proportion to the shoe pieces.

Fig. 4.2.5 Standard Dimensions of Propeller Posts



2 The thickness of the boss of the propeller post is not to be less than that obtained from the following formula:

$0.9L + 10$ (*mm*)

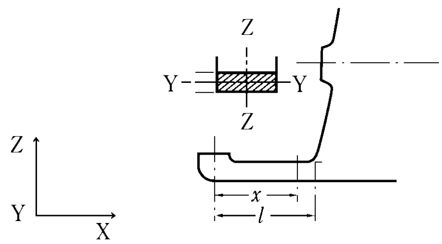
3 The propeller posts of cast steel stern frames and those of steel plate stern frames are to be provided with ribs at a suitable interval. Where the radius of curvature is large, a centre line stiffener is to be provided.

4 For ships with relatively high speed for their length, the scantlings of various parts of propeller posts are to be suitably increased.

2.2.3 Shoe Pieces

1 The scantling of each cross-section of the shoe piece (*See* **Fig. 4.2.6**) is to be determined by the following formulae **(1)** to **(4)**, considering the bending moment and shear force acting on the shoe piece when the rudder force specified in **2.1.4** is applied to the rudder.

Fig. 4.2.6 Shoe piece



(1) The section modulus Z_Z around the vertical Z-axis is not to be less than:

$$Z_Z = \frac{MK_{sp}}{80} \quad (cm^3)$$

Where:

M : Bending moment (*N-m*) at the section considered, which is obtained from the following formula

$M = Bx \ (M_{max} = Bl)$

Where:

B : Supporting force (*N*) in the pintle bearing as given in **2.1.6**.

x : Distance (*m*) from the mid-point of the pintle bearing to the section considered, as specified in **Fig. 4.2.6**

l : Distance (*m*) from the mid-point of the pintle bearing to the fixed point of the shoe piece, as specified in **Fig. 4.2.6**

K_{sp} :Material factor for the shoe piece as given in **3.1.2**

(2) The section modulus Z_Y around the transverse *Y*-axis is not to be less than:

$$Z_Y = 0.5Z_Z \quad (cm^3)$$

Where:

Z_Z : As specified in **(1)**

(3) The total section area A_s of the members in the Y-direction is not to be less than:

$$A_s = \frac{BK_{sp}}{48} \quad (mm^2)$$

Where:

B and K_{sp} : As specified in **(1)**

(4) At no section within length *l* is the equivalent stress to exceed 115 (N/mm^2).
The equivalent stress σ_e is to be obtained from the following formula:

$$\sigma_e = \sqrt{\sigma_b^2 + 3\tau^2} \quad (N/mm^2)$$

The bending stress and the shear stress acting on the shoe piece are to be obtained from the following formulae respectively:

Bending stress: $$\sigma_b = \frac{M}{Z_Z(x)} \quad (N/mm^2)$$

Shear stress: $$\tau = \frac{B}{A_S} \quad (N/mm^2)$$

Where:

Z_Z, A_S, M, and B : As specified in **(1)** to **(3)**

2 The thickness of the steel plates forming the main part of the shoe piece of steel plate stern frame is not to be less than that of the steel plates forming the main part of the propeller post. Ribs are to be arranged in the shoe piece below the propeller post, under brackets and at other suitable positions.

2.2.4 Heel Pieces

The heel piece of the stern frame is to be of a length at least 3 *times* the frame space at that part and is to be strongly connected to the keel.

2.2.5 Attachment of Stern Frame to Floor Plates

The stern frame is to be sufficiently extended upward at the part of the propeller post and connected securely to the transom floor of a thickness not less than the value obtained from the following formula. At the upper part of the extended stern frame, the transom floor is to be reinforced to avoid a sudden change in stiffness.

$0.035\,L + 10.0$ (*mm*)

2.2.6 Gudgeons

1 The depth of gudgeons is not to be less than the length of the pintle bearing.

2 The thickness of the gudgeon is not to be less than $0.25d_{p0}$.

Where:

d_{p0} :Actual diameter (*mm*) of the pintle measured at the outer surface of the sleeve

Chapter 3 BOTTOM STRUCTURES

3.1 Single Bottoms

3.1.1 Centre Girder

1 All single bottom ships are to have centre girder composed of continuous web plates in association with face plates, and the centre girder is to extend as far forward and afterward as practicable.

2 The thickness of web plates is not to be less than that obtained from the following formula. Beyond the midship part, the thickness may be gradually reduced to 0.85 *times* the midship value at the end parts of the ship.

$$4.7 + 0.059L \quad (mm)$$

3 The height of web plates is not to be less than that of floors.

4 The thickness of face plates is not to be less than the thickness of web plates amidships and the sectional area of face plates is not to be less than that obtained from the following formula. Beyond the midship part, the thickness may be gradually reduced to 0.85 *times* the midship value at the end parts of the ship.

$$0.2L + 5 \quad (cm^2)$$

3.1.2 Side Girders

1 Side girders are to be so arranged that their spacing is not more than 2.5 *m* between the centre girder and the side shell plating.

2 The side girders are to be composed of continuous web plates in association with face plates, and they are to extend as far forward and afterward as practicable.

3 The thickness of web plates is not to be less than that obtained from the following formula. Beyond the midship part, the thickness may be gradually reduced to 0.85 *times* the midship value at the end parts of the ship.

$$5.2 + 0.038L \quad (mm)$$

4 The thickness of web plates in the engine space is not to be less than that required in **3.1.1-2**.

5 The thickness of face plates is not to be less than that required for the web plates, and the sectional area of face plates amidships is not to be less than that obtained from the following formula. Beyond the midship part, the sectional area may be gradually reduced to 0.85 *times* the midship value at the end parts of the ship.

$$0.16L + 5 \quad (cm^2)$$

3.1.3 Floor Plates

1 In ships with the bottom of transverse framing, the standard spacing of floors is as stipulated in **4.2.1**.

2 In ships with the bottom of longitudinal framing, floors are to be so arranged that their spacing is not more than about 3.5 *m*.

3 Upper edges of floor plates at any part are not to be below the level of the upper edges at the centre line.

4 In the midship part, the depth of floors measured at a distance d_0 specified in **-5**, from the inner edge of the frames along the upper edge of floors is not to be less than $0.5d_0$. (*See* **Fig. 4.3.1**) Where frame brackets are provided, the depth of floors at the inner edge of brackets may be $0.5d_0$.

5 The scantlings of floor plates are not to be less than that obtained from the following formulae:

Depth at the centre line: $0.0625l$ (m)

Thickness: $9d_0+3.6$ (mm) or 11 *mm*, whichever is the smaller

Section modulus: $4.27Shl^2$ (cm^3)

Where:

S : Spacing (m) of floors

h : d (m) or $0.66D$ (m), whichever is the greater

l : Distance (m) between the toes of frame brackets plus 0.3 *m* measured at amidship

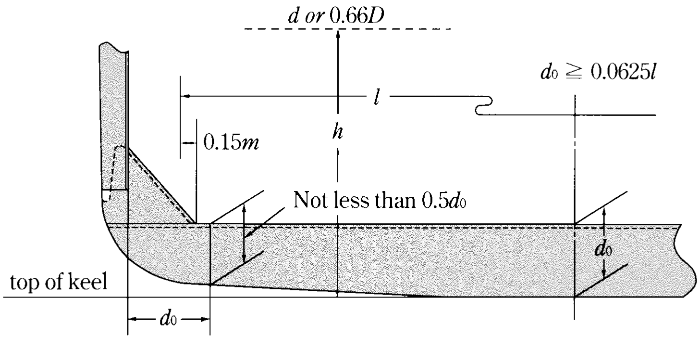
Where curved floors are provided, the length l may be suitably modified. (*See* **Fig. 4.3.1**)

6 The thickness of face plates on the floor plates is not to be less than that required for the floor plates, and the breadth of face plates is to be adequate for lateral stability of the floors.

7 Beyond 0.5L amidships, the thickness of floor plates may be gradually reduced to 0.85 *times* the value specified in **-5** at the end parts of the ship.

8 Floors under engines and thrust seats are to be of ample depth and to be especially strengthened. Their thickness is not to be less than that of the centre girder web plates.

Fig. 4.3.1 Shape of Floors



3.1.4 Bottom Longitudinals

1 The standard spacing of bottom longitudinals is obtained from the following formula:

$$2L + 550 \quad (mm)$$

2 The section modulus of bottom longitudinals is not to be less than that obtained from the following formula, and is not to be less than 24 cm^3:

$$7.2Shl^2 \quad (cm^3)$$

Where:

l : Spacing (m) of solid floors

S : Spacing (m) of bottom longitudinals

h : Vertical distance (m) from the longitudinals to a point of d + 0.026L above the top of the keel

3.2 Double Bottoms

3.2.1 General

1 No structural member of the double bottom construction is to be less than 5 *mm* in thickness.

2 Where the longitudinal system of framing is transformed into the transverse system, or depth of the double bottom changes suddenly, special care is to be taken for the continuity of strength by means of additional intercostal girders or floors.

3.2.2 Centre Girder

1 Centre girder is to extend as far forward and afterward as practicable.

2 The thickness of centre girder plate is not to be less than that obtained from the following formula:

$$0.05L + 5 \quad (mm)$$

3.2.3 Side Girders

1 Side girders in 0.5L amidships 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 side shell does not exceed 4.6 *m*, and to extend as far afterwards as practicable.

2 Adequate strengthening is to be made under main engines and thrust seatings by means of additional full or half-height girders.

3 The thickness of side girders or half-height girders is not to be less than that obtained from the following formula and in the engine room, the thickness is to be increased by 1.5 *mm*.

$$0.65\sqrt{L} + 1.5 \quad (mm)$$

3.2.4 Solid Floors

1 Solid floors are to be provided at a spacing not exceeding approximately 3.5 *m*.

2 In addition to complying with the requirements in **-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

3 The thickness of solid floors is not to be less than that obtained from the following formulae and in the engine room, the thickness is to be increased by 1.5 *mm*.

In ships with transverse framing: $0.6\sqrt{L}+1.5$ (mm)

In ships with longitudinal framing: $0.7\sqrt{L}+1.5$ (mm)

4 Vertical stiffeners are to be provided at a suitable spacing on solid floors when the double bottom is framed transversely, and at every longitudinal when the double bottom is framed longitudinally.

3.2.5 Open Floors

1 Where the double bottom is framed transversely, open floors are to be provided at every frame between solid floors in accordance with the requirements in **3.2.5**.

2 The section modulus of frames is not to be less than that obtained from the following formula:

$6Shl^2$ (cm^3)

Where:

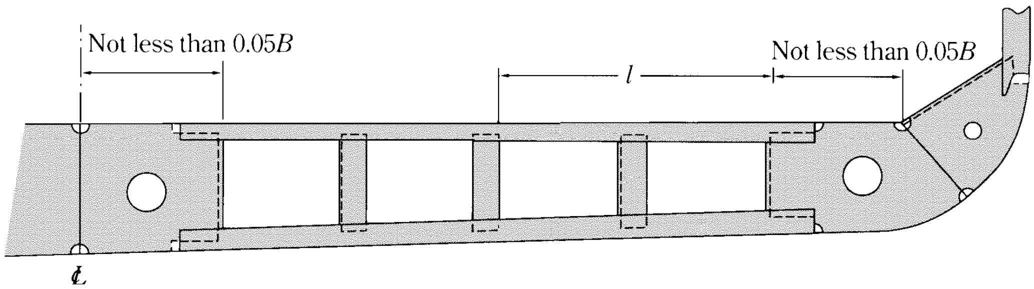
l : Distance (m) between the brackets attached to the centre girder and the margin plate
Where side girders are provided, l is the greatest distance among the distance between the vertical stiffeners on side girders and the brackets. (*See* **Fig. 4.3.2**)

S : Spacing (m) of frames

h : $d + 0.026L$ (m)

3 The section modulus of reverse frames is not to be less than that obtained from the formula in **-2** equal to 0.85 *times* the value specified for frames at the same location.

Fig. 4.3.2 Open Floors



3.2.6 Longitudinals

1 The standard spacing of longitudinals is obtained from the following formula:

$2L+550$ (mm)

2 The section modulus of bottom longitudinals is not to be less than that obtained from the following formula, and is not to be less than 24 cm^3:

$6.88Shl^2$ (cm^3)

Where:

l : Spacing (m) of solid floors

S : Spacing (m) of longitudinals

h : Vertical distance (m) from the longitudinals to a point of d + 0.026L above the top of the keel

3 The section modulus of inner bottom longitudinals is not to be less than that obtained from the formula in **-2** equal to 0.85 *times* the value specified for bottom longitudinals at the same location.

3.2.7 Inner Bottom Plating

The thickness of the inner bottom plating is not to be less than that obtained from the following formula:

$$3.8S\sqrt{d}+1.5 \quad (mm)$$

Where:

S : Spacing (m) of inner bottom longitudinals for longitudinally framed inner bottom plating, or spacing (m) of floor plates for transversely framed inner bottom plating

Chapter 4　FRAMES

4.1 General

4.1.1 Application

The requirements in this Chapter apply to ships having sufficient transverse strength and transverse stiffness due to bulkheads. Where transverse strength and transverse stiffness provided by bulkheads is not sufficient, additional stiffening is to be made by means of increasing scantlings of frames, provision of web frames, etc.

4.1.2 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.

4.2 Frame Spacing

4.2.1 Transverse Frame Spacing

1 The standard spacing of transverse frame is obtained from the following formula:

$$450 + 2L \quad (mm)$$

2 Transverse frame spacing in fore and aft peaks as well as between $0.2L$ from the fore end and the collision bulkhead is not to exceed 610 *mm* or the standard spacing specified in **-1**, whichever is smaller.

3 The requirements in **-2** may be modified, where structural arrangement or scantlings are suitably considered.

4.2.2 Longitudinal Frame Spacing

The standard spacing of longitudinal frames is obtained from the following formula:

$$550 + 2L \quad (mm)$$

4.2.3 Consideration for Frame Spacing Exceeding the Standard

Where the spacing of frames is equal to or above 170 *mm* plus the standard spacing specified in **4.2.1** and **4.2.2**, the scantlings and structural arrangement of single and double bottoms and of other relevant structures are to be specially considered.

4.3 Transverse Frames

4.3.1 Transverse Frames below Freeboard Deck

The section modulus of transverse frames below the freeboard deck is not to be less than that obtained from the following formula, and is not to be less than 24 cm^3.

$$2.08Shl^2 \quad (cm^3)$$

S : Frame spacing (m)

l : Vertical distance (m) from the top of inner bottom plating or single bottom floors at side to the top of deck beams above the frames

h : Vertical distance (m) from the lower end of the hold frame to a point of $d + 0.044L - 0.54$ above the top of the keel

4.3.2 Superstructure Frames

1 The section modulus of superstructure frames is not to be less than that obtained from the following formula, and is not to be less than 24 cm^3.

$$0.35SlL \quad (cm^3)$$

Where:

S : Frame spacing (m)

l : Tween deck height (m)

However, the height is to be taken as 1.8 *m* where it is less than 1.8 *m*.

2 In the design of tween deck framing, considerations are to be given to the continuity of strength in the framing from the bottom to the top of the hull.

3 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.

4.4 Side Longitudinals and Other Structural Members

4.4.1 Side Longitudinals

1 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 formulae, whichever is greater, and is not to be less than 24 cm^3.

$$6.88Shl^2 \quad (cm^3)$$

$$2.32\sqrt{L}Sl^2 \quad (cm^3)$$

Where:

S : Spacing (*m*) of longitudinals

l : Distance (*m*) between the web frames or between the transverse bulkhead and the web frame including the length of connection

h : Vertical distance (*m*) from the longitudinals to a point of d + 0.044L - 0.54 above the top of the keel

2 Beyond the midship part, the section modulus of side longitudinals may be gradually reduced towards the ends of the ship, and may be 0.85 *times* that obtained from the formula in **-1** at the ends.

3 The section modulus of bilge longitudinals need not exceed that required for bottom longitudinals.

4.4.2 Web Frames

1 The web frames supporting side longitudinals are to be arranged at an interval not exceeding 4.8 *m* at sections where solid floors are provided.

2 The scantlings of web frames are not to be less than that obtained from the following formulae:

Depth: 0.1l (*m*) or 2.5 *times* the depth of the slots for longitudinals, whichever is greater

Section modulus: $4.7Shl^2 \quad (cm^3)$

Thickness of web: $0.045\dfrac{Shl}{d_1}+2.5 \quad (mm)$

Where:

S : Web frame spacing (*m*)

l : Vertical distance (*m*) from the top of inner bottom plating or single bottom floors at side to the deck at the top of web frames

However, where there are effective deck transverses, l may be measured up to the lower surface of such transverses.

d_1 : Depth (*m*) of web frames

However, the depth of slots for side longitudinals is to be deducted from the web depth.

h : Vertical distance (*m*) measured from the lower end of l to a point of d + 0.044L - 0.54 above the top of the keel

However, the distance is to be taken as 1.43l where it is less than 1.43l.

Chapter 5 BEAMS

5.1 General

5.1.1 Camber of Weather Deck

The standard camber of weather deck is B/50 at the midship.

5.1.2 End Connection 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 uphold the sectional area and to have sufficient strength to withstand 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.

5.1.3 Parts where Longitudinal Beams are transformed to Transverse Beams

In the parts where the longitudinal beams are transformed to the transverse beams, special care is to be taken to keep the continuity of strength.

5.2 Longitudinal Beams

5.2.1 Spacing

The standard spacing of longitudinal beams is obtained from the following formula:

$$2L + 550 \quad (mm)$$

5.2.2 Proportion

1 Longitudinal beams are to be supported by deck transverses of appropriate spacing. In strength deck of midship part are to be of slenderness ratio not greater than 60. However, this requirement may be suitably modified where longitudinal beams are given a sufficient strength to prevent buckling.

2 The depth of flat bars used for longitudinal beams is not to exceed 15 *times* the thickness of flat bars.

5.2.3 Section Modulus of Longitudinal Beams

1 The section modulus of longitudinal beams on the strength deck of the midship part is not to be less than that obtained from the following formula:

$$0.97Shl^2 \quad (cm^3)$$

Where:

S : Spacing (m) of longitudinal beams

h : Deck loads (kN/m^2) specified in **12.2**

l : Horizontal distance (m) between bulkhead and deck transverse or between deck transverses

2 Beyond the midship part, the section modulus of longitudinal beams on strength decks may be gradually reduced, but the section modulus is not to be less than that obtained from the following formula:

$$0.37Shl^2 \quad (cm^3)$$

Where:

S, h and l : As specified in **-1**

3 The section modulus of longitudinal beams, except where specified in **-1** and **-2**, is not to be less than that obtained from the formula in above **-2**.

5.2.4 Deck Transverses Supporting Longitudinal Beams

In single deck ships, the deck transverse are to be provided in line with the solid floors in the bottom. In two deck ships, the transverses are also to be provided in line with the solid floors in the double bottom as far as is practicable.

5.3 Transverse Beams

5.3.1 Arrangement of Transverse Beams

Transverse beams are to be provided on every frame.

5.3.2 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 the hull) and superstructure decks as far as practicable.

5.3.3 Section Modulus of Transverse Beams

The section modulus of transverse beams is not to be less than that obtained from the following formula:

$0.37Shl^2 \quad (cm^3)$

Where:

S : Spacing (m) of transverse beams

h : Deck load (kN/m^2) specified in **12.2**

l : Horizontal distance (m) from the inner edge of beam brackets to the longitudinal deck girder, or between the longitudinal deck girders

5.4 Beams on Top of Deep Tanks

5.4.1 Section Modulus

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 **9.2.3**, taking the top of deck beams as the lower end of h and beams as stiffeners.

5.5 Deck Beams Supporting Especially Heavy Loads

5.5.1 Reinforcement of Deck Beams

The deck beams supporting especially heavy loads or arranged at the ends of superstructures or deckhouses, in way of windlasses and auxiliary machinery, etc. are to be properly reinforced by increasing the scantlings of the beams, or by the addition of deck girders or pillars.

Chapter 6 PILLARS

6.1 General

6.1.1 Tween Deck Pillars

Tween deck pillars are to be arranged directly above those in the holds, or effective means are to be provided for transmitting their loads to the supports below.

6.1.2 End Connection of Pillars

The head and heel of pillars are to be secured by thick doubling plates and brackets as necessary. For pillars which may be subject to tensile loads in locations such as under tunnel tops or deep tank tops, the head and heel of the pillars are to be efficiently secured to withstand these loads.

6.1.3 Reinforcement of Structures Connected to Pillars

Where the pillars are connected to the deck plating, the top of shaft tunnels, or the frames, those structures are to be efficiently strengthened.

6.2 Scantlings

6.2.1 Sectional Area of Pillars

The sectional area of pillars is not to be less than that obtained from the following formula:

$$\frac{0.223w}{2.72-\dfrac{l}{k_0}} \quad (cm^2)$$

Where:

l : Distance (m) 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 (*See* **Fig. 4.6.1**)

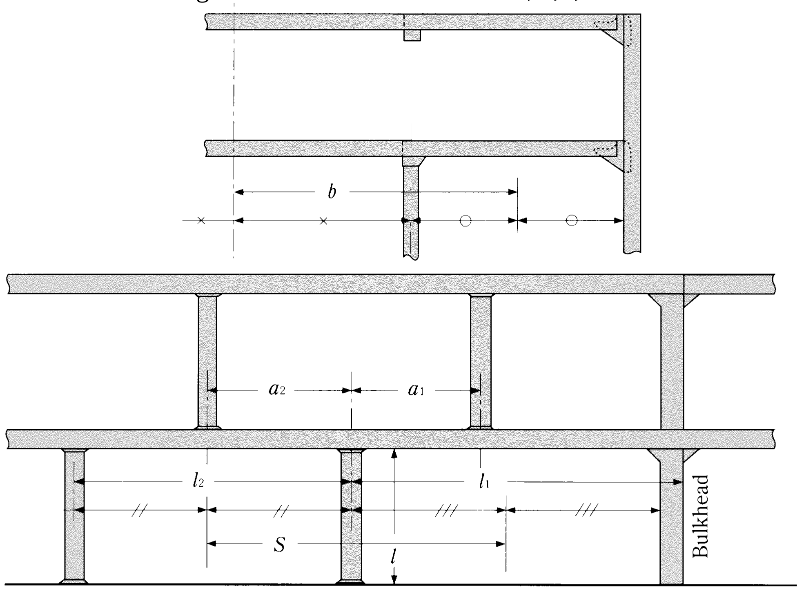
$$k_0=\sqrt{\frac{I}{A}}$$

I : The least moment of inertia (cm^4) of the pillar

A : Sectional area (cm^2) of the pillar

w : Deck load (kN) supported by pillars as specified in **6.2.2**

Fig. 4.6.1 Measurement of *S*, *b*, *l*, etc.



6.2.2 Deck Load Supported by Pillars

1 Deck load w supported by pillars is not to be less than that obtained from the following formula:

$$kw_0 + Sbh \quad (kN)$$

Where:

S : Distance (m) between the mid-points of two adjacent spans of girders supported by the pillars or the stiffeners or the girders on bulkheads (*See* **Fig. 4.6.1**)

b : Distance (m) between the mid-points of two adjacent spans of beams supported by the pillars or the beam brackets. (*See* **Fig. 4.6.1**)

h : Deck load (kN/m^2) specified in **12.2** for the deck under consideration

w_0 : Deck load (kN) supported by the upper tween deck pillar

k : As obtained from the following formula:

$$2\left(\frac{a_i}{l_j}\right)^3 - 3\left(\frac{a_i}{l_j}\right)^2 + 1$$

a_i : Horizontal distance (m) from the pillars to the tween deck pillars above

l_j : Span (m) of girder supporting the tween deck pillar or bulkhead (*See* **Fig.4.6.1**)

2 Where there are two or more tween deck pillars provided on the deck girder supported by a line of lower pillars, the lower pillars are to be of the scantling required in **-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 located athwartships from the lower pillars, the scantlings of the lower pillars are to be determined by applying the same principles asin **-1** and **-2**.

6.2.3 Thickness of Plates

1 The plate thickness of tubular pillars is not to be less than that obtained from the following formula:

$$0.022d_p + 4.6 \quad (mm)$$

d_p : Outside diameter (mm) of the tubular pillar.

However, this requirement may be suitably modified for pillars provided in accommodation spaces.

2 The thickness of web and flange plate of built-up pillars is to be sufficient for the prevention of local buckling.

6.2.4 Outside Diameters of Round Pillars

The outside diameter of solid round pillars and tubular pillars is not to be less than 50 *mm*.

6.2.5 Pillars provided in Deep Tanks

1 Pillars provided in deep tanks are not to be tubular pillars.

2 The scantlings of pillars installed in deep tanks are not to be less than that obtained from the formula in **6.2.1.**

6.3 Bulkheads in Lieu of Pillars

6.3.1 Construction

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 that required for pillars.

6.4 Casing provided in lieu of Pillars

6.4.1 Construction

The casings provided in lieu of pillars are to be of sufficient scantlings to withstand the deck load and side pressure.

Chapter 7 DECK GIRDERS

7.1 General

7.1.1 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.

7.1.2 Arrangement

In way of the top of tanks, deck girders are to be arranged at intervals not exceeding 4.6 *metres* as far as practicable.

7.1.3 Construction

1 Deck girders are to be composed of face plates provided along the lower edge.

2 Tripping brackets are to be provided at intervals 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:

$$85.4\sqrt{d_0 l} \quad (mm)$$

Where:

d_0 : Depth (m) of girders

l : Distance (m) between the supports of girders

However, where effective tripping brackets are provided, they may be taken as the supports.

4 The depth of girders between bulkheads is to be constant between two adjacent bulkheads, and not to be less than 2.5 *times* that of the slots for beams.

5 The girders are to have sufficient rigidity to prevent excessive deflection of decks and excessive additional stresses in deck beams.

7.1.4 End Connection

1 End connections of deck girders are to be in accordance with the requirements in **1.3.6**.

2 Bulkhead stiffeners or girders at the ends of deck girders are to be suitably strengthened to support deck girder.

3 Longitudinal deck girders are to be continuous or to be effectively connected so as to maintain the continuity at ends.

7.2 Longitudinal Deck Girders

7.2.1 Section Modulus of Girders

1 The section modulus of longitudinal deck girders of the strength deck for the midship part is not to be less than that obtained from the following formula:

$$1.1l(lbh + kw) \quad (cm^3)$$

Where:

l : Distance (m) between the centres of pillars or from the centre of the pillar to the bulkhead

Where the longitudinal deck girder is effectively bracketed to bulkhead, l may be modified as specified in **1.3.8**. (*See* **Fig. 4.7.1**)

b : Distance (m) between the mid-point of the distances between the girder in question and the girders or bulkheads located immediately both fpre and aft (*See* **Fig.4.7.1**)

h : Deck loads (kN/m^2) specified in **12.2**

w : Deck load (kN) supported by the tween deck pillar as specified in **6.2**

k : As specified in the following **(1)** and **(2)**:

(1) Coefficient obtained from the following formula according to the ratio of the horizontal distance (m) from the pillar or bulkhead supporting the deck girder to the tween deck pillar a and l. (*See* **Fig. 4.7.1**)

$$12\frac{a}{l}\left(1-\frac{a}{l}\right)^2$$

(2) Where there is only one tween deck pillar, k is to be obtained by measuring a from the closest pillar or bulkhead. 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 sum of kw is to be used for the calculation of the formula. In this case, the greater value of kw is to be used.

2 Beyond the midship part, the section modulus of longitudinal deck girders of strength deck may be gradually reduced, but the section modulus is not to be less than that obtained from the following formula:

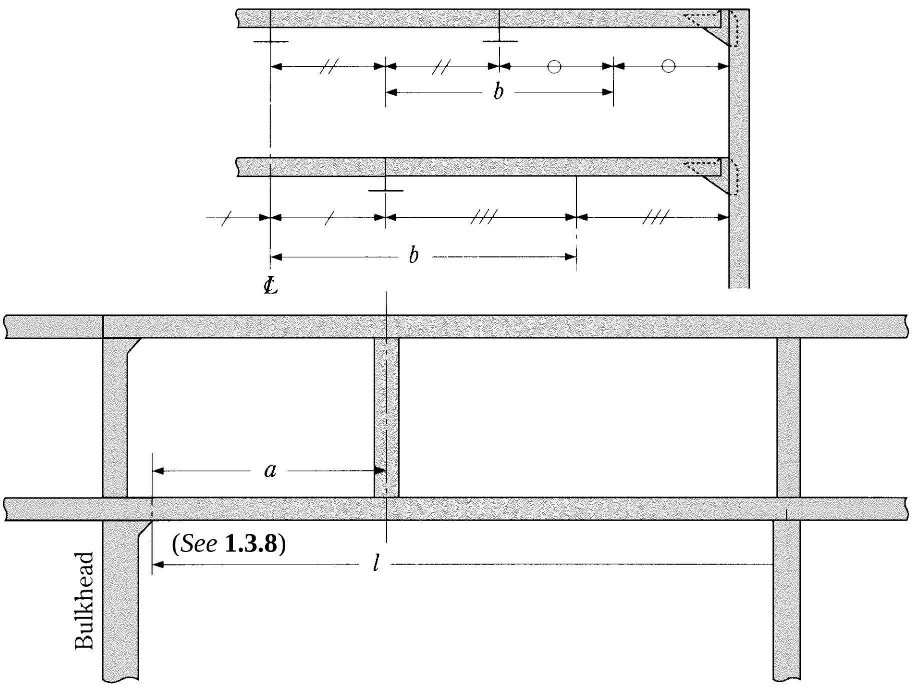
$$0.411l(lbh+kw) \quad (cm^3)$$

Where:

l, b, h, w and k : As specified in **-1**

3 The section modulus of longitudinal deck girders for parts other than that specified in **-1** and **-2** is not to be less than that obtained from the formula in **-2**.

Fig. 4.7.1 Measurement of l, a and b



7.2.2 Moment of Inertia of Girders

It is advised that the moment of inertia of girders is not to be less than that obtained from the following formula:

$$CZl \quad (cm^4)$$

Where:

C : Coefficient obtained from the followings:

For deck girders arranged strength deck of midship part of ship: 1.6

For other deck girders: 4.2

Z : Required section modulus (cm^3) of girders specified in **7.2.1**

l : As specified in **7.2.1-1**

7.2.3 Thickness of Web Plates

1 The thickness of web plates is not to be less than that obtained from the following formula:

$$10S_1 + 2.5 \quad (mm)$$

Where:

S_1 : Spacing (m) of web stiffeners or depth of girders, whichever is smaller

2 The thickness of web plates at both end parts for $0.2l$ is not to be less than that specified in **-1** and obtained from the following formula, whichever is greater.

$$\frac{4.43}{1000}\frac{bhl}{d_0}+2.5 \quad (mm)$$

Where:

d_0 : Depth of girder (m)

b, h and l : As specified in **7.2.1-1**

7.3 Transverse Deck Girders

7.3.1 Section Modulus of Girders

1 The section modulus of transverse deck girders is not to be less than that obtained from the following formula:

$$0.411l(lbh+kw) \quad (cm^3)$$

Where:

l : Distance (m) between the centres of pillars or from the centre of the pillar to the inner edge of the beam bracket

b : Distance (m) between the centres of two adjacent girders or bulkheads

h : Deck load (kN/m^2) specified in **12.2**

w and k : In accordance with **7.2.1-1**

7.3.2 Moment of Inertia of Girders

It is advised that the moment of inertia of girders is not to be less than that obtained from the following formula:

$$4.2Zl \quad (cm^4)$$

Where:

Z : Required section modulus (cm^3) of girders specified in **7.3.1**

l : As specified in **7.3.1**

7.3.3 Thickness of Web Plates

The thickness of web plates is to be in accordance with the requirements in **7.2.3**.

7.4 Deck Girders in Tanks

7.4.1 Section Modulus of Girders

The section modulus of deck girders in tanks is to be in accordance with the requirements in **7.2.1** or **7.3.1**, and the requirements in **9.2.4-1**.

7.4.2 The Moment of Inertia of Girders

The moment of inertia of girders in tanks is to be in accordance with the requirements in **9.2.4-2**.

7.4.3 Thickness of Web Plates

The thickness of web plates is to be in accordance with the requirements in **7.2.3** or **7.3.3**, and the requirements in **9.2.4-3**.

Chapter 8 WATERTIGHT BULKHEADS

8.1 Arrangement of Watertight Bulkheads

8.1.1 Collision Bulkheads

1 All ships are to have a collision bulkhead, at a position not less than $0.05L$, from the forward terminal of the total length on the designed maximum load line, but not more than $0.08L$ or $0.05L + 3.0$ (m), whichever is greater, unless for special reasons which are approved by the Society. 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 total length on the designed maximum load line, the above-mentioned distance is to be measured from the point that gives the smallest measurement from the following.

(1) The mid-length of such an extension

(2) A distance $0.015L$ forward from the above-mentioned forward terminal

2 The bulkhead may have steps or recesses within the limits specified in **-1** above.

3 Any access openings, doors, manholes or ducts for ventilation, etc. are not to be cut in to the collision bulkhead below the bulkhead deck.

8.1.2 After Peak Bulkheads

1 All ships are to have an after peak bulkhead at a suitable position.

2 The stern tube is to be enclosed in a watertight compartment by the after peak bulkhead or other suitable arrangements.

8.1.3 Machinery Space Bulkheads

A watertight bulkhead is to be provided at each end of the machinery space.

8.1.4 Chain Lockers

Chain Lockers located abaft the collision bulkhead or in the fore peak tank are to be watertight.

8.1.5 Transverse Strength of Hull

Where the watertight bulkheads required in **8.1.1** to **8.1.3** 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.

8.2 Construction of Watertight Bulkheads

8.2.1 Thickness of Bulkhead Plates

The thickness of bulkhead plates is not to be less than that obtained from the following formula:

$$3.2S\sqrt{h} + 2.5 \quad (mm)$$

Where:

S : Spacing (m) of stiffeners

h : Vertical distance (m) measured from the lower edge of the bulkhead plates to the bulkhead deck at the centre line of ship. In no case is it to be less than 3.4 *metres*.

8.2.2 Stiffeners

The section modulus of bulkhead stiffeners is not to be less than that obtained from the following formula:

$$2.8CShl^2 \quad (cm^3)$$

Where:

l : Span (m) measured between the adjacent supports of stiffeners including the length of connection. Where girders are provided, l is the distance from the heel of the end connection to the first girder or the distance between the girders.

S : Spacing (m) of stiffeners

h : Vertical distance (m) measured from the mid-point of l for vertical stiffeners, and from the mid-point of distance between the adjacent stiffeners for horizontal stiffeners, to the top of bulkhead deck at the centre line of the ship. Where the vertical distance is less than 6.0 *metres*, h is to be taken as 1.2 *metres* plus 0.8 *times* the vertical distance.

C : Coefficient given in **Table 4.8.1**

Table 4.8.1 Value of *C*

Vertical Stiffener				
Lower end	Upper end			
	Lug-connection of supported by horizontal girders	Connection		End of stiffener unattached
		Type A	Type B	
Lug-connection or supported by horizontal girders	1.00	1.00	1.15	1.35
Bracketed	0.80	0.80	0.90	1.00
Only the web of stiffener attached at end	1.15	1.15	1.35	1.60
End of stiffener unattached	1.35	1.35	1.60	2.00
Horizontal Stiffener				
The other end	One end			
	Lug-connection, bracketed or supported by vertical girders	End of stiffener unattached		
Lug-connection, bracketed or supported by vertical girders	1.00	1.35		
End of stiffener unattached	1.35	2.00		

Notes:

1 "Lug-connection" is a connection where both webs and face plates of stiffeners are effectively attached to the bulkhead plating, decks or inner bottoms and which are strengthened by effective supporting members on the opposite side of the 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. 4.8.1**).

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 connection mentioned above. (*See* **Fig. 4.8.2**).

Fig. 4.8.1 Types of End Connection (Connection Type A)

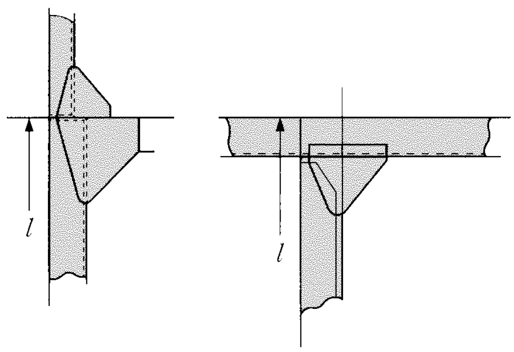
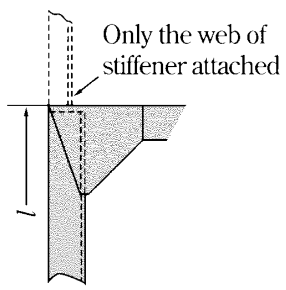


Fig. 4.8.2 Types of End Connection (Connection Type B)



8.2.3 Collision Bulkheads

For collision bulkheads, the plate thickness and section modulus of stiffeners are not to be less than that those specified in **8.2.1** and **8.2.2** taking *h* as 1.25 *times* the specified height.

8.2.4 Girders Supporting Bulkhead Stiffeners

1 The section modulus of girders is not to be less than that obtained from the following formula:

$$4.75Shl^2 \quad (cm^3)$$

Where:

S : Breadth (*m*) of the area supported by the girder

h : Vertical distance (*m*) measured from the mid-point of *l* for vertical girders, and from the mid-point of *S* for horizontal girders, to the top of the bulkhead deck at the centre line of the ship. Where the vertical distance is less than 6.0 *metres*, *h* is to be taken as 1.2 *metres* plus 0.8 *times* the vertical distance.

l : Span (*m*) between the adjacent supports of girders

2 The moment 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.

$$10hl^4 \quad (cm^4)$$

Where:

h and l : As specified in **-1**

3 The thickness of web plates is not to be less than that obtained from the following formula:

$$10S_1 + 2.5 \quad (mm)$$

Where:

S_1 : Spacing (*m*) of web stiffeners or depth of girders, whichever is smaller

4 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.

Chapter 9 DEEP TANKS

9.1 General

9.1.1 Definition

The deep tank is a tank used for the carriage of water, fuel oil and other liquids, forming a part of the hull in fore and after peaks or tween decks. The deep tanks used for carriage of oils are designated as “deep oil tanks”, if necessary.

9.1.2 Application

1 Peak tank bulkheads and boundary bulkheads of deep tanks (excluding the deep tanks for the carriage of oils having a flashpoint below $60°C$) are to be constructed 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 requirements in **Chapter 8**, as well.

2 The bulkheads of the deep tanks for carriage of oils having a flashpoint below $60°C$ are to comply with the requirements in **Chapter 24, Part CS of the Rules for the Survey and Construction of Steel Ships**, in addition to those in this Chapter.

9.2 Deep Tank Bulkheads

9.2.1 Application

The construction of bulkheads and decks forming boundaries of deep tanks is to be in accordance with the requirements in **Chapter 8**, unless otherwise specified in this Chapter.

9.2.2 Bulkhead Plates

The thickness of deep tank bulkhead plating is not to be less than that obtained from the following formula:

$$3.6S\sqrt{h}+2.5 \quad (mm)$$

Where:

S : Spacing of stiffeners (m).

h : Vertical distance (m) measured from the lower edge of plate to the top of overflow pipes

However, for bulkheads of large tanks, additional water pressure is to be appropriately considered.

9.2.3 Bulkhead Stiffeners

The section modulus of bulkhead stiffeners is not to be less than that obtained from the following formula:

$$7CShl^2 \quad (cm^3)$$

Where:

S and l: As specified in **8.2.2**

h: Vertical distances (m) measured from the mid-point of l for vertical stiffeners, and from the mid-point of distance between the adjacent stiffeners for horizontal stiffeners, to the top of the overflow pipes

However, for bulkhead stiffeners of large tanks, additional water pressure is to be appropriately considered.

C : Coefficient given in **Table 4.9.1**, according to the type of end connections.

Table 4.9.1 Value of C

Vertical Stiffener					
The other end of stiffeners		One end of stiffeners			
		Lug-connection or supported by girders	Connection		End of stiffener unattached
			Type A	Type B	
Lug-connection or supported by girders		1.00	0.85	1.30	1.50
Connection	Type A	0.85	0.70	1.15	1.30
	Type B	1.30	1.15	0.85	1.15
End of stiffener unattached		1.50	1.30	1.15	1.50

Notes:

1 “Connection Type A” is a connection by bracket of the stiffener to the double bottoms or to a stiffener of equivalent strength attached to the face plates of adjacent members, or a connection of equivalent strength.(*See* **Fig. 4.9.1**)

2 “Connection Type B” is a connection by bracket of the stiffener to the transverse members such as beams, frames or equivalent thereto. (*See* **Fig. 4.9.2**)

Fig. 4.9.1 Types of End Connection (Connection Type A)

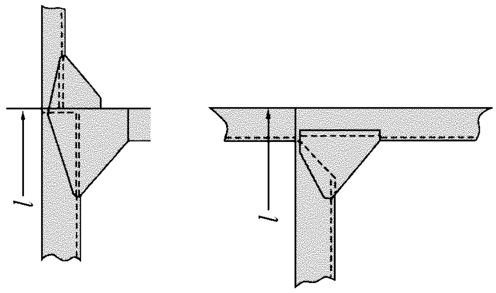
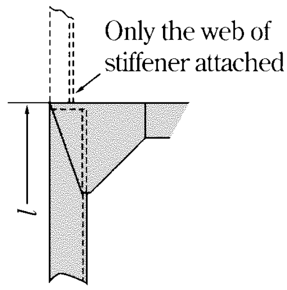


Fig. 4.9.2 Types of End Connection (Connection Type B)



9.2.4 Girders supporting Bulkhead Stiffeners

1 The section modulus of girders is not to be less than that obtained from the following formula:

$$7.13Shl^2 \quad (cm^3)$$

Where:

S : Breadth (m) of the area supported by the girders

h : Vertical distance (m) measured from the mid-point of S for horizontal girders, and from the mid-point of l for vertical girders, to the top of the overflow pipes

l : Span (m) measured between the adjacent supports of girders

2 The moment of inertia of girders is not to be less than that obtained from the following formula. The depth of girders is not to be less than 2.5 *times* the depth of slots for stiffeners.

$$30hl^4 \quad (cm^4)$$

Where:

h and l : As specified in **-1**

3 The thickness of web plates is not to be less than that obtained from the following formula:

$$10S_1 + 3.5 \quad (mm)$$

Where:

S_1 : Spacing (m) of web stiffeners or the depth of girders, whichever is smaller

9.3 Fittings of Deep Tanks

9.3.1 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.

9.3.2 Drainage from Top of Tanks

Efficient arrangements are to be made for draining bilge water from the top of deep tanks.

9.3.3 Cofferdams

1 Oiltight cofferdams are to be provided between tanks carrying oils and those carrying fresh water, such as for personnel use or boiler feed water, etc., to prevent the fresh water from being contaminated by the oil.

2 Crew spaces and passenger spaces are not to be directly adjacent to tanks carrying fuel oil. Such compartments are to be separated from the fuel oil tanks by cofferdams which are well ventilated and accessible. Where the top of fuel oil tanks have no opening and is coated with incombustible coverings of 38 *mm* and over in thickness, the cofferdam between such compartments and the top of the fuel oil tanks may be omitted.

Chapter 10 LONGITUDINAL STRENGTH

10.1 General

10.1.1 Special Cases in Application

Where there are items for which direct application of the requirements in this Chapter is deemed unreasonable, these items are to be in accordance with the discretion of the Society.

10.1.2 Continuity of Strength

Longitudinal members are to be so arranged as to maintain the continuity of strength.

10.2 Bending Strength

10.2.1 Bending Strength at the Midship Part

1 The section modulus of the transverse section of the hull at the middle point of L is not to be less than the value of W_{min} obtained from the following formulae:

$$W_{min} = 34.5 D_s L (B + 12) \quad (cm^3) \text{ for } \quad L \le 75m$$

$$W_{min} = 0.46 D_s L^2 (B + 12) \quad (cm^3) \text{ for } \quad L > 75m$$

2 The scantlings of longitudinal members in way of the midship part are not to be less than the scantlings of longitudinal members at the middle point of L which are determined by the requirement in **-1** above, excluding changes in the scantlings due to variations in the sectional form of the transverse section of the hull.

10.2.2 Bending Strength at Sections Other Than the Midship Part

The bending strength of hull at sections other than the midship part is to be as determined according to the requirements of **12.3**.

10.2.3 Calculation of Section Modulus of Transverse Section of Hull

The section modulus of the hull is to be calculated in accordance with the followings:

(1) All longitudinal members which are considered effective to longitudinal strength are to be included in the calculation.

(2) Deck openings on the strength deck are to be deducted from the sectional area used in the calculation of the section modulus. However, small openings not exceeding 2.5 *metres* in length and 1.2 *metres* in breadth need not be deducted, provided that the sum of their breadths in any single transverse section is not more than $0.06\left(B - \sum b\right)$. $\sum b$ is the sum of the openings exceeding 1.2 *metres* in breadth or 2.5 *metres* in length.

(3) Notwithstanding the requirement in **(2)**, small openings on the strength deck need not be deducted, provided that the sum of their breadths in one single transverse section does not reduce the section modulus at the strength deck or the ship bottom by more than 3%.

(4) Deck openings specified in **(2)** and **(3)** include shadow areas obtained by drawing two tangential lines with an opening angle of 30 *degrees* having their apex on the line drawn through the centre of the small openings along the length of the ship.

(5) 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 greater.

(a) Vertical distance (m) from the neutral axis to the top of the strength deck beam and the side of the ship

(b) Distance (m) obtained from the following formula:

$$Y(0.9 + 0.2\frac{X}{B})$$

Where:

X: Horizontal distance (m) from the top of continuous strength member to the centre line of the ship

Y: Vertical distance (m) from the neutral axis to the top of the continuous strength member

In this case, X and Y are to be measured at the point which gives the largest value, for the above formula.

(6) The section modulus at the ship bottom is to be calculated by dividing the moment of inertia of the athwartship section about its horizontal neutral axis by the vertical distance from the neutral axis to the top of the keel.

10.2.4 Loading Manual

For ships whose length L is 65 m and over, in order to avoid the occurrence of unacceptable stress in the ship's structure, ships are to be provided with a loading manual approved by the Society, except those approved by the Society.

Chapter 11 SHELL PLATING

11.1 General

11.1.1 Special Consideration for Contact with Quay, etc.

For Ships having many opportunities of contact with quay etc., special consideration is to be given to the thickness of shell plating to prevent indent of shell plating.

11.2 Shell Plating

11.2.1 Minimum Thickness

The minimum thickness of shell plating below the strength deck is not to be less than that obtained from the following formula:

$$0.04L + 5 \quad (mm)$$

11.2.2 Thickness of Side Shell Plating

The thickness of side shell plating is not to be less than that obtained from the following formula:

$$3.69S\sqrt{d + 0.04L} + 2.3 \quad (mm)$$

Where:

S : Spacing (m) of longitudinal or transverse frames

11.2.3 Thickness of Bottom Shell Plating

The thickness of bottom shell plating (including keel plate and bilge strake) is to be as required in the following **(1)** and **(2)**.

(1) In ships with transverse framing, the thickness is not to be less than that obtained from the following formula:

$$4.23S\sqrt{d + 0.035L} + 2.3 \quad (mm)$$

Where:

S : Spacing (m) of transverse frames

(2) In ships with longitudinal framing, the thickness is not to be less than that obtained from the following formula.

$$3.6S\sqrt{d + 0.035L} + 2.3 \quad (mm)$$

Where:

S : Spacing (m) of longitudinal frames

Chapter 12 DECKS

12.1 General

12.1.1 Steel deck plating

Decks are to be plated from side to side of the ship except where there are specialized deck openings. However, decks may be of only stringer plates and tie plates, subject to the approval by the Society.

12.1.2 Watertightness of Decks

Weather decks are to be made watertight.

12.1.3 Compensation for Openings

Openings on strength decks are to have well rounded corners, and suitable compensation is to be provided as necessary.

12.1.4 Rounded Gunwales

Rounded gunwales, where adopted, are to have a sufficient radius for the thickness of the plates.

12.2 Deck Load

12.2.1 Value of Deck Load *h*

1 Deck load h (kN/m^2) for the weather deck is to be as specified in the following **(1)** to **(3)**.

(1) For the freeboard decks, superstructure deck and top of deckhouses on the freeboard deck, h is not to be less than that obtained from the following formula:

$a(0.067bL - y)$ (kN/m^2)

Where:

a and b : As given by **Table 4.12.1**.

However, where C_b is less than 0.7, value of b may be suitably modified.

y : Vertical distance (m) from the designed maximum load line to the weather deck at side, and y is to be measured at midship.

(2) Notwithstanding the provision in **(1)**, h is not to be less than that obtained from the formulae given by **Table 4.12.2**. However, where the h value calculated from the formula in **Table 4.12.2** is less than 12.8, the h value is to be taken as 12.8.

(3) Value of h may be suitably modified where the ship has an unusually large freeboard.

2 On the first and second tiers above the freeboard deck, h is to be 12.8 for enclosures of superstructure decks and of top of deckhouses in accommodation or navigation spaces.

Table 4.12.1 Values of *a* and *b*

a				*b*
Deck plating	Beams	Pillars	Deck girders	
6.90	4.60	2.25	2.25[1] 3.45[2]	1.00

Notes:

1 For longitudinal deck girders of the strength deck for the midship part

2 For deck girders other than 1

Table 4.12.2 Minimum Value of h

h	C		
	Beams	Pillars, Longitudinal and transverse deck girders	Deck plating
$C\sqrt{L+50}$	1.37	1.18	2.05

12.3 Effective Sectional Area of Strength Deck

12.3.1 Definition

The effective sectional area of the strength deck is the sectional area, on each side of the ship, of steel plating, longitudinal beams, girders, etc. extending for 0.5L amidships.

12.3.2 Effective Sectional Area of Strength Deck

1 The effective sectional area for the midship part for which the modulus of athwartship section of the hull is specified in **Chapter 10** is to be so determined as to comply with the requirements in **Chapter 10**.

2 Beyond the midship part, the effective sectional area of strength deck may be gradually reduced less than the value at the end of the midship part. However, the values at the position 0.15L from the after and fore end of L, respectively, are not to be less than 0.4 *times* the value at the middle point of L for ships with machinery amidships, or 0.5 *times* for ships with machinery aft.

3 Where the section modulus of the athwartship section other than the midship part is greater than the value approved by the Society, the requirements specified in the provisory clause in **-2** may not be necessarily applied.

12.3.3 Strength Deck Beyond 0.15*L* from Both Ends

Beyond 0.15L from each end, the effective sectional area and the thickness of the strength deck plating may be gradually reduced avoiding abrupt changes.

12.4 Deck Plating

12.4.1 Thickness of Deck Plating

1 The thickness of deck plating is not to be less than that obtained from the formula in **(1)** or **(2)**. However, within enclosed spaces such as superstructures and deckhouses, the thickness may be reduced by 1 *mm*.

(1) The thickness of strength deck plating:

(a) Midship part with longitudinal beams

$1.47S\sqrt{h}+1.5$ (mm)

Where:

S : Spacing (m) of longitudinal beams

h : Deck load (kN/m^2) specified in **12.2**

(b) Midship part with transverse beams

$1.63S\sqrt{h}+1.5$ (mm)

Where:

S : Spacing (m) of transverse beams

h : Deck load (kN/m^2) specified in**12.2**

(c) Elsewhere

$1.25S\sqrt{h}+1.5$ (mm)

Where:

S : Spacing (m) of longitudinal or transverse beams

h : Deck load (kN/m^2) specified in **12.2**

(2) The thickness of deck plating other than the strength deck is to be specified in the following:

$1.25S\sqrt{h}+1.5$ (mm)

Where:

S and h : As specified in **(1)(c)**

2 Notwithstanding the requirements in **-1**, the thickness of deck plating is not to be less than 5 *mm*.

12.4.2 Deck Plating Forming the Tops of Tanks

The thickness of deck plating forming the top of tanks is not to be less than that required in **9.2.2**, taking the beam spacing as the stiffener spacing.

12.4.3 Deck Plating Under Boilers

The thickness of deck plating under boilers is to be increased by 3 *mm* above the specified thickness.

Chapter 13 SUPERSTRUCTURES AND DECKHOUSES

13.1 General

13.1.1 Application

1 Where a forecastle is provided, the standard forecastle is to be accordance with this chapter.

2 The construction and scantlings of superstructures and deckhouses are to be in accordance with the relevant Chapters in addition to this Chapter.

3 The requirements in this Chapter are prescribed for the superstructures and deckhouses up to the third tier above the freeboard deck. As for the superstructures and deckhouses above the third tier, the construction and scantlings thereof are to be as deemed appropriate by the Society.

4 As for the superstructures and deckhouses in ships with an especially large freeboard, the construction of bulkhead may be suitably modified subject to the approval by the Society.

13.2 Construction and Scantlings

13.2.1 Head of Water *h*

1 The head of water for the calculation of the scantlings of superstructure end bulkheads and boundary walls of deckhouses is not to be less than that obtained from the following formula:

$$ac\left(0.067bL - y\right) \quad (m)$$

Where:

a : As given by the following formulae:

Exposed front bulkhead and wall of the first tier:

$$2.0 + \frac{L}{120}$$

Exposed front bulkhead and wall of the second tier:

$$1.0 + \frac{L}{120}$$

Exposed front bulkhead and wall of the third tier, and side walls and protected end bulkheads and front walls:

$$0.5 + \frac{L}{150}$$

Aft bulkheads and walls located abaft the midship:

$$0.7 + \frac{L}{1000} - 0.8\frac{x}{L}$$

Aft bulkheads and walls located afore the midship:

$$0.5 + \frac{L}{1000} - 0.4\frac{x}{L}$$

b : As given by the following formulae:

Where $\frac{x}{L}$ is less than 0.45: $1.0 + \left(0.5 - 1.1\frac{x}{L}\right)^2$

Where $\frac{x}{L}$ is 0.45 and over: $1.0 + 1.5\left(1.1\frac{x}{L} - 0.5\right)^2$

x : Distance (m) from the bulkhead or end wall to the after perpendicular, or distance from the mid-point of the side wall to the after perpendicular

However, where the length of the side wall exceeds 0.15*L*, the side wall is to be equally subdivided into span not exceeding 0.15*L* and the distance from the mid-point of the subdivisions to the after perpendicular is to be taken.

c : Coefficient as given by the following formulae:

For end bulkheads of superstructures: 1.0

For boundary walls of deckhouses: $0.3+0.7\dfrac{b'}{B'}$

However, where b'/B' is less than 0.25, b'/B' is to be taken as 0.25.

b' : Breadth (m) of deckhouse at the position under consideration

B' : Breadth (m) of ship on the exposed deck at the position under consideration

y : Vertical distance (m) from the designed maximum load line to the mid-point of the span of stiffeners when determining the scantlings of stiffeners; and to the mid-point of plating when determining the thickness of bulkhead or boundary wall plating

2 The head of water for the calculation of the scantlings of superstructure end bulkheads and boundary walls of deckhouses is not to be less than that obtained from the formulae in **Table 4.13.1** irrespective of the provision in **-1**.

Table 4.13.1

	Exposed front bulkhead and wall of the first tier	Others
L is 50 *metres* and under	3.0 (m)	1.5 (m)
L exceeds 50 *metres*	$2.5+\dfrac{L}{100}$ (m)	$1.25+\dfrac{L}{200}$ (m)

13.2.2 Thickness of Bulkhead and Wall Plating

1 The thickness of superstructure end bulkhead plating and boundary wall plating is not to be less than that obtained from the following formula:

$2.7S\sqrt{h}$ (mm)

Where:

h : Head of water (m) specified in **13.2.1**

S : Spacing (m) of stiffeners

2 The thickness of bulkhead and wall plating is not to be less than that obtained from the following formulae or 5 *mm*, whichever is greater, irrespective of the provisions in **-1**:

Bulkhead plating of the first tier: $5.0+\dfrac{L}{100}$ (mm)

Plating of other bulkheads: $4.0+\dfrac{L}{100}$ (mm)

13.2.3 Stiffeners

1 The section modulus of stiffeners on superstructure end bulkheads and deckhouse boundary walls is not to be less than that obtained from the following formula:

$3.15Shl^2$ (cm^3)

Where:

S and h : As specified in **13.2.2**

l : Tween deck height (m)

However, where l is less than 2 *metres*, l is to be taken as 2 *metres*.

2 Both ends of stiffeners on the exposed bulkheads of superstructures and boundary walls of deckhouses are to be connected to the deck by welding except where otherwise approved by the Society.

Chapter 14 MACHINERY SPACE OPENINGS AND OTHER DECK OPENINGS

14.1 General

14.1.1 Relaxation from the Requirements

Relaxation from the requirements in this Chapter will be specially considered where the ship has an unusually large freeboard.

14.2 Machinery Space Openings

14.2.1 Protection of Machinery Space Openings

Machinery space openings are to be enclosed by steel casings.

14.2.2 Exposed Machinery Space Casings

1 Exposed machinery space casings are to have scantlings not less than those required in **13.2.1** and **13.2.2** taking the c value as 1.0.

2 The thickness of the top plating of exposed machinery space casing is not to be less than that obtained from the following formula:

$$6.3S + 2.5 \ (mm)$$

Where:

S: Spacing (m) of stiffeners

14.2.3 Machinery Space Casings below Freeboard Deck or within Enclosed Spaces

The scantlings of machinery space casings below the freeboard deck or within enclosed superstructures or deckhouses are to comply with the following requirements:

(1) The thickness of the plating is to be at least 6.5 *mm*; where the spacing of stiffeners is greater than 760 *mm*, the thickness is to be increased at the rate of 0.5 *mm* per 100 *mm* excess in spacing. In accommodation spaces, the thickness of the plating may be reduced by 2 *mm*.

(2) The section modulus of stiffeners is not to be less than that obtained from the following formula:

$$1.2Sl^3 \quad (cm^3)$$

Where:

l : Tween deck height (m)

S : Spacing of stiffeners (m)

14.2.4 Machinery Space Casings Within Unenclosed Superstructure or Deckhouses

Machinery space casings within unenclosed superstructures or deckhouses and doors provided thereon are to be constructed to the satisfaction of the Society, having regard to the degree or protection afforded by the superstructure or deckhouse.

14.3 Other Deck Openings

14.3.1 Weathertightness

Deck openings other than the machinery space openings specified in **14.2.1** are to be provided with weathertight means of closing.

Chapter 15 MACHINERY SPACES, BOILER ROOMS AND TUNNEL RECESSES

15.1 General

15.1.1 Application

The construction of machinery spaces is to be in accordance with the requirements in the relevant Chapters, in addition to this Chapter.

15.1.2 Construction

Machinery spaces are to be sufficiently strengthened by means of web frames, strong beams and pillars or other arrangements.

15.1.3 Supporting Structures for Machinery and Shafting

All parts of the machinery and shafting are to be efficiently supported and the adjacent structures are to be adequately stiffened.

15.1.4 Twin Screw Ships and Those with High Power Engines

In twin screw ships and those with high power engines, the structure and attachments of the engines' foundations are to be especially strengthened in relation to the engines' proportions, weight, power, type, etc.

15.2 Main Engine Foundations

15.2.1 Ships with Single Bottoms

1 In ships with single bottoms, the main engines are to be seated upon thick rider plates laid across the top of deep floors or heavy foundation girders efficiently bracketed and stiffened and having sufficient strength in proportion to the power and size of the engines.

2 The main lines of bolting that hold down the main engines to the rider plates mentioned in **-1** are to pass through the rider plates into the girder plates provided underneath.

3 In ships with longitudinal girders of not excessive spacing beneath the engine which is on the centre line of the hull, the centre keelson may be omitted for the section where the engine is located.

15.2.2 Ships with Double Bottoms

1 In ships with double bottoms, the main engines are to be seated directly upon thick inner bottom plating or thick seat plates on the top of heavy foundations so arranged as to effectively distribute the weight.

2 Additional side girders are to be provided within the double bottom beneath the main lines of bolting and other suitable positions so as to ensure satisfactory distribution of the weight and rigidity of the structure.

15.3 Construction of Boiler Rooms

15.3.1 Boiler Foundations

1 Boilers are to be supported by deep saddle shape 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 especially stiffened.

15.3.2 Boiler Location

Boilers are to be so placed as to ensure accessibility and proper ventilation.

15.3.3 Clearance between Boilers and Adjacent Structures

1 Boilers are to be at least 457 *mm* clear of adjacent structures such as tank tops. The thickness of adjacent members is to be increased as may be required where the clearance is unavoidably less. The available clearance is to be indicated on the plans submitted for approval.

2 Decks are to be kept well clear of the boilers and uptakes, or provided with suitable insulating arrangements.

15.4 Thrust Blocks and Foundations

15.4.1 Thrust Foundations

Thrust blocks are to be bolted to efficient foundations extending well beyond the thrust blocks and so arranged as to effectively distribute the loads into the adjacent structures.

15.4.2 Construction Under Thrust Foundations

Additional girders are to be provided in way of the foundations, as necessary.

15.5 Plummer Blocks and Auxiliary Machinery Seats

15.5.1 General

Plummer blocks and auxiliary machinery seats are to be of ample strength and stiffeness in proportion to the weight supported and the height of the foundations.

15.6 Tunnels and Tunnel Recesses

15.6.1 Arrangement

1 In ships with machinery amidships, the shafting is to be enclosed by a watertight tunnel of sufficient dimensions.

2 Watertight doors are to be provided at the fore end of tunnel.

3 In tunnels which are provided with watertight doors in accordance with the requirements in **-2**, escape trunks are to be provided at a suitable location and they are to lead to the bulkhead deck or above.

15.6.2 Flat Side Plating

The thickness of plating on flat sides of the tunnel is not to be less than that obtained from the following formula:

$$2.9S\sqrt{h} + 2.5 \quad (mm)$$

Where:

S : Spacing of stiffeners (m)

h : Vertical distance (m) from the lower edge of the side wall plating to the bulkhead deck at the centre line of the ship

15.6.3 Flat Top Plating

1 The thickness of flat plating of the top of tunnels or tunnel recesses is not to be less than that obtained from the formula in **15.6.2**, h being taken as the height from the top plates to the bulkhead deck at the centre line of the ship.

2 Where the top of tunnels or tunnel recesses forms part of the deck, the thickness is to be increased by at least 1 *mm* above that obtained from the requirements in **-1**, but it is not to be less than that required for the deck plating at the same position.

15.6.4 Curved Top or Side Plating

The thickness of curved top or side plating is to be determined by the requirements in **15.6.2** using a stiffener spacing reduced by 150 *mm* from the actual spacing.

15.6.5 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.

$$4.0Shl^2 \quad (cm^3)$$

Where :

l : Distance (m) from the heel of the lower edge of the side wall to the top of the flat side

S : Spacing of stiffeners (m).

h : Vertical distance (m) from the mid-point of l to the bulkhead deck

3 Where the ratio of the radius of the rounded tunnel top to the height of the tunnel is comparatively large, the section modulus of stiffeners is to be adequately increased over that specified in **-2**.

4 Each stiffener is to overlap and to be riveted to the boundary angles, and the lower ends of stiffeners over 150 *mm* in depth are to be connected to parts such as the inner bottom plating by lug connections.

15.6.6 Construction Under Stanchions and Other Vertical Pieces

Where vertical pieces such as stanchions are attached atop tunnels or tunnel recesses, local strengthening is to be provided in proportion to the weight carried.

15.6.7 Ventilators and Escape Trunks

Escape trunks and ventilators provided in 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.

15.6.8 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.

15.6.9 Watertight Tunnels

Where watertight tunnels similar to shaft tunnels are provided, they are to be of similar construction to the shaft tunnels.

15.6.10 Cylindrical Tunnels

Where cylindrical tunnels 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:

$$9.1 + 0.134 d_t h \quad (mm)$$

Where:

d_t : Diameter of tunnel (m)

h : Vertical distance (m) measured from the bottom of tunnel to the top of overflow pipes

Chapter 16 EQUIPMENT

16.1 Anchors, Chain Cables and Ropes

16.1.1 General

1 Ships, according to their equipment numbers, are to be provided with anchors, chain cables and ropes which are not less than that given in **Table 4.16.1**.

2 Anchors, chain cables and ropes for ships having equipment numbers not more than 70 or more than 1670 are to be determined by the Society.

3 Two of the anchors given in **Table 4.16.1** are to be connected to their chain cables and be positioned on board ready for use.

4 Anchors, chain cables, wire ropes and fibre ropes are to be in compliance with the requirements in **Chapter 2**, **3.1 of Chapter 3**, **Chapter 4** and **Chapter 5, Part L of Rules for the Survey and Construction of Steel Ships** or to be those deemed appropriate by the Society.

5 Notwithstanding the provisions specified in **-1** to **-3** above, in cases where the owner of ships request modification of requirements with its reasons, the Society may permit equipment which is less than that given in **Table 4.16.1** to be provided or permit omission of a part or all equipment specified in **Chapter 16** of this Part.

16.1.2 Equipment Number

Equipment number is the value obtained from the following formula:

$$W^{2/3} + 2.0(fB + \Sigma h''b) + 0.1A$$

W : Full load displacement (t)

f , $\sum h''b$ and A : Values specified in the following **(1)** to **(4)**.

(1) f : Vertical distance (m), at the midship, from the designed maximum load line to the top of the uppermost continuous deck beam at side

(2) A is the value obtained from the following formula:

$$fL_1 + \sum h''l$$

f : Value specified in **(1)**

L_1 : Length (m) of ship specified in **2.1.4-1** of **Part 1**

$\sum h''l$: Sum 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 L_1 and also have a breadth greater than B/4 and a height greater than 1.5 m

(3) $\sum h''b$: Sum of the products of the height h'' (m) and the breadth b (m) of the widest superstructure and deckhouse of each tier which has a breadth greater than $B/4$ and is located above the uppermost continuous deck

(4) In the application of **(2)** and **(3)**, screens and bulwarks more than 1.5 m in height are to be regarded as parts of superstructures or deckhouses.

Table 4.16.1 Anchors, Chain Cables and Ropes

Equipment letter	Equipment number		Anchor		Chain cable (stud link chain)				Mooring line		
			Number	Mass per anchor (stock less anchor)	Total length	Diameter			Number	Length of each line	Breaking load
						Grade 1	Grade 2	Grade 3			
	over	Up to		*kg*	*m*	*mm*	*mm*	*mm*		*m*	*kN*
RA 2	70	90	2	180	220	14	12.5		3	80	● 34
RA 3	90	110	2	240	220	16	14		3	100	● 37
RA 4	110	130	2	300	247.5	17.5	16		3	110	● 39
RA 5	130	150	2	360	247.5	19	17.5		3	110	● 44
RB 1	150	175	2	420	275	20.5	17.5		3	120	● 49
RB 2	175	205	2	480	275	22	19		3	120	● 54
RB 3	205	240	2	570	302.5	24	20.5		3	120	● 59
RB 4	240	280	2	660	302.5	26	22	20.5	4	120	● 64
RB 5	280	320	2	780	330	28	24	22	4	120	● 69
RC 1	320	360	2	900	357.5	30	26	24	4	140	● 74
RC 2	360	400	2	1,020	357.5	32	28	24	4	140	● 78
RC 3	400	450	2	1,140	385	34	30	26	4	140	● 88
RC 4	450	500	2	1,290	385	36	32	28	4	140	● 98
RC 5	500	550	2	1,440	412.5	38	34	30	4	140	● 108
RD 1	550	600	2	1,590	412.5	40	34	32	4	160	● 123
RD 2	600	660	2	1,740	440	42	36	34	4	160	● 132
RD 3	660	720	2	1,920	440	44	38	36	4	160	● 147
RD 4	720	780	2	2,100	440	46	40	36	4	160	● 157
RD 5	780	840	2	2,280	467.5	48	42	38	4	170	● 172
RE 1	840	910	2	2,460	467.5	50	44	40	4	170	● 186
RE 2	910	980	2	2,640	467.5	52	46	40	4	170	● 201
RE 3	980	1,060	2	2,850	495	54	48	42	4	170	● 216
RE 4	1,060	1,140	2	3,060	495	56	50	44	4	180	⊕ 230
RE 5	1,140	1,220	2	3,300	495	58	50	46	4	180	⊕ 250
RF 1	1,220	1,300	2	3,540	522.5	60	52	46	4	180	⊕ 270
RF 2	1,300	1,390	2	3,780	522.5	62	54	48	4	180	⊕ 84
RF 3	1,390	1,480	2	4,050	522.5	64	56	50	4	180	⊕ 309
RF 4	1,480	1,570	2	4,320	550	66	58	50	4	180	⊕ 324
RF 5	1,570	1,670	2	4,590	550	68	60	52	5	190	⊕ 324

Notes:

1. In cases where wire ropes are used, the following wire ropes corresponding to the marks shown in the Table, ●(6×12), ⊕ (6×24), are to be provided as standards.
2. Length of chain cables may be that including shackles for connection.
3. In cases where equipment other than that complying with **Chapter 2**, **3.1 of Chapter 3**, **Chapter 4** and **Chapter 5, Part L of Rules for the Survey and Construction of Steel Ships** is provided in accordance with **16.1.1-4**, diameters of chain cables are to be to the satisfaction of the Society.
4. Wire ropes may be used in lieu of chain cables.

16.1.3 Anchors

1 In cases where individual anchors are increased than the mass given in **Table 4.16.1** (hereinafter referred to as "required mass"), the mass is not to be increased more than 7% of the required mass notwithstanding the provisions of **16.1.1-1**. However, where approval by the Society is obtained, anchors which are increased in mass by more than 7% may be used.

2 Notwithstanding the provisions of **16.1.1-1**, in cases where two anchors are provided, the mass of one of the two anchors may be 85% of the mass given in **Table 4.16.1**.

3 In cases where stocked anchors are used, the mass excluding the stock is to be 0.8 *times* the mass given in **Table 4.16.1**.

4 In cases where high holding power anchors are used, the mass of each anchor may be 0.75 *times* the mass given in **Table 4.16.1**.

5 Where super high holding power anchors are used, the mass of each anchor may be 0.5 *times* the mass given in **Table 4.16.1**. However, super high holding power anchor mass is not to exceed 1,500 *kg*.

16.1.4 Chain Cables

Chain cables for anchors are to be stud link chains of Grade 1, 2 or 3, specified in **3.1** of **Chapter 3, Part L of Rules for the Survey and Construction of Steel Ships** or those deemed appropriate by the Society. However, Grade 1 chains made of Class 1 chain bars (*KSBC*31) complying with **3.1** of **Chapter 3, Part L of Rules for the Survey and Construction of Steel Ships** are not to be used in association with high holding power anchors.

16.1.5 Mooring Lines

1 As for wire ropes and hemp ropes used as mooring lines, the breaking test load specified in **Chapter 4** or **5, Part L of Rules for the Survey and Construction of Steel Ships** is not to be less than the breaking load given in **Table 4.16.1** respectively.

2 For ships having the ratio of *A* specified in **16.1.2-1(2)** to equipment number (*A/EN*) above 0.9, the following number of mooring lines is to be added to the number required by **Table 4.16.1** for mooring lines.

Where *A/EN* is above 0.9 up to 1.1: 1

Where *A/EN* is above 1.1 up to 1.2: 2

Where *A/EN* is above 1.2: 3

3 Application of synthetic fibre ropes for mooring lines is to be as deemed appropriate by the Society.

4 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 the Society.

5 The length of individual mooring lines may be reduced by up to 7% of the lengths given in **Table 4.16.1**, provided that the total length of the stipulated number of mooring lines is not less than that obtained from multiplying the length by the number given in **Table 4.16.1**.

16.1.6 Miscellaneous

1 Ships are to be provided with suitable appliances for handling anchors.

2 The inboard end of the chain cable is to be secured to the hull through a strong eye plate by means of a shackle or by other equivalent means.

16.2 Equipment for Special Purpose

16.2.1 Pushers

For contact with other vessels and land-based facilities, the ship is to be equipped with sufficient fenders.

16.2.2 Tugs

1 General

(1) In cases where equipment and devices for the ship's purpose are fitted, suitable measures are to be taken so that ship safety is not impaired.

(2) Cargo gear is to be in accordance with **Rules for Cargo Handling Appliances** and at the discretion of the Society.

2 Towing Equipment

(1) The towing hooks, winches, towing bits or towing bollards fitted onto tugs are to be located as low as practicable, and close to, but abaft of, the centre of gravity of the ship in the expected towing condition.

(2) Equipment, such as winches, for towing operations is to be provided with suitable safety devices so that towing wires are able to be released or cut in *times* of emergency.

3 Fenders

For contact with other vessels and land-based facilities, ships are to be equipped with sufficient fenders.

Part 5 HULL CONSTRUCTION AND EQUIPMENT OF BARGES

Chapter 1 GENERAL

1.1 Application

1.1.1 Application

1 This part applies to hull construction and equipment of barge of less than 90 *m* in length mainly navigating inland waterways, specified in **1.1.1-2(2)(a)** to **(c)**, **Part 1**.

(1) barges carrying dry cargoes in holds, specified in **1.1.1-2.(2)(a)**: **Chapter 1** to **14**

(2) pontoon barges specified in **1.1.1-2(2)(b)**: **Chapter 1** and **15**

(3) tank barges specified in **1.1.1-2(2)(c)** and intended to carry crude oils, petroleum products having absolute vapour pressure less than 0.28*MPa* at 37.8°*C*, or other similar liquid cargoes in bulk: **Chapter 1** and **16**

(4) tank barges specified in **1.1.1-2(2)(c)** and intended to liquid cargoes other than crude oils, petroleum products or other similar liquid cargoes in bulk: **Chapter 1** to **14**

2 In ships of not less than 90 *m* in length, the requirements concerning hull construction, equipment, arrangement and scantlings will be decided individually basing upon the general principle of this Part instead of the requirements in this Part.

1.1.2 Special Cases in Application

Notwithstanding the provisions in **1.1.1**, the requirements for hull construction, equipment, arrangement and scantlings of ships less than 30 *m* in length or that do not comply with the requirements in this Part for some special reason are to be at the Society's discretion.

1.1.3 Ships of Unusual Form or Proportion, or Intended for Carriage of Special Cargoes

In ships of unusual form or proportion, the requirements concerning hull construction, equipment, arrangement and scantlings will be decided individually basing upon the general principle of this Part instead of the requirements in this Part.

1.2 General

1.2.1 Direct Calculations

1 Where approved by the Society, direct calculations may be used to determine the scantlings of structural members and structural details for joints and discontinuities of structural members. In this case, if the scantlings which are determined by the reference of results of the direct calculations are not less than the scantlings of each provisions in this chapter, the scantlings are not to be less than the scantlings which are determined by the reference of results of the direct calculations.

2 In case of utilizing the direct calculations, the data necessary for the calculation are to be submitted to the Society.

1.3 General for Materials, Construction, etc.

1.3.1 Materials and Welding

1 Application of steels used for hull structures is to be at the Society's discretion.

2 Service limitation for materials of piping, valves and fittings is to be in accordance with the requirements in **10.1.5** and **10.2.2 of Part 7**.

3 Materials used for pneumatic piping system with the maximum working pressure above 2 *MPa*, and for fuel oil pipes, valves and fittings in fuel oil piping system, and also for valves, distance pieces and pipes attached to the shell plating and valves attached to the collision bulkheads are to be in compliance with the requirements of standards acceptable by the Society.

4 For materials used for piping system, except for those specified in **-3**, Surveyor may require to submit the results of tests carried out by the manufactures.

1.3.2 Scantlings

1 The scantlings of hull structural members are framed for the case where mild steel is used. Where material other than mild steel is used for hull structural members, the scantling of which are to be in accordance with the discretion of the Society.

2 Section moduli specified by the Rules include the steel plates with an effective breadth of $0.1l$ on either side of the members, unless specified otherwise. However, the $0.1l$ steel plates are not to exceed one-half of the distance to the next member. l is the length of the member specified in the relevant Chapters.

3 The standard depth of girders supporting frames, beams or stiffeners, unless otherwise specified, is to be one-twelfth of l, where l is the length specified in the relevant Chapter.

4 The inside radius of flanged plates is not to be less than twice but not more than 3 *times* the thickness of steel plates.

5 Girders are to be properly increased in scantlings where angle of inclination between web of the girder and shell plating is small, and suitable means are to be provided for tripping as the case may require.

1.3.3 Continuity of Structural Members

Attention is to be paid sufficiently to all structural members to be kept in continuity of strength.

1.3.4 Connection of Ends of Stiffeners, Girders and Frames

1 Where girders are connected at their ends with the bulkhead or top plating of tanks, the effective supporting members are to be provided on the bulkhead or top plating of tanks at their back side.

2 Where the frames or the stiffeners are connected with brackets, unless otherwise specified, the length of arm of brackets is not to be less than one-eighth of l specified in the relevant Chapters.

1.3.5 Equipment

Mooring and anchoring arrangements, towing apparatus and other fittings for which there are no particular requirements in this Part are to be of appropriate construction and arrangement suitable for their respective purposes; and tests are to be carried out to the satisfaction of the Surveyor, where deemed necessary.

1.3.6 Carriage of Oil or Other Flammable Liquid Substances

1 The requirements for construction and arrangement of ships for the carriage of fuel oils specified in this Part apply to ships carrying fuel oils having a flashpoint not less than $60°C$ determined by a closed cup test.

2 The construction and arrangement of ships for the carriage of fuel oils having a flashpoint less than $60°C$ determined by a closed cup test, are to be in accordance with the requirements provided in this Chapter, as well as other requirements deemed necessary by the Society.

3 The construction and arrangement of deep oil tanks of ships intended to carry cargo oils are to be in accordance with the requirements in **Chapter 16**.

1.3.7 Lightening Holes

Sizes of lightening holes of girders are to be as follows:

Girder with slot: $d \le \frac{d_G}{4}$

Girder without slot: $d \le \frac{d_G}{3}$

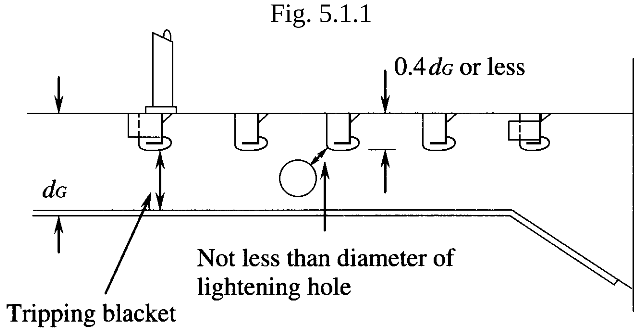
Where:

d_G : Depth of girder

d : Diameter of lightening hole

No lightening hole is to be provided near the toes of brackets or under pillars where shearing force is augmented. The distance between the lightening hole and slot is not to be less than the diameter of the lightening hole. (*See* **Fig. 5.1.1**)

Fig. 5.1.1



0.4 d_G or less
d_G
Not less than diameter of lightening hole
Tripping blacket

Chapter 2 BOTTOM STRUCTURES

2.1 General

2.1.1 Application

1 The provisions of this Chapter are applied to the bottom structures composed of centre girder and side girders as well as floors. Other bottom structures are to be as deemed appropriate by the Society.

2 Notwithstanding the provisions in this Chapter, the construction and scantlings of single bottoms in Pontoon Barges are to be in accordance with the requirements in **Chapter 15**.

2.2 Single Bottoms

2.2.1 Centre Girder

1 All single bottom ships are to have the centre girder composed of continuous web plates in association with face plates, and the centre girder is to extend as far forward and afterward as practicable.

2 The thickness of web plate is not to be less than that obtained from the following formula. Beyond the midship part, the thickness may be gradually reduced to 0.85 *times* the midship value at the end parts of the ships.

$$4.7 + 0.059L \quad (mm)$$

3 The height of web plates is not to be less than that of floors.

4 The thickness of face plates is not to be less than the thickness of web plate amidships.

5 The sectional area of face plates is not to be less than that obtained from the following formula. Beyond the midship part, the thickness may be gradually reduced to 0.85 *times* the midship value at the end parts of the ships.

$$0.54L + 8 \quad (cm^2)$$

2.2.2 Side Girders

1 Side girders are to be so arranged that their spacing is not more than 2.5 *m* between the centre girder and the side shell plating.

2 The side girders are to be composed of continuous web plates in association with face plates, and they are to extend as far forward and afterward as practicable.

3 The thickness of web plates is not to be less than that obtained from the following formula. Beyond the midship part, the thickness may be gradually reduced to 0.85 *times* the midship value at the end parts of the ships.

$$5.2 + 0.038L \quad (mm)$$

4 The thickness of face plates is not to be less than that required for the web plates, and the sectional area of face plates amidships is not to be less than that obtained from the following formula. Beyond the midship part, the sectional area may be gradually reduced to 0.85 *times* the midship value at the end parts of the ships.

$$7.9 + 0.4L \quad (cm^2)$$

2.2.3 Floor Plates

1 In ships with the bottom of transverse framing, the standard spacing of floors is to comply with the requirements in **3.2.1**.

2 In ships with the bottom of longitudinal framing, floors are to be so arranged that their spacing is not more than about 3.5 *m*.

3 Upper edges of floor plates at any part are not to be below the level of upper edge at the centre line.

4 In the midship part of the ships, the depth of floor at the toe of frame brackets is to be not less than 0.5 *times* d_0 specified in **-5**. (*See* **Fig. 5.2.1**)

5 The scantlings of floor plates are not to be less than that obtained from the following formulae:

Depth at the centre line: $0.0625l$ (m)

Thickness: $9d_0 + 3.6$ (mm) or $11mm$, whichever is the smaller.

Section modulus: $4.27Shl^2$ (cm^3)

Where:

S : Spacing(m) of floor

h : d (m) or 0.66D (m), whichever is greater

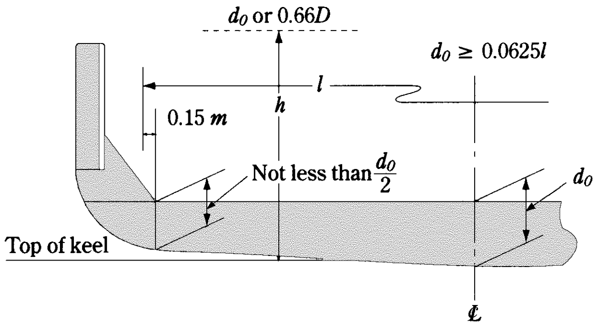
l : Distance (m) between the toes of frame brackets plus 0.3 m measured at amidship.

Where curved floors are provided, the length l may be suitably modified. (*See* **Fig. 5.2.1**)

6 The thickness of face plates on the floor plates is not to be less than that required for the floor plates, and the breadth of face plates is to be adequate to prevent lateral instability of the floors.

7 Beyond 0.5L amidships, the thickness of floor plates may be gradually reduced to 0.85 *times* the value specified in **-5** at the end parts of the ships.

Fig. 5.2.1 Shape of Floors



2.2.4 Bottom Longitudinals

1 The standard spacing of bottom longitudinals is obtained from the following formula:

$$2L+550 \quad (mm)$$

2 The section modulus of bottom longitudinals is not to be less than that obtained from the following formula, and is not to be less than 24 cm^3:

$$6.88Shl^2 \quad (cm^3)$$

Where:

l : Spacing (m) of solid floors

S : Spacing (m) of bottom longitudinals

h : Vertical distance (m) from the longitudinals to a point of d + 0.026L above the top of keel

2.3 Double Bottoms

2.3.1 General

1 No structural member of the double bottom construction is to be less than 5 mm in thickness.

2 Where the longitudinal system of framing is transformed into the transverse system, or 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.

3 Bottom structure of holds intended to carry heavy cargoes is to be subjected to special consideration.

2.3.2 Centre Girder

1 Centre girder is to extend as far forward and afterward as practicable.

2 The thickness of centre girder plate is not to be less than that obtained from the following formula:

$$0.05L+5 \quad (mm)$$

2.3.3 Side Girders

1 Side girders in 0.5L amidships 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 side shell plating does not exceed approximately 4.6 m.

2 The thickness of side girders or half-height girders is not to be less than that obtained from the following formula:

$$0.65\sqrt{L}+1.5 \quad (mm)$$

2.3.4 Solid Floors

1 Solid floors are to be provided at under transverse bulkheads.

2 The thickness of solid floors is not to be less than that obtained from the following formulae:

In ships with transverse framing: $0.6\sqrt{L}+1.5$ (mm)

In barges with longitudinal framing: $0.7\sqrt{L}+1.5$ (mm)

3 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.

2.3.5 Open Floors

1 Where the double bottom is frame transversely, open floors are to be provided at every hold frame between solid floors in accordance with the requirements in **2.3.5**.

2 The section modulus of frames is not to be less than that obtained from the following formula.

$6Shl^2$ (cm^3)

Where:

l : Distance (m) between the brackets attached to the centre girder and the margin plate. Where side girders are provided, l is the greatest distance between the vertical stiffeners on side girders and the brackets.

S : Spacing (m) of frames

h : d + 0.026L (m).

3 The section modulus of reverse frames is not to be less than that obtained from the formula in **-2** equal to 0.85 *times* the value specified for frames at the same location.

2.3.6 Longitudinals

1 The standard spacing of longitudinals is obtained from the following formula:

$2L+550$ (mm)

2 The section modulus of bottom longitudinals is not to be less than that obtained from the following formula, and is not to be less than 24 cm^3.

$6.88Shl^2$ (cm^3)

Where:

l : Spacing of solid floors (m).

S : Spacing of longitudinals (m).

h : Vertical distance from the longitudinals to a point of d + 0.026L above the top of keel.

3 The section modulus of inner bottom longitudinals is not to be less than that obtained from the formula in **-2** equal to 0.85 *times* the value specified for bottom longitudinals in the same location.

2.3.7 Inner Bottom Plating

1 The thickness of inner bottom plating is not to be less than that obtained from the following formula:

$3.8S\sqrt{d}+1.5$ (mm)

Where:

S : Spacing of inner bottom longitudinals for longitudinally framed inner bottom plating, or spacing of floor plates for transversely framed inner bottom plating (m).

2 In ships which regularly handle cargoes by grabs or similar mechanical appliances, the thickness of inner bottom plating is not to be less than that obtained from the following formula, unless ceiling is provided.

$3.8S\sqrt{d}+5.0$ (mm)

Where:

S : As stipulated in **-1**

Chapter 3 FRAMES

3.1 General

3.1.1 Transverse Strength

For ships with long holds or hatchways in length, additional stiffening is to be made by means of increasing scantlings of frames, provision of web frames, etc. to compensate the transverse strength of hull.

3.1.2 Frames in Way of Deep Tanks

The strength of frames in way of deep tanks is not to be less than that required for stiffeners on deep tank bulkheads.

3.2 Frame Spacing

3.2.1 Transverse Frame Spacing

1 The standard spacing of transverse frame is obtained from the following formula:

$$450 + 2L \quad (mm)$$

2 Transverse frame spacing in fore and after peaks is not to exceed 610*mm* or the standard spacing specified in **-1**, whichever is smaller.

3 The requirements in **-2** may be modified, where structural arrangement or scantlings are suitably considered.

3.2.2 Longitudinal Frame Spacing

The standard spacing of longitudinal frames is obtained from the following formula:

$$550 + 2L \quad (mm)$$

3.2.3 Consideration for Frame Spacing Exceeding the Standard

Where the spacing of frames is equal to or above 250*mm* plus the standard spacing specified in **3.2.1** and **3.2.2**, the scantlings and structural arrangement of single and double bottoms and of other relevant structures are to be specially considered.

3.3 Transverse Hold Frames

3.3.1 Scantlings

The section modulus of transverse hold frames provided below the upper deck is not to be less than that obtained from the following formula, and is not to be less than $24cm^3$.

$$2.08Shl^2 \quad (cm^3)$$

Where:

S : Frame spacing (m)

l : Vertical distance (m) from the top of inner bottom plating or single bottom floors at side to the top of deck beams above the frames

h : Vertical distance (m) from the lower end of the hold frame to a point of $d + 0.044L - 0.54$ above the top of the keel

3.4 Side Longitudinals and Other Structural Members

3.4.1 Side Longitudinals

The section modulus of side longitudinals below the upper deck is to be as required in the following **(1)** and **(2)**, and is not to be less than $24cm^3$:

(1) The section modulus of side longitudinals for the midship part is not to be less than that obtained from the following formulae, whichever is greater.

$6.88Shl^2 \quad (cm^3)$

$2.32\sqrt{L}Sl^2 \quad (cm^3)$

Where:

S : Spacing (m) of longitudinals

l : Distance (m) between the web frames or between the transverse bulkhead and the web frame

h : Vertical distance (m) from the lower end of the hold frame to a point of $d + 0.044L - 0.54$ above the top of the keel

(2) Beyond the midship part, the section modulus of side longitudinals may be gradually reduced towards the end of ships, and may be 0.85 *times* that obtained from the formula in **(1)** at the ends.

3.4.2 Web Frames

1 The web frames supporting side longitudinals are to be arranged at an interval not exceeding about 4.8 *m* at positions where solid floors are provided.

2 The scantlings of web frames are not to be less than that obtained from the following formulae:

Section modulus: $4.7Shl^2 \quad (cm^3)$

Thickness of web: $0.045\dfrac{Shl}{d_1} + 2.5 \quad (mm)$

Where:

S : Web frame spacing (m).

l : Vertical distance (m) from the top of inner bottom plating or single bottom floors at side to the deck at the top of web frames
However, where there are effective deck transverses, l may be measured up to the lower surface of such transverse.

h : Vertical distance (m) from the lower end of l to a point of $d + 0.044L - 0.54$ above the top of the keel, but is to be taken as $1.43l$ (m), where it is less than $1.43l$ (m).

d_1 : Depth (m) of web frames subtracted by the depth of slot for longitudinals

Chapter 4 BEAMS

4.1 General

4.1.1 Camber of Weather Deck

The standard camber of weather deck is B/50 at the midship.

4.1.2 End Connection 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 uphold the sectional area and to have sufficient strength to withstand 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.

4.1.3 Parts where Longitudinal Beams are transformed to Transverse Beams

In the parts where the longitudinal beams are transformed to the transverse beams, special care is to be taken to keep the continuity of strength.

4.2 Longitudinal Beams

4.2.1 Spacing

The standard spacing of the longitudinal beams is obtained from the following formula:

$$2L + 550(mm)$$

4.2.2 Proportion

1 Longitudinal beams are to be supported by deck transverses at intervals of approximately 3.5 *metres*, and in strength deck of midship part are to be of slenderness ratio not greater than 60. However, this requirement may be suitably modified where longitudinal beams are given a sufficient strength to prevent buckling.

2 The depth of flat bars used for longitudinal beams is not to exceed 15 *times* the thickness of flat bars.

4.2.3 Section Modulus of Longitudinal Beams

1 The section modulus of longitudinal beams outside the line of opening on strength decks of the midship part is not to be less than that obtained from the following formula:

$$0.97Shl^2 \quad (cm^3)$$

Where:

S : Spacing (m) of longitudinal beams

h : Deck load (kN/m^2) specified in **11.2**

l : Horizontal distance (m) between bulkhead and deck transverse or between deck transverses

2 Beyond the midship part, the section modulus of longitudinal beams outside the line of openings on strength decks may be gradually reduced, but the section modulus is not to be less than that obtained from the following formula:

$$0.37Shl^2 \quad (cm^3)$$

S, h and l : As specified in **-1**.

3 The section modulus of longitudinal beams, except where specified in **-1** and **-2**, is not to be less than that obtained from the formula in above **-2**.

4.2.4 Deck Transverse supporting Longitudinal Beams

Deck transverses supporting longitudinal beams are provided at the positions of solid floors.

4.3 Transverse Beams

4.3.1 Arrangement of Transverse Beams

Transverse beams are to be provided on every frame.

4.3.2 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 superstructure decks as far as practicable.

4.3.3 Section Modulus of Transverse Beams

The section modulus of transverse beams is not to be less than that obtained from the following formula:

$$0.37Shl^2 \quad (cm^3)$$

Where:

- S : Spacing (m) of transverse beams
- h : Deck load (kN/m^2) specified in **11.2**
- l : Horizontal distance (m) from the inner edge of beam brackets to the longitudinal deck girder, or between the longitudinal deck girders

4.4 Beams on Top of Deep Tanks

4.4.1 Section Modulus

The section modulus of beams at deck forming the top of deep tanks is to be in accordance with this Chapter and **8.2.2**.

4.5 Deck Beams Supporting Especially Heavy Loads

4.5.1 Reinforcement of Deck Beams

The deck beams supporting especially heavy loads or arranged at the ends of superstructures or deckhouses, in way of windlasses and auxiliary machinery, etc. are to be properly reinforced by increasing the scantlings of the beams, or by the addition of deck girders or pillars.

Chapter 5 PILLARS AND TRUSSES

5.1 General

5.1.1 Arrangement

1 Pillars and trusses are to be provided in line with girders in single bottom or double bottom or as close thereto as practicable. And the structures under pillars and trusses are to be of sufficient strength to distribute the load effectively.

2 The head and heel of pillars and trusses which may be subjected to tensile loads such as pillars and trusses supporting deep tank tops are to be efficiently connected to withstand the tensile loads.

5.2 Scantlings of Pillars

5.2.1 Sectional Area of Pillars

The sectional area of pillars is not to be less than that obtained from the following formula:

$$\frac{0.223w}{2.72-\dfrac{l}{k_0}} \ (cm^2)$$

Where:

l : Length (m) of the pillars

$$k_0 = \sqrt{\frac{I}{A}}$$

I : The least moment of inertia (cm^4) of the pillar

A : Sectional area (cm^2) of the pillar

w : Deck load (kN) supported by pillars as specified in **5.2.2**

5.2.2 Load supported by Pillars

Load w supported by pillars is not to be less than that obtained from the following formula:

$Sbh\,(kN)$

S : Distance (m) between the mid-points of two adjacent spans of girders supported by the pillars or the stiffeners or the girders on bulkheads (*See* **Fig. 5.5.1**)

b : Distance (m) between the mid-points of two adjacent spans of beams supported by the pillars or the beam brackets (*See* **Fig. 5.5.1**)

h : Deck loads (kN/m^2) specified in **11.2** for the deck supported

5.2.3 Thickness of Plates of Pillars

1 The plate thickness of tubular pillars is not to be less than obtained from the following formula:

$0.022d_p + 4.6(mm)$

d_p : Outside diameter (mm) of the tubular pillar

However, this requirement may be suitably modified for pillars provided in accommodation spaces.

2 The thickness of web and flange of built-up pillars is to be sufficient for the prevention of local buckling.

5.2.4 Outside Diameters of Round Pillars

The outside diameter of solid round pillars and tubular pillars is not to be less than 50*mm*.

5.2.5 Pillars provided in Deep Tanks

1 Pillars provided in deep tanks are not to be tubular pillars.

2 The scantlings of pillars installed in deep tanks are not to be less than that obtained from the formula in **5.2.1.**

5.3 Trusses

5.3.1 Pillars

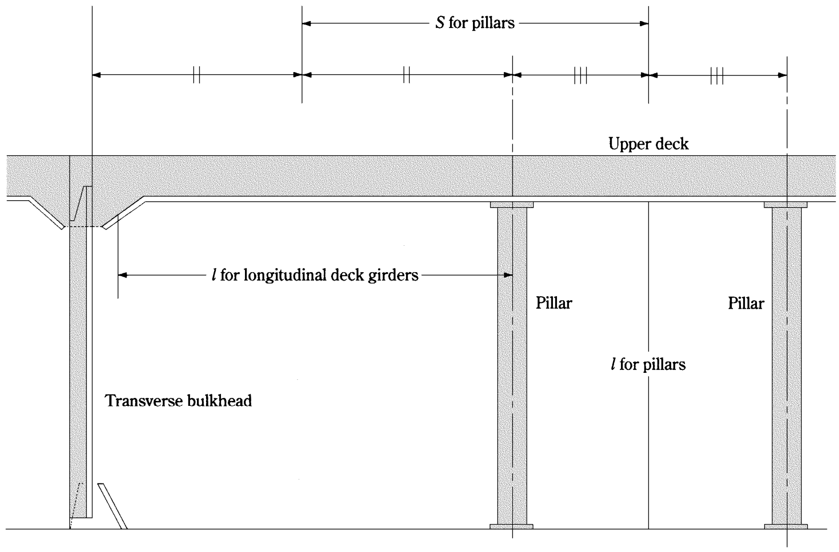
The scantlings of pillars in the truss structure are to comply with the requirements in **5.2**.

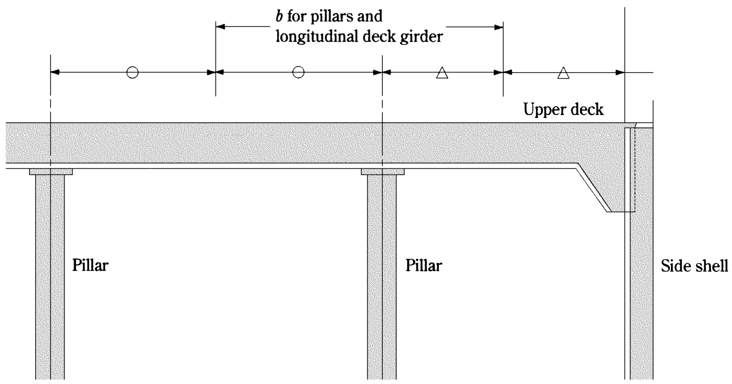
5.3.2 Diagonals

1 Diagonals in trusses are to be arranged so as to have angle of inclination of about 45 *degrees*.

2 The sectional area of diagonals is not to be less than 0.5 *times* the value specified in **5.3.1**.

Fig. 5.5.1 The Way of Measuring *S*, *b* and *l* for Pillars, Transverse and Longitudinal Girder





Chapter 6 DECK GIRDERS

6.1 General

6.1.1 Application

Transverse deck girders supporting longitudinal beams and longitudinal deck girders supporting transverse beams are to be in accordance with the requirements in this Chapter.

6.1.2 Arrangement

In way of the top of tanks, deck girders are to be arranged at intervals not exceeding 4.6 *metres* as far as practicable.

6.1.3 Construction

1 Deck girders are to be composed of face plates provided along the lower edge.

2 Tripping brackets are to be provided at intervals 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:

$$85.4\sqrt{d_0 l}\ (mm)$$

Where:

d_0 : Depth (m) of girders

l : Distance (m) between the supports of girders

However, where effective tripping brackets are provided, they may be taken as the supports.

4 The depth of girders between bulkheads is to be constant between two adjacent bulkheads, and not to be less than 2.5 *times* that of slots for beams.

5 The girders are to have sufficient rigidity to prevent excessive deflection of decks and excessive additional stresses in deck beams.

6.1.4 End Connection

1 End connections of deck girders are to be in accordance with the requirements in **1.3.4**.

2 Bulkhead stiffeners and girders at the ends of deck girders are to be suitably strengthened to support deck girder.

3 Longitudinal deck girders are to be continuous or to be effectively connected so as to maintain the continuity at ends.

6.2 Longitudinal Deck Girders

6.2.1 Section Modulus of Girders

1 The section modulus of longitudinal deck girders outside the line of openings on upper decks of midship part is not to be less than that obtained from the following formula:

$$1.1bhl^2 \quad (cm^3)$$

Where:

b : Distance (m) between the mid-point of the distances between the girder in question and the girders or bulkheads located immediately both fore and aft

h : Deck loads (kN/m^2) specified in **11.2**

l : Distance (m) between the centres of pillars or from the centre of the pillar to the bulkhead

Where the longitudinal deck girder is effectively bracketed to bulkhead, l may be suitably modified.

2 Beyond the midship part, the section modulus of longitudinal deck girders outside the line of openings on upper decks may be gradually reduced, but the section modulus is not to be less than that obtained from the following formula:

$0.411bhl^2$ (cm^3)

b, h and l : As specified in **-1**

3 The section modulus of longitudinal deck girders for parts other than that specified in **-1** and **-2** is not to be less than that obtained from the formula in **-2**.

6.2.2 Thickness of Web Plates

The thickness of web plates is not to be less than that obtained from the following formula:

$10S_1 + 2.5(mm)$

Where:

S_1 : Spacing (m) of web stiffeners or depth of the girders, whichever is smaller

6.3 Transverse Deck Girders

6.3.1 Section Modulus of Girders

The section modulus of transverse deck girders is not to be less than that obtained from the following formula:

$0.411bhl^2$ (cm^3)

Where:

b : Distance (m) between the centres of two adjacent girders or bulkheads

h : Deck loads (kN/m^2) specified in **11.2**

l : Distance (m) between the centres of pillars or from the centre of the pillar to the inner edge of the beam bracket

6.3.2 Thickness of Web Plates

The thickness of web plates is to be generally in accordance with the requirements in **6.2.2**.

6.4 Deck Girders in Tanks

6.4.1 Section Modulus of Girders

The section modulus of deck girders in tanks is to be in accordance with the requirements in **6.2.1** or **6.3.1** and the requirements in **8.2.3-1**.

6.4.2 Thickness of Web Plates

The thickness of web plates is to in accordance with the requirements in **8.2.3-3**.

6.5 Hatch Side Girders

6.5.1 Girders having Deep Coamings above Decks

Where deep coamings are provided above decks such as hatchways in weather decks, the coaming plate up to an including the horizontal coaming stiffener may be added to the calculation of the section modulus subject to the approval by the Society.

6.5.2 Brackets of Hatch Side Girders not extended to Bulkheads

Where hatch side girders do not extend to the bulkheads, brackets extending for at least two frame spaces beyond the ends of hatchways are to be provided.

6.5.3 Strength Continuity at Hatchway Corners

At hatchway corners, the face plates of hatch side girders and hatch end beams are to be effectively connected so as to maintain the strength continuity.

6.6 Hatch End Beams

6.6.1 Scantlings

The construction and scantlings of hatch end beams are to be generally in accordance with the requirements in **6.3** and **6.4**.

Chapter 7 WATERTIGHT BULKHEADS

7.1 Arrangement of Watertight Bulkheads

7.1.1 Transverse Bulkheads

The ships are to have transverse bulkheads at a suitable position.

7.1.2 Hold Bulkheads

The ships are to have hold bulkheads so as to make the spacing of adjacent bulkheads to be under 30*m* as possible, in addition to the bulkheads specified in **7.1.1**.

7.1.3 Chain Lockers

Chain Lockers are to be watertight.

7.2 Construction of Watertight Bulkheads

7.2.1 Thickness of Bulkhead Plates

The thickness of bulkhead plates is not to be less than that obtained from the following formula:

$$3.2S\sqrt{h} + 2.5 (mm)$$

S : Spacing (*m*) of stiffeners

h : Vertical distance (*m*) measured from the lower edge of the bulkhead plates to the upper deck at the centre line of ship. In no case is it to be less than 3.4 *metres*.

7.2.2 Stiffeners

The section modulus of bulkhead stiffeners is not to be less than that obtained from the following formula:

$$2.8CShl^2 (cm^3)$$

Where:

l : Span (*m*) measured between the adjacent supports of stiffeners including the length of connection. Where girders are provided, l is the distance from the heel of end connection to the first girder or the distance between the girders.

S : Spacing (*m*) of stiffeners

h : Vertical distance (*m*) measured from the mid-point of l for vertical stiffeners, and from the mid-point of the distance between the adjacent stiffeners for horizontal stiffeners, to the top of upper deck at the centre line of ship. Where the vertical distance is less than 6.0 *metres*, h is to be taken as 1.2 *metres* plus 0.8 *times* the vertical distance.

C : Coefficients as given in **Table 5.7.1**

Table 5.7.1 Value of C

The other end of stiffeners	One end of stiffeners	
	Lug-connection, bracketed or supported by vertical girders	End of stiffeners unattached
Lug-connection, Bracketed or supported by vertical girders	1.00	1.35
End of stiffeners unattached	1.35	2.00

7.2.3 Girders Supporting Bulkhead Stiffeners

1 The section modulus of girders is not to be less than that obtained from the following formula:

$$4.75Shl^2 (cm^3)$$

Where:

S : Breadth (m) of the area supported by the girder

h : Vertical distance (m) measured from the mid-point of l for vertical girders, and from the mid-point of S for horizontal girders, to the top of upper deck at the centre line of the ship. Where the vertical distance is less than 6.0 *metres*, h is to be taken as 1.2 *metres* plus 0.8 *times* the vertical distance.

l : Span (m) between the adjacent supports of girders

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.

$$10hl^4 (cm^4)$$

Where:

h and l : As specified in **-1**

3 The thickness of web plates is not to be less than that obtained from the following formula:

$$10S_1 + 2.5 (mm)$$

Where:

S_1 : Spacing (m) of web stiffeners or depth of girders, whichever is smaller

4 Tripping brackets are to be provided at an interval of about 3 *metres*, and these brackets are to be so arranged as to support the face plates.

Chapter 8 DEEP TANKS

8.1 General

8.1.1 Definition

The deep tank is a tank used for carriage of water, fuel oil and other liquids, forming a part of the hull construction. The deep tanks used for carriage of oils are designated as “deep oil tanks”, if necessary.

8.1.2 Application

Peak tank bulkheads and boundary bulkheads of deep tank are to be constructed 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 requirements in **Chapter 7**, as well.

8.1.3 Divisions in Tanks

1 Deep tanks are to be of proper size and to be provided with such longitudinal watertight divisions as necessary to meet the requirements for stability of the ship in service conditions as well as while the tanks are being filled or discharged.

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 are necessary to minimize the dynamic forces acting to the structure.

3 Where it is impracticable to comply with the requirements in **-2**, the scantlings required in this Chapter are to be properly increase.

8.2 Deep Tank Bulkheads

8.2.1 Bulkhead Plates

The thickness of deep tank bulkhead plating is not to be less than that obtained from the following formula:

$$3.6S\sqrt{h} + 2.5 (mm)$$

Where:

S : Spacing of stiffeners (m)

h : Vertical distance (m) measured from the lower edge of plate to the top of overflow pipes

However, for bulkhead stiffeners of large tanks, additional water pressure is to be appropriately considered.

8.2.2 Bulkhead Stiffeners

The section modulus of bulkhead stiffeners is not to be less than that obtained from the following formula:

$$7CShl^2 \ (cm^3)$$

S and l : As specified in **7.2.2**

h: Vertical distances (m) measured from the mid-point of l for vertical stiffeners, and from the mid-point of distance between the adjacent stiffeners for horizontal stiffeners, to the top of the overflow pipes

However, for bulkhead stiffeners of large tanks, additional water pressure is to be appropriately considered.

C : Coefficient given in **Table 5.8.1**, according to the type of end connections.

Table 5.8.1 Values of C

The other end of stiffeners	One end of stiffeners		
	Connection by brackets	Lug-connection or supported by girders	End of stiffener unattached
Connection by brackets	0.70	0.85	1.30
Lug-connection or supported by girders	0.85	1.00	1.50
End of stiffeners unattached	1.30	1.50	1.50

8.2.3 Girders supporting Bulkhead Stiffeners

1 The section modulus of girders is not to be less than obtained from the following formula:

$$7.13Shl^2\ (cm^3)$$

S : Breadth (m) of the area supported by the girder

h : Vertical distance (m) measured from the mid-point of S for horizontal girders, and from the mid-point of l for vertical girders, to the top of overflow pipes

l : Span (m) between the adjacent support of girders

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.

$$30hl^4\ (cm^4)$$

h and l : As specified in **-1**

3 The thickness of web plates is not to be less than that obtained from the following formula:

$$10S_1 + 2.5(mm)$$

Where:

S_1 : Spacing (m) of web stiffeners or the depth of girders, whichever is smaller

8.3 Fittings of Deep Tanks

8.3.1 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.

8.3.2 Cofferdams

1 Oiltight cofferdams are to be provided between tanks for carrying oils and those carrying fresh water such as that for personnel use, boiler feed water etc., to prevent the fresh water from being contaminated by the oil.

2 Crew spaces are not to be directly adjacent to the tanks for carriage of fuel oil. Such compartments are to be separated from the fuel oil tanks by cofferdams which are well ventilated and accessible. Where the top of fuel oil tanks has no opening and is coated with incombustible covering of 38*mm* and over in thickness, the cofferdam between such compartments and the top of fuel oil tanks may be omitted.

Chapter 9 LONGITUDINAL STRENGTH

9.1 Longitudinal Strength

9.1.1 Section Modulus of Hull

1 The section modulus of the transverse section of the hull at the middle point of L is not to be less than the value of W_{min} obtained from the following formulae:

$$W_{min} = 34.5 D_s L (B + 12) \ (cm^3) \text{ for } L \le 75m$$

$$W_{min} = 0.46 D_s L^2 (B + 12) \ (cm^3) \text{ for } L > 75m$$

2 Additional requirements concerning special considerations for longitudinal strength, for example where cargoes are loaded inhomogeneously, may be required where deemed necessary by the Society.

9.1.2 Calculation of Section Modulus of Transverse Section of Hull

The section modulus of the hull is to be calculated in accordance with the followings:

(1) The section modulus at the upper deck and at the bottom are to be calculated by dividing the moment of inertia of the athwartship section about its horizontal neutral axis by the vertical distance from the neutral axis to the top of upper deck beams at side, and by the vertical distance from the neutral axis to the top of keel, respectively.

(2) Below the upper deck, all longitudinal members which are considered effective to the longitudinal strength of the hull may be included in the calculation. Above the upper deck, only the extensions of the sheer strakes may be included in the calculation.

(3) Deck openings on the strength deck are to be deducted from the sectional area used in the calculation of the section modulus. However, small openings not exceeding 2.5 *metres* in length and 1.2 *metres* in breadth need not be deducted, provided that the sum of their breadths in any transverse section is not more than $0.06(B - \sum b)$. Where, $\sum b$ is the sum of the openings exceeding 1.2 *metres* in breadth or 2.5 *metres* in length (m).

(4) The area is in mm^2 and the distance in *metres*.

9.1.3 Loading Manual

In order to enable the master to adjust the loading of cargo and ballast avoiding occurrence of unacceptable stress in the ship's structure, loading manual approved by the Society is to be supplied to the master. However, this manual may not be required in the case of barges for which the Society considers such manual is not necessary.

Chapter 10 SHELL PLATING

10.1 General

10.1.1 Special Consideration for Contact with Quay, etc.

For Ships having many opportunities of contact with quay etc., special consideration is to be given to the thickness of shell plating to prevent indent of shell plating.

10.2 Shell Plating

10.2.1 Minimum Thickness

The minimum thickness of shell plating below the strength deck is not to be less than that obtained from the following formula:

$$0.04L + 5 \quad (mm)$$

10.2.2 Thickness of Side Shell Plating

1 The thickness of side shell plating is not to be less than that obtained from the following formula:

$$3.69S\sqrt{d + 0.04L} + 2.3 \quad (mm)$$

Where:

S : Spacing (m) of longitudinal or transverse frames

2 In Ships with square bilge, the thickness of the lowest strake of side shell plating is not to be less than obtained from the formula in **-1** and **10.2.3**, whichever is greater.

10.2.3 Thickness of Bottom Shell Plating

The thickness of bottom shell plating (including keel plate and bilge strake) is to be as required in the following **(1)** and **(2)**.

(1) In ships with transverse framing, the thickness is not to be less than that obtained from the following formula:

$$4.23S\sqrt{d + 0.035L} + 2.3 \quad (mm)$$

Where:

S : Spacing (m) of transverse frames

(2) In ships with longitudinal framing, the thickness is not to be less than that obtained from the following formula.

$$3.6S\sqrt{d + 0.035L} + 2.3 \quad (mm)$$

Where:

S : Spacing (m) of longitudinal frames

Chapter 11 DECKS

11.1 General

11.1.1 Steel Deck Plating

Decks are to be plated from side to side of the ship except where there are specialized deck openings. However, decks may be of only stringer plates and tie plates, subject to the approval by the Society.

11.1.2 Watertightness of Decks

Weather decks are to be made watertight. Weather decks, however, may be made weathertight, subject to the approval by the Society.

11.1.3 Compensation for Openings

Hatchways or other openings on decks are to have well rounded corners, and suitable compensation is to be provided as necessary.

11.2 Deck Load

11.2.1 Value of Deck Load *h*

1 Deck load h (kN/m^2) for decks intended to carry ordinary cargoes or stores is to be in accordance with the following **(1)** through **(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/or other cargoes are intended to be carried on the weather deck, h is to be the maximum design cargo weight per unit area of deck (kN/m^2), or the value specified in **-2**, whichever is 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 **(3)**.

(1) For the freeboard decks, superstructure deck and top of deckhouses on the freeboard deck, h is not to be less than that obtained from the following formula:

$$a(0.067L - y) \quad (kN/m^2)$$

Where:

a : As given by **Table 5.11.1**.

y : Vertical distance (m) from the designed maximum load line to the weather deck at side, and y is to be measured at midship.

(2) Notwithstanding the provision in **(1)**, h is not to be less than obtained from the formulae given by **Table 5.11.2**. However, where the h value calculated from the formula in **Table 5.11.2** is less than 12.8, the h value is to be taken as 12.8.

Table 5.11.1 Values of *a*

a			
Deck plating	Beams	Pillars	Deck girders
6.90	4.60	2.25	2.25[1] 3.45[2]

Notes:

1 For longitudinal deck girders of the upper deck for the midship part

2 For deck girders other than 1

Table 5.11.2 Minimum Value of h

h	C		
	Beams	Pillars, Longitudinal and transverse deck girders	Deck plating
$C\sqrt{L+50}$	1.37	1.18	2.05

11.3 Effective Sectional Area of Strength Deck

11.3.1 Definition

The effective sectional area of the strength deck is the sectional area, on each side of the ship, of steel plating, longitudinal beams, girders, etc. extending for 0.5L amidships.

11.3.2 Effective Sectional Area of Strength Deck

1 The effective sectional area for the midship part for which the modulus of athwartship section of the hull is specified in **Chapter 9** is to be so determined as to comply with the requirements in **Chapter 9**.

2 Beyond the midship part of Ship, the effective sectional area may be gradually reduced, and at 0.15L from both ends it is not to be less than 0.5 *times* the area required for the midship part.

11.4 Deck Plating

11.4.1 Thickness of Deck Plating

1 The thickness of deck plating is not to be less than that obtained from the formula in **(1)** or **(2)**. However, within enclosed spaces such as superstructures and deckhouses, the thickness may be reduced by 1 *mm*.

(1) The thickness of strength deck plating outside the line of openings for the midship part is not to be less than that obtained from the following formula.

(a) For decks with longitudinal beams

$$1.47S\sqrt{h}+1.5 \quad (mm)$$

(b) For decks with transverse beams

$$1.63S\sqrt{h}+1.5 \quad (mm)$$

Where:

S : Spacing (m) of longitudinal beams

h : Deck load (kN/m^2) specified in **12.2**

(2) The thickness of strength deck plating except where specified in **(1)** and of other decks is not to be less than obtained from the following formula.

$$1.25S\sqrt{h}+1.5 \quad (mm)$$

Where:

S and h : As specified in **(1)**

2 Notwithstanding the requirements in **-1**, the thickness of deck plating is not to be less than 5 *mm*.

3 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.

11.4.2 Deck Plating Forming Part of Tanks

The thickness of deck plating which forms part of tanks is not to be less than required in **8.2.1**, taking the beam spacing as the stiffener spacing.

11.4.3 Deck Plating under Boilers or Refrigerated Cargoes

1 The thickness of deck plating under boilers is to be increased by 3 *mm* above the normal thickness.

2 The thickness of deck plating under refrigerating chamber 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.

Chapter 12 SUPERSTRUCTURES AND DECKHOUSES

12.1 General

12.1.1 Ships with superstructures and deckhouses

Ships with superstructures and deckhouses are to comply with the relevant requirements in **Part Q of the Rules for the Survey and Construction of Steel Ships**.

Chapter 13 HATCHWAYS AND OTHER DECK OPENINGS

13.1 General

13.1.1 Application

1 The requirements of this Chapter are to apply to the hatchways on the exposed parts of upper deck of the ships.

2 Where the ship has an unusually large freeboard, the requirements in this Chapter may be reduced subject to the approval by the Society.

13.2 Hatchways

13.2.1 Hatchway Coamings

1 The height of coamings above the upper surface of deck may be as given in **(1)** and **(2)**.

(1) 380 *mm* for hatchway whose opening area is $1.5m^2$ and under

(2) 450 *mm* for elsewhere

2 The thickness of hatchway coamings is not to be less than that obtained from the following formula.

$0.05L + 5.0$ (*mm*)

3 On the hatchway coamings, horizontal stiffeners are to be provided at an appropriate position, and the upper edges of the hatchway coamings are to be stiffened by half round bars or other suitable means.

4 The hatchway coamings are to be stiffened with efficient brackets or stays fixed with the horizontal stiffeners and the deck at an interval of not greater than about 3.0 *metres*.

13.2.2 Protection of Hatchways

Hatchways are to be protected from the weather appropriately. Where the measures deemed appropriate by the Society are taken, the protection of hatchways may be omitted.

Chapter 14 EQUIPMENT

14.1 Anchors, Chain Cables and Ropes

14.1.1 General

1 Ships, according to their equipment numbers, are to be provided with anchors, chain cables and ropes which are not less than that given in **Table 5.14.1**.

2 Anchors, chain cables and ropes for ships having equipment numbers not more than 70 or more than 3210 are to be determined by the Society.

3 Anchors, chain cables, wire ropes and fibre ropes are to be in compliance with the requirements in **Chapter 2**, **3.1 of Chapter 3**, **Chapter 4** and **Chapter 5, Part L of Rules for the Survey and Construction of Steel Ships** or to be those deemed appropriate by the Society.

4 Notwithstanding the provisions specified in **-1** to **-2** above, in cases where the owner of ships request modification of requirements with its reasons, the Society may permit equipment which is less than that given in **Table 5.14.1** to be provided or permit omission of a part or all equipment specified in **Chapter 14** of this Part.

14.1.2 Unmanned Barges

Notwithstanding the provisions in **-1** to **-3** of **14.1.1**, for the unmanned barges the following requirements are applied:

(1) The number of anchors may be one of the unit weight in **Table 5.14.1**.

(2) The length of chain cables may be half of length in **Table 5.14.1**.

(3) Except where specified in **(1)** and **(2)**, the **Table 5.14.1** is applied.

14.1.3 Equipment Numbers

Equipment number is the value obtained from the following formula:

$W^{2/3}+2.0hB+0.1A$

W : Full load displacement (t).

h and A : Values specified in the following **(1)** to **(3)**.

(1) h is the value obtained from the following formula:

$f+h'$

f : Vertical distance, at the midship, from the load line to the top of upper deck beam at side (m).

h' : Height from the upper 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:

$fL+\sum h''l$

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 upper deck within the length of barge 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)**, screen and bulwarks more than 1.5 *metres* in height are to be regarded as parts of superstructures or deckhouses.

Table 5.14.1 Anchors, Chain Cables and Ropes

Equipment letter	Equipment number		Anchor		Chain cable (stud link chain)				Mooring line		
			Number	Mass per anchor (stock less anchor)	Total length	Diameter			Number	Length of each line	Breaking load
						Grade 1	Grade 2	Grade 3			
	over	Up to		*kg*	*m*	*mm*	*mm*	*mm*		*m*	*kN*
RB A 2	70	90	2	180	220	14	12.5		3	80	● 34
RB A 3	90	110	2	240	220	16	14		3	100	● 37
RB A 4	110	130	2	300	247.5	17.5	16		3	110	● 39
RB A 5	130	150	2	360	247.5	19	17.5		3	110	● 44
RB B 1	150	175	2	420	275	20.5	17.5		3	120	● 49
RB B 2	175	205	2	480	275	22	19		3	120	● 54
RB B 3	205	240	2	570	302.5	24	20.5		3	120	● 59
RB B 4	240	280	2	660	302.5	26	22		4	120	● 64
RB B 5	280	320	2	780	330	28	24		4	120	● 69
RB C 1	320	360	2	900	357.5	30	26		4	140	● 74
RB C 2	360	400	2	1,020	357.5	32	28		4	140	● 78
RB C 3	400	450	2	1,140	385	34	30		4	140	● 88
RB C 4	450	500	2	1,290	385	36	32		4	140	● 98
RB C 5	500	550	2	1,440	412.5	38	34		4	140	● 108
RB D 1	550	600	2	1,590	412.5	40	34		4	160	● 123
RB D 2	600	660	2	1,740	440	42	36		4	160	● 132
RB D 3	660	720	2	1,920	440	44	38		4	160	● 147
RB D 4	720	780	2	2,100	440	46	40		4	160	● 157
RB D 5	780	840	2	2,280	467.5	48	42		4	170	● 172
RB E 1	840	910	2	2,460	467.5	50	44		4	170	● 186
RB E 2	910	980	2	2,640	467.5	52	46	40	4	170	● 201
RB E 3	980	1,060	2	2,850	495	54	48	42	4	170	● 216
RB E 4	1,060	1,140	2	3,060	495	56	50	44	4	180	⊕ 230
RB E 5	1,140	1,220	2	3,300	495	58	50	46	4	180	⊕ 250
RB F 1	1,220	1,300	2	3,540	522.5	60	52	46	4	180	⊕ 270
RB F 2	1,300	1,390	2	3,780	522.5	62	54	48	4	180	⊕ 284
RB F 3	1,390	1,480	2	4,050	522.5	64	56	50	4	180	⊕ 309
RB F 4	1,480	1,570	2	4,320	550	66	58	50	4	180	⊕ 324
RB F 5	1,570	1,670	2	4,590	550	68	60	52	5	190	⊕ 324
RB G 1	1,670	1,790	2	4,890	550	70	62	54	5	190	⊕ 333
RB G 2	1,790	1,930	2	5,250	577.5	73	64	56	5	190	⊕ 353
RB G 3	1,930	2,080	2	5,610	577.5	76	66	58	5	190	⊕ 378
RB G 4	2,080	2,230	2	6,000	577.5	78	68	60	5	190	⊕ 402
RB G 5	2,230	2,380	2	6,450	605	81	70	62	5	200	⊕ 422
RB H 1	2,380	2,530	2	6,900	605	84	73	64	5	200	⊕ 451
RB H 2	2,530	2,700	2	7,350	605	87	76	66	5	200	⊕ 480
RB H 3	2,700	2,870	2	7,800	632.5	90	78	68	6	200	⊕ 480
RB H 4	2,870	3,040	2	8,300	632.5	92	81	70	6	200	◎490
RB H 5	3,040	3,210	2	8,700	632.5	95	84	73	6	200	◎500

Notes:

1. In cases where wire ropes are used, the following wire ropes corresponding to the marks shown in the Table, ●(6×12), ⊕ (6×24) and ◎(6×37) are to be provided as standards.
2. Length of chain cables may be that including shackles for connection.

3. In cases where equipment other than that complying with **Chapter 2**, **3.1 of Chapter 3**, **Chapter 4** and **Chapter 5, Part L of Rules for the Survey and Construction of Steel Ships** is provided in accordance with **14.1.1-3**, diameters of chain cables are to be to the satisfaction of the Society.
4. Wire ropes may be used in lieu of chain cables.

14.1.4 Anchors

1 Notwithstanding the provisions of **14.1.1-1**, in cases where two anchors are provided, the mass of one of the two anchors may be 85% of the mass given in **Table 5.14.1**.

2 In cases where stocked anchors are used, the mass excluding the stock is to be 0.8 *times* the mass given in **Table 5.14.1**.

3 In cases where high holding power anchors are used, the mass of each anchor may be 0.75 *times* the mass given in **Table 5.14.1**.

4 Where super high holding power anchors are used, the mass of each anchor may be 0.5 *times* the mass given in **Table 5.14.1**. However, super high holding power anchor mass is not to exceed 1,500 *kg*.

Chapter 15 PONTOON BARGES

15.1 General

15.1.1 Application

1 The requirements in this Chapter apply to steel pontoon barges with longitudinal framing intended for carriage cargoes on the upper deck only.

2 Unless otherwise specially specified in this Chapter, relevant requirements of other Chapters in this Part are to be applied as appropriate.

15.2 Construction

15.2.1 General

Special consideration is to be given, such as provision of longitudinal bulkheads at the centre line or similar strengthened constructions.

15.2.2 Arrangement

Bottom transverses, side transverses and deck transverses are to be provided at an interval of less than about 3.5 *metres* in one plane.

15.2.3 Bottom Longitudinals

The section modulus of bottom longitudinals is not to be less than that obtained from the following formula:

$7.6SDl^2$ (cm^3)

S : Spacing (m) of longitudinals

l : Span (m) measured between the adjacent supports of longitudinals

15.2.4 Bottom Transverses

The scantlings of bottom transverses are not to be less than that obtained from the following formulae:

Section modulus:$5.9SDl^2$ (cm^3)

Thickness of web:$10d_0 + 2.5$ (mm)

S : Spacing (m) of transverses

l : Span (m) measured between the adjacent supports of transverses

d_0 : Depth (m) of web

15.2.5 Side Longitudinals

The section modulus of side longitudinals is not to be less than that obtained from the following formula.

$7.6Shl^2$ (cm^3)

S : Spacing (m) of longitudinals

l : Span (m) measured between the adjacent supports of longitudinals

h : Vertical distance from the longitudinals to a point of D above the top of keel, but to be taken as $0.3\sqrt{L}$ (m), where the distance is less than $0.3\sqrt{L}$ (m)

15.2.6 Side Transverses

The scantlings of side transverses are not to be less than that obtained from the following formulae:

Section modulus:$6.4Shl^2$ (cm^3)

Thickness of web:$10d_0 + 2.5$(mm)

S : Spacing (m) of transverses

l : Span (m) measured between the adjacent supports of transverses

h : Vertical distance (m) from the centre of l to a point of D above the top of keel, but to be taken as $0.3\sqrt{L}$ (m), where the distance is less than $0.3\sqrt{L}$ (m)

d_0 : Depth (m) of web

15.2.7 Longitudinal Beams

1 The section modulus of longitudinal beams for the midship part is not to be less than that obtained from the following formula:

$0.77Shl^2$ (cm^3)

S : Spacing (m) of longitudinal beams

l : Span (m) measured between the adjacent supports of longitudinal beams

h : Deck load (kN/m^2) specified in **11.2**

2 Beyond the midship part, the section modulus of longitudinal beams may be gradually reduced, but the section modulus is not to be less than that obtained from the following formula:

$0.37Shl^2$ (cm^3)

S, h and l :As specified in **-1**

15.2.8 Deck Transverses

The scantlings of deck transverses are not to be less than that obtained from the following formulae:

Section modulus: $0.411Shl^2$ (cm^3)

Thickness of web: $10d_0 + 2.5$ (mm)

S : Spacing (m) of deck transverses

l : Span (m) measured between the adjacent supports of deck transverses

h : Deck load (kN/m^2) specified in **11.2**

d_0 : Depth (m) of web

Chapter 16 TANK BARGES

16.1 General

16.1.1 Application

1 The requirements in this Chapter apply to the tank barges intended for carriage crude oils, petroleum products having absolute vapour pressure less than 0.28*MPa* at 37.8°*C*, or other similar liquid cargoes in bulk.

2 Unless otherwise specially specified in this Chapter, relevant requirements of other Chapters in this Part are to be applied as appropriate.

16.2 Structural Members in Cargo Oil Spaces

16.2.1 Longitudinal Strength

1 The section modulus of the transverse section of the hull for the midship part is not to be less than obtained from the following formulae, whichever is greater:

Z_1 : $0.88(0.03L+5)\, L^2 B\, (C_b + 0.7)\ (cm^3)$

Z_2 : $6.15C\{1.28(0.0028L + 0.46)L^2 BC_b (1 + 0.04L/B) + Ms\}(cm^3)$

C_b : Block coefficient

C : As given in **Table 5.16.1**

Ms : Longitudinal bending moment (*kN-m*) in still water specified in **-3**

2 Additional requirements concerning special considerations for longitudinal strength, for example where cargoes are loaded inhomogeneously, may be required where deemed necessary by the Society.

3 The longitudinal bending moments in still water, *Ms*, are taken the maximum sagging and hogging moments calculated for all of designed loaded and ballast conditions by the method deemed appropriate by the Society. Furthermore, in a pusher barge, the effect of the joint part is to be considered to the longitudinal bending moment.

4 For tank barges less than 60 *metres* in length the requirement of Z_2 in **-1** above may be dispensed with. However, longitudinal bending moment in still water are to be calculated for tank barges designed for special loading or ballasting.

Table 5.16.1 Coefficient *C*

	Sagging condition	Hogging condition
Upper deck	1.00	1.03
Bottom	1.06	1.03

16.2.2 Thickness of Members

The thickness of structural members in cargo oil spaces is to be in accordance with the following:

(1) The thickness of shell plating is to be as required in **Chapter 10**. But the thickness of shell plating obtained from the formula in **10.2.2** and **10.2.3** is to be increased by 0.5*mm* above that;

(2) The thickness of upper deck plating is to be as required in **Chapter 11**. But the thickness of upper deck plating obtained from the formula in **11.4.1** is to be increased by 0.5*mm* above that;

(3) The thickness of webs of girders is to be increased by 1*mm* above that obtained from the relevant formulae;

16.2.3 Scantlings of Members

The section moduli of bottom longitudinals, side longitudinals, longitudinal beams, transverse girders, bulkhead stiffeners and longitudinal girders in cargo oil spaces are not to be less than 1.1 *times* that of obtained from the formulae in **Chapter 15**.

Part 6 INTACT STABILITY

Chapter 1 GENERAL

1.1 General

1.1.1 Application

1 The requirements on intact stability (hereinafter referred to as “stability” in this Part) in this Part apply to the following ships:

(1) Ships of 24 *metres* in length and over;

(2) Ships of 20 *gross tonnage* and over.

2 This requirements may be suitably modified based on certain conditions of navigation area etc. subject to approval by the Society.

3 Particular attention should be paid to complying with the requirement of national regulations of the flag-government of ships and national regulations of the government of sovereign nation in which ships navigate, in addition to the requirements in this Part.

4 Notwithstanding the provisions of preceding **-1**, considering the navigating area and records of application etc., other standards may be regarded as equivalent to this Part.

1.1.2 Special Cases in Application

Notwithstanding the provisions of **1.1.1**, in case of the ships considered inadequate to be fully and/or directly applied the requirements in this Part because of some special reasons (*e.g*. novel design features, unusual form of ships), stability will be individually determined by the Society.

1.1.3 Definitions

1 The definition of “downflooding angle” refers to the angle of heel at which openings in the hull, superstructures or deckhouses which cannot be closed weathertight, immerse.

2 Terms not defined in this Chapter are subject to the provisions in other Chapters of the Rules.

1.2 Stability Information

1.2.1 Stability Information Booklet

Ships are to be provided with a stability information booklet approved by the Society, to ensure the enough stability of the ship under varying conditions of service. Such booklet is to include principal particulars regarding the ship’s stability, the results of stability experiments and information as necessary by the master to verify the ship’s stability. However, for barges, a stability information booklet is not required to be provided on board.

1.2.2 Stability Computer

1 Where a computer for stability calculation is on board the ship as a supplement to the stability information booklet, such computer is to be approved by the Society.

2 The computer specified in **-1** above, is to be provided with an operation manual.

1.3 Marking of draughts

1.3.1 Marking of bow and stern draughts

Every ship is to have scales of draughts marked clearly at the bow and stern. In the case where the draught marks are not located where they are easily readable, or operational constraints for a particular trade make it difficult to read the draught marks, then the ship is to also be fitted with a reliable draught indicating system by which the bow and stern draughts can be determined.

Chapter 2 INTACT STABILITY REQUIREMENTS

2.1 General

2.1.1 General

1 Stability curves and heeling moment curves are to be prepared by the method deemed appropriate by the Society for all designed loading conditions and they are to be verified to comply with the requirements in **2.2**.

2 Free surface effects are to be accounted for in all conditions of loading.

3 In cases where anti-rolling devices are installed in a ship, the requirements given in **2.2** are to be satisfied when such devices are in operation and when there is either a failure of power supply to the device(s) or a failure of the device(s).

4 Influences such as the icing of topsides, water trapped on deck, etc., adversely affect stability and the Administration is advised to take these into account, so far as is deemed necessary.

5 Provisions are to be made for a safe margin of stability at all stages of the navigation, regard being given to additions of weight, such as those due to the absorption of water and icing as well as to losses of weight such as those due to the consumption of fuel and stores.

6 Curves or tables of minimum operational metacentric height (*GM*) or maximum centre of gravity (*VCG*) are to extend over the full range of operational trims.

2.1.2 Calculation on Stability

Stability is to be calculated under the following conditions.

(1) In preparing stability curves, the position centre of gravity is to be determined on the basis of the data obtained at inclining test required in **2.3.2, Part 2**.

(2) Free surface effects of liquid in tanks are to be of what the stability during navigation under all loading condition is most severely affected.

(3) Where anti-rolling devices are installed in a ship, the requirements in this Chapter are to be satisfied taking into consideration the negative effects of installation of anti-rolling devices.

2.2 General Stability Requirements

2.2.1 Stability Curves

1 The stability curves of tugs and pushers are to comply with the following requirements in **Fig. 6.2.1**.

(1) G_0M is not to be less than 0.15 *m*.

(2) θ_{max} is to be comply with the following requirements:

 (a) θ_{max} is not to be less than 15°

 (b) With respect to the requirements given in **Fig. 6.2.1**, the area under a stability curve between 0° and θ_{max} (m･rad) is to be not less than:

$$0.055 + 0.001(30° - \theta_{max})$$

Where:

θ_{max}: Heeling angle at which the righting arm reaches maximum (*degree*). If the downflooding angle is less than the heeling angle at which the righting arm reaches maximum, θ_{max} is to be replaced by the downflooding angle.

G_0M: Initial metacentric height (*m*) corrected by free surface effect

2 Notwithstanding the provisions of **-1**, the stability curves of tugs and pushers which are less than 24 *metres* in length and barges may comply with the following requirements in **Fig. 6.2.1**.

(1) G_0M is not to be taken less than zero.

(2) GZ_{max} is not to be taken less than 0.0215*B* or 0.275m, whichever is less.

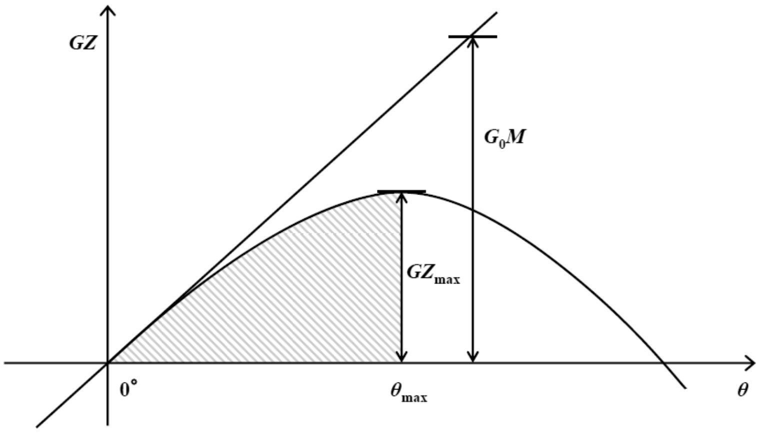
Where:

G_0M: As specified in **-1** .

GZ_{max}: Maximum righting lever (m).

(3) For tugs and pushers, special consideration is to be paid to stability during designated operations.

Fig. 6.2.1 Stability Curve (General Stability Requirements)



Part 7 MACHINERY INSTALLATIONS

Chapter 1 GENERAL

1.1 General

1.1.1 Scope

1 The requirements of this Part apply to the main propulsion machinery, power transmission systems, shafting systems, propellers, prime movers other than the main propulsion machinery, boilers and related equipment, incinerators, pressure vessels, auxiliaries, piping systems, and all of their respective control systems (hereinafter all of the above will be referred to as "machinery installations").

2 The requirements in **Chapter 1** through **Chapter 14** apply to tugs and pushers.

3 The requirements in **Chapter 1** and **Chapter 15** apply to barges.

1.1.2 Equivalency

Machinery installations that do not fully comply with the requirements of this Part may be accepted provided that they are deemed by the Society to be equivalent to those specified in this Part.

1.1.3 Machinery Installations with Novel Design Features

Machinery installations with novel design features may be accepted, provided the installation complies with any additional requirements on design and test procedures (other than those in this Part) as deemed necessary, with those results satisfactory to the Society.

1.1.4 Modification of Requirements

1 For the following machinery installations, piping systems and all their respective control systems, some requirements of this Part may be modified appropriately provided that the Society considers such modifications acceptable:

(1) Small prime movers for either driving generators or auxiliary machinery (including power transmission systems and shafting systems)

(2) Auxiliary machineries for cargo handling and their prime movers

(3) Machinery installations as deemed appropriate by the Society after considering their capacity, purpose and conditions of service

2 In cases where requested by the Owner, the Society may modify some of the requirements in this Part in consideration of the navigating areas and operating mode of the concerned ship.

1.1.5 Terminology

1 In this Part auxiliaries are classified into five groups. When auxiliaries have multiple uses and may be classified as belonging to more than one group, they are deemed to belong to the higher class. The five groups are given as follows with group **(1)** being the highest and group **(5)** being the lowest:

(1) Auxiliary machinery essential for main propulsion.
Defined as all auxiliary machinery that is used for the operation of the main propulsion machinery.

(2) Auxiliary machinery for manoeuvring and safety.
Defined as all auxiliary machinery that is used for ensuring safe manoeuvring, the safety of the ship as well as the safety of all persons on board.

(3) Auxiliary machinery for cargo handling.
Defined as all auxiliary machinery that is used for cargo loading and unloading as well as for cargo maintenance.

(4) Auxiliary machinery for specific use.
Defined as all auxiliary machinery that is used for a specific operation while either under way or at anchorage.

(5) Other auxiliary machinery.

Defined as any other auxiliary machinery that is not included in **(1)** to **(4)**.

2 Propulsion Shafting Systems

Defined as the thrust shaft, intermediate shaft, stern tube shaft, propeller shaft, their respective bearings as well as all propellers.

1.1.6 Drawings and Data to be Submitted

All the drawings and data that are to be submitted in connection with machinery installations are to conform to the requirements specified in each Chapter of this Part.

1.2 Materials

1.2.1 General

Materials intended to be used for machinery installations are to be selected in consideration of the purpose and the conditions of service of the concerned machinery installation. Materials intended to be used for principal components are to be of those tested and inspected in accordance with the requirements specified in this Part.

1.3 General Requirements for Machinery Installations of Tugs and Pushers

1.3.1 General

1 Machinery installations are to be of a design and construction adequate for the service for which they are intended and are to be so installed and protected as to reduce to a minimum any danger to persons on board, due regard being paid to moving parts, hot surfaces and other hazards. The design is to have regard to the purpose for which the equipment is intended, the working conditions to which it will be subjected and the environmental conditions on board.

2 Special consideration is to be given to the reliability of any of the single essential machinery and components listed below. In addition, for ships in which unconventional machinery is used as the main propulsion machinery and propulsion shafting system, additional machinery which enables the ship to proceed at a navigable speed in the event of possible failure of the machinery may be required by the Society.

(1) For diesel ships:
Diesel engines used as the main propulsion machinery, high elastic couplings, reduction gears and propulsion shafting systems

(2) For electric propulsion ships:
Propulsion motors, reduction gears and propulsion shafting systems

3 For electric propulsion ships, two or more propulsion generators are to be provided.

4 Main propulsion machinery and prime movers for driving generators, and auxiliary machinery (excluding auxiliary machinery for specific use etc.) and their prime movers that are installed in the ships are to be designed to operate under the conditions given in **Table 7.1.1**. However, deviation from the angles given in **Table 7.1.1** may be permitted after taking into consideration the type, size and service conditions of the ship.

5 Machinery installations are to be designed to operate smoothly under the temperature conditions given in **Table 7.1.2**.

6 Provisions are to be made for the facilitation of the cleaning, the inspection and the maintenance of machinery installations.

7 Special consideration is to be given to the design, construction and installation of the machinery installations so that undue stresses caused by vibrations do not occur within normal operating ranges.

Table 7.1.1 Angle of Inclination

<table>
<tr><th rowspan="2">Type of machinery installation</th><th colspan="2">Athwartships[2]</th><th colspan="2">Bow-and-stern[2]</th></tr>
<tr><th>Static inclination (List)</th><th>Dynamic inclination (Rolling)</th><th>Static inclination (Trim)</th><th>Dynamic inclination (Pitching)</th></tr>
<tr><td>Main propulsion machinery
Essential boilers
Prime movers driving generators auxiliary machinery (excluding auxiliary machinery for specific use, etc.) and their driving units</td><td>15°</td><td>22.5°</td><td>5° [3]</td><td>7.5°</td></tr>
<tr><td>Switchgears[1] (Circuit breakers, etc.)
Automatic or remote operated equipment</td><td>22.5°</td><td>22.5°</td><td>10°</td><td>10°</td></tr>
</table>

Notes:

(1) Up to an angle of inclination of 45°, undesired switching operations or operational changes are not to be caused.

(2) Athwartships and bow-and-stern inclinations may occur simultaneously.

(3) Where the length of the ship exceeds 100 *m*, the fore-and-aft static angle of inclination may be taken as follows:

$\theta = 500/L$

θ : The static angle of inclination in *degrees* (°)

L : Length of the ship specified in **2.1.4, Part 1** (*m*)

Table 7.1.2 Temperature

<table>
<tr><th></th><th>Installed location</th><th>Temperature (°C)</th></tr>
<tr><td rowspan="3">Air</td><td>In enclosed spaces</td><td>0 to 45[1]</td></tr>
<tr><td>Machinery components or boilers in spaces subject to temperatures exceeding 45°C, and below 0°C</td><td>According to specific conditions</td></tr>
<tr><td>On the open deck</td><td>-25 to 45[1]</td></tr>
<tr><td>Water</td><td>-</td><td>32[1]</td></tr>
</table>

Note:

(1) Other temperatures deemed appropriate by the Society might be accepted in cases where the Society deemed appropriate.

1.3.2 Astern Power

1 Sufficient power for going astern is to be provided to secure proper control of the ship in all normal circumstances.

2 The main propulsion machinery is to be capable of maintaining in free route astern at least at 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.

3 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 the propulsion machinery.

1.3.3 Limitation in the Use of Fuel Oil

Limitation in the use of fuel oil is to comply with the requirements in **3.2.1, Part 9**.

1.3.4 Fire Protections

1 Machinery installations are to be free from leakages of fuel oil, lubricating oil and other flammable oils. For those from which these oils may leak, proper means of leading the leaked oil to a safe location are to be provided.

2 Machinery installations are to be free from the leakage of any gases that may have a harmful effect on the health of the operator as well as any flammable gases. When fear of such gas leaks exists, machinery installations are to be installed in well-ventilated spaces that are capable of purging such gases quickly.

3 In addition to **1.3.4**, fire protections are to comply with the requirements in **3.2** and **4.1**, **Part 9**.

1.3.5 Ventilating Systems for Machinery Spaces

Machinery spaces of category *A* are to be adequately ventilated so as to ensure that when any of the machinery or boilers therein are operating at full power, that an adequate supply of air is maintained to the spaces for the safety and comfort of personnel and the operation of the machinery in all weather conditions. Any other machinery spaces other than those classified as category *A* are to be adequately ventilated in a manner that is appropriate for the purpose of that machinery space.

1.3.6 Machinery Spaces

1 Machinery spaces are to be sufficiently large enough to ensure the effective operation of any machinery installations installed in that machinery space.

2 Means to reduce machinery space noise are to be provided as much as possible. Excessive sources of noise are to be blocked or isolated. In cases where crew members need to work in such spaces, another space for them to escape to is to be provided. Furthermore, noise insulation devices to enter such spaces are to be provided as necessary.

1.3.7 Communication between the Navigating Bridge and Control Stations for the Speed and Direction of Thrust of the Propellers

Communication between the navigating bridge and control stations for the speed and direction of thrust of the propellers are to comply with following requirements:

(1) 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 the direction of thrust of the propellers are normally controlled. One of these means is to be an engine-room telegraph which provides visual indication of any such orders and responses both on the navigating bridge and in such control stations mentioned above.

(2) Means of communication as deemed appropriate by the Society, are to be provided from the navigating bridge and the engine-room to any position, other than those specified in **(1)** above, from which either the speed or direction of thrust of the propellers may be controlled.

1.4 General Requirements for Machinery Installations of Barges

1.4.1 General

1 The machinery is to be capable of satisfactorily operating under the service conditions and environmental conditions on board.

2 All rotating, reciprocating or high temperature parts of machinery as well as live parts of electrical apparatus liable to come into inadvertent contact with operators or other persons are to be provided with suitable protection to prevent injuries.

3 It is recommended that no unhealthy gases or dangerous gases that may cause fire be allowed to leak from the machinery. Where it is impracticable, the machinery is to be located in well-ventilated spaces and to be capable of discharging such gases.

4 The machinery is to be so constructed and installed as to be capable of being easily maintained.

5 Machinery used for important systems, excluding mooring systems, is to be capable of being easily and satisfactorily operated when the barge is inclined from the normal at any angle up to 15° transversely and 10° longitudinally, and when rolling up to 22.5° from the vertical.

6 Power transmission systems, shaft couplings and gearing systems used for important systems are to be so designed and manufactured as to have strength sufficient to withstand maximum working stress under normal operating conditions.

1.5 Tests

1.5.1 Shop Tests

1 Before being installed on board, all equipment and components constituting a machinery installation (excluding auxiliary machinery for specific use, etc.) are to be tested at facilities (hereinafter referred to as “Shop Tests”) that have the proper equipment necessary to conduct such tests in accordance with the relevant requirements of this Part.

2 For equipment and component parts of the machinery installations where shop tests are not specified in the requirements in any chapter of this Part, and for those of auxiliary machinery for specific use etc., records of the tests carried out by the manufacturer are to be submitted to the Society upon request.

1.5.2 Mass-production Equipment

For equipment manufactured by a mass-production system deemed appropriate by the Society, a test procedure suited to the production method may be accepted in place of the tests specified in the Rules upon the request of the manufacturer, notwithstanding the requirements of **1.5.1-1** above.

1.5.3 Omission of Tests

Where machinery installations have test certificates that are deemed appropriate by the Society, a part of or all of the tests for the machinery specified in **1.5.1** may be omitted.

1.5.4 Tests after Installation on Board

1 Machinery is to be tested after installation on board in accordance with the requirements specified in each chapter of this Part.

2 Certain auxiliary machinery for specific use, etc., as deemed necessary by the Society, are to be tested to the satisfaction of the Society at an appropriate time before being put into service in order to verify that they do not endanger either the ship or the crew during normal operation.

3 The Society may require other tests than those specified in this Part when deemed necessary.

Chapter 2 DIESEL ENGINES

2.1 General

2.1.1 Scope

1 The requirements of this Chapter apply to diesel engines which are used as the main propulsion machinery or used to drive generators and auxiliaries (hereinafter referred to in this Chapter as all auxiliaries excluding auxiliary machinery for specific use etc.).

2 Electronically-controlled diesel engines which are used as the main propulsion machinery are to be in accordance with the requirements specified otherwise by the Society in addition to those in this Chapter.

2.1.2 Drawings and Data

Drawings and data to be submitted are generally as follows:

(1) Drawings and data for approval
- (a) Engine particulars (to be in the form designated by the Society)
- (b) Details of welding procedures for principal components
- (c) Crankshaft (including component details, shaft coupling bolts, balance weights and their fastening bolts)
- (d) Connecting rod and its bearings (including bolts details) of 4-stroke cycle engines
- (e) Thrust shaft (if integral with engine)
- (f) Arrangement of foundation bolts (including foundation bolts, chocks and stoppers)
- (g) Structural detail and arrangement of crankcase explosion relief valves
- (h) Material specifications of principal components
- (i) High pressure oil pipe for driving exhaust valve with its shielding
- (j) High pressure fuel oil pipe with its shielding and clamping
- (k) Piping arrangements fitted to engines (including fuel oil, lubricating oil, cooling oil, cooling water, pneumatic and hydraulic systems, and information regarding the size, materials and working pressure of pipes)
- (l) Sectional assembly of exhaust driven turboblower

(2) Drawings and data for reference
- (a) A list containing all drawings and data submitted (including relevant drawing numbers and revision status)
- (b) Longitudinal section of engine
- (c) Transverse cross-section of engine
- (d) Bedplate and thrust block (if integral with engine)
- (e) Frames
- (f) Cylinder cover, cylinder jacket, and cylinder liner
- (g) Piston and gudgeon pin
- (h) Tie rods (including coupling and set-screw)
- (i) Assembly of piston and piston rod
- (j) Piston rod
- (k) Connecting rod and its bearings (including bolts details) of 2-stroke cycle engines
- (l) Assembly of thrust bearing
- (m) Assembly of crosshead
- (n) Camshaft driving gear and assembly of cam and camshaft
- (o) Rocker valve gear
- (p) Fuel oil injection pump
- (q) Main bearing bolts
- (r) Cylinder cover fixing bolts and valve box fixing bolts
- (s) Flywheel (in the case of a power transmission component)
- (t) Engine control system diagram (including the monitoring, safety and alarm systems)

(u) Construction and arrangement of thermal insulation for exhaust pipes fitted to the engine
(v) Construction and arrangement of dampers, detuners, balancers or compensators, bracings as well as all calculation sheets related to engine balancing and engine vibration prevention
(w) Operation and service manuals for the engine
(x) Other drawings and data deemed necessary by the Society

2.2 Materials, Construction and Strength

2.2.1 Materials

1 Materials intended for the principal components of diesel engines and their non-destructive tests are to conform to the requirements given in **Table 7.2.1**. However, with respect to ultrasonic testing, submission or presentation of test results to the Surveyor may be considered sufficient.
2 Cylinders, pistons and other parts subjected to high temperature or pressure as well as any parts used for transmitting propulsion torque are to be of materials suitable to sufficiently withstand high temperature and loads.

2.2.2 Construction, Installation and General

1 Cylinders, pistons and other parts subjected to high temperature or pressure are to be of a construction that is suitable to sufficiently withstand the mechanical and thermal stresses.
2 Where the principal components of a diesel engine are of welded construction, they are to comply with the requirements of **Chapter 9**.
3 The frames and bedplates are to be of rigid and oiltight construction. The bedplate is to be provided with a sufficient number of foundation bolts to secure it firmly to the entire length of the engine seating.
4 Crankcase and crankcase doors are to be of sufficient strength to withstand a crankcase explosion. Crankcase doors are to be fastened sufficiently securely for them not to be readily displaced by a crankcase explosion.
5 A warning notice is to be fitted on a prominent position, preferably on a crankcase door on each side of the engine, or alternatively at the engine room control station. This warning notice is to specify that whenever overheating is suspected within the crankcase, the crankcase doors or sight holes are not to be opened until a reasonable time, sufficient to permit adequate cooling has elapsed after stopping the engine.
6 Ventilation of crankcase, and any arrangement which could produce a flow of external air into the crankcase, is not permitted except in cases **(1)** to **(3)** below.
(1) Ventilation pipes, where provided, are to be as small as practicable to minimize the inrush of air after a crankcase explosion. In addition, ventilation pipes for each engine are to be independent of any other engine. Ventilation pipes from the crankcase of main propulsion engine are to lead to a safe position on deck or to some other approved position.
(2) If provision is made for the extraction of gases from the crankcase (*e.g.* for oil mist detection purposes), the vacuum in the crankcase is not to exceed 2.5×10^{-4} *MPa*
(3) In cases where trunk piston type dual fuel diesel engines are provided with crankcase ventilation for preventing the accumulation of leaked gas.
7 The ambient reference conditions for the purpose of determining the power of diesel engines are to be as follows:

Total barometric pressure: 0.1*MPa*
Air temperature: 45°*C*
Relative humidity: 60%
Seawater temperature (charge air intercooler-inlet): 32°*C*

Table 7.2.1 Application of Materials and Non-destructive Tests to Principal Components of Diesel Engines

Principal components			Cylinder bore D (mm)								
			$D \leq 300$			$300 < D \leq 400$			$400<D$		
			I	II	III	I	II	III	I	II	III
1	Crankshaft	Solid forged type	○	○	○	○	○	○	○	○	○
		Web, pin and journal for all built-up and semi-built-up types	○	○	○	○	○	○	○	○	○
		Others (for example welded type)	○	○	○	○	○	○	○	○	○
2	Coupling flanges on crankshaft (if not integral)								○		
3	Coupling bolts for crankshaft								○		
4	Steel piston crowns				○			○	○	○	○
5	Piston rods		○	○		○	○		○	○	○
6	Connecting rods together with connecting rod bearing caps		○	○		○	○		○	○	○
7	Steel parts of cylinder liners					○			○		
8	Steel cylinder covers				○	○		○	○	○	○
9	Bedplates of welded construction	Plates and transverse bearing girders made of forged or cast steel	○			○			○		
		Cast steel parts including welded joints		○	○		○	○		○	○
10	Thrust blocks of welded construction, plates and transverse bearing girders made of forged or cast steel		○			○			○		
11	Frames and crankcases of welded construction		○			○			○		
12	Entablatures, scavenging reserves, etc. of welded construction		○			○			○		
13	Tie rods		○	○		○	○		○	○	
14	Steel gear wheels for camshaft drives								○	○	
15	Bolts and studs (for cylinder cover crossheads, connecting rod bearings, main bearings)					○			○	○	
16	Turbine discs, blades, blower impellers and rotor shafts of exhaust driven turboblowers as well as shafts, rotors and blades of superchargers (excluding auxiliary blowers)		○	○	○	○	○	○	○	○	○
17	Crossheads								○		
18	Pipes, valves and fittings attached to engines classified in Chapter 10 as either Group I or Group II.		○			○			○		

Notes:

(1) Materials intended for the components marked by a circle in Column I are to comply with the requirements in **Part K of the Rules for the Survey and Construction of Steel Ships**.

(2) Materials intended for the components marked by a circle in Column II are to be tested by a magnetic particle test or a liquid penetrant test.

(3) Materials intended for the components marked by a circle in Column III are to be tested by an ultrasonic test.

2.3 Crankshafts

2.3.1 Solid Crankshafts

1 The diameters of crankpins and journals are to be not less than the value given by the following formula:

$$d_c = \left\{ \left(M + \sqrt{M^2 + T^2} \right) D^2 \right\}^{\frac{1}{3}} K_m K_s K_h$$

Where:

d_c : Required diameter of crankshaft (mm)

M : $10^{-2} ALP_{max}$

T : $10^{-2} BSP_{mi}$

S : Length of stroke (mm)

L : Span of bearings adjacent to crank measured from centre to centre (mm)

P_{max} :Maximum combustion pressure in cylinder (MPa)

P_{mi} : Indicated mean effective pressure (MPa)

A and B : Coefficients given in **Table 7.2.2** and **Table 7.2.3** for engines having equal firing intervals (in the case of Vee engines, those with equal firing intervals on each bank.). Special consideration will be given to values A and B for diesel engines having unequal firing intervals or for those not covered by the Tables.

D : Cylinder bore (mm)

K_m : Value given by the following **a)** or **b)** in accordance with the specified tensile strength of the crankshaft material. However, the value of K_m for materials other than steel forgings and steel castings is to be determined by the Society in each case.

a) In cases where the specified tensile strength of material exceeds 440 N/mm^2;

$$K_m = \sqrt[3]{\frac{440}{440 + \frac{2}{3}(T_s - 440)}}$$

Where:

T_s : Specified tensile strength of material (N/mm^2)

The value of T_s is not to exceed 760N/mm^2 for carbon steel forgings and 1080N/mm^2 for low alloy steel forgings.

b) In cases where the specified tensile strength of material is not more than 440N/mm^2 but not less than 400N/mm^2;

$K_m = 1.0$

K_s : Value given by the following **a)**, **b)**, or **c)** in accordance with the manufacturing method of crankshafts.

a) In cases where the crankshafts are manufactured by a special forging process approved by the Society as well as where the product quality is stable and the fatigue strength is considered to be improved by 20% or more in comparison with that of the free forging process;

$$K_s = \sqrt[3]{\frac{1}{1.15}}$$

b) In cases where the crankshafts are manufactured by a manufacturing process using a surface treatment approved by the Society as well as where the product quality is stable and the fatigue strength is recognized as being superior;

$$K_s = \sqrt[3]{\frac{1}{1 + \rho / 100}}$$

Where:

ρ : Degree of improvement in strength approved by the Society relative to the surface hardening (%)

c) In cases other than **a)** and **b)** above;

$K_s = 1.0$

K_h : Value given by the following **a)** or **b)** in accordance with the inside diameter of the crankpins or journals.

a) In cases where the inside diameter is one-third or more than that of the outside diameter;

$$K_h = \sqrt[3]{\frac{1}{1 - R^4}}$$

Where:

R : Quotient obtained by dividing the inside diameter of a hollow shaft by its outside diameter

b) In cases where the inside diameter is less than one-third of the outside diameter;
$K_h = 1.0$

Table 7.2.2 Value of Coefficients *A* and *B* for Single Acting In-line Engines

Number of cylinders	2-stroke cycle		4-stroke cycle	
	A	*B*	*A*	*B*
1	1.00	8.8	1.25	4.7
2		8.8		4.7
3		10.0		4.7
4		11.1		4.7
5		11.4		5.4
6		11.7		5.4
7		12.0		6.1
8		12.3		6.1
9		12.6		6.8
10		13.4		6.8
11		14.2		7.4
12		15.0		7.4

Table 7.2.3(1) Value of Coefficients *A* and *B* for Single Acting 2-stroke cycle Vee Engines with Parallel Connecting Rods

Number of cylinders	Minimum firing interval between two cylinders on one crankpin					
	45°		60°		90°	
	A	*B*	*A*	*B*	*A*	*B*
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

Table 7.2.3(2) Value of Coefficients *A* and *B* for Single Acting 4-stroke cycle Vee Engines with Parallel Connecting Rods

Number of Cylinders	Minimum firing interval between two cylinders on one crankpin											
	45°		60°		90°		270°		300°		315°	
	A	*B*	*A*	*B*	*A*	*B*	*A*	*B*	*A*	*B*	*A*	*B*
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

2 The dimensions of crank webs are to comply with the following requirements:

(1) The thickness and breadth of crank webs, the diameters of the crankpins and journals, are to comply with the conditions of the following formula. However, the thickness of crank webs is to be not less than 0.36 *times* the diameter of crankpins and journals. When the actual diameters of the crankpin and journal are larger than the required diameter of the crankshaft as determined by the formula in **-1**, the left side of the following formula may be multiplied by $(d_c / d_a)^3$.

$$\{0.122(2.20 - b / d_a)^2 + 0.337\}(d_a / t)^{1.4} \leq 1$$

Where:

b : Breadth of crank web (*mm*)
d_a : Actual diameter of crankpin or journal (*mm*)
t : Thickness of crank web (*mm*)

(2) The radius in fillets at the junctions of crank webs with crankpins or journals is to be not less than 0.05 *times* the actual diameter of crankpins or journals, respectively.

2.3.2 Built-up Crankshafts

1 The dimensions of crankpins and journals of built-up crankshafts are to comply with the following requirements in **(1)** and **(2)**:

(1) The diameters of crankpins and journals are to comply with the requirements in **2.3.1-1**.

(2) The diameters of axial bores in journals are to comply with the following formula:

$$D_{BG} \le D_S \cdot \sqrt{1 - \frac{4000 \cdot S_R \cdot M_{\max}}{\mu \cdot \pi \cdot D_S^2 \cdot L_S \cdot \sigma_{SP}}}$$

D_{BG} : Diameter of axial bore in journal (*mm*)
D_S : Journal diameter at the shrinkage fit (*mm*)
S_R : Safety factor against slipping (a value not less than 2 is to be taken)
M_{max} : Absolute maximum torque at the shrinkage fit (*N-m*)
μ : Coefficient for static friction (a value not greater than 0.2 is to be taken)
L_S : Length of shrinkage fit (*mm*)
σ_{SP} : Minimum yield strength of material used for journal (N/mm^2)

2 The dimensions of crank webs are to comply with the following requirements in **(1)** and **(2)**:

(1) The thickness of crank webs in way of the shrinkage fit is to comply with the following formula:

$$t \ge \frac{C_1 T D^2}{C_2 {d_h}^2} \frac{1}{\left(1 - \frac{1}{{r_s}^2}\right)}$$

$$t \ge 0.525 d_c$$

Where:

t : Thickness of crank web measured parallel to the axis (*mm*)
C_1 : 10 for 2-stroke cycle in-line engines / 16 for 4-stroke cycle in-line engines
T : Same as given in **2.3.1-1**
D : Cylinder bore (*mm*)
C_2 : $12.8\alpha - 2.4\alpha^2$, but in the case of a hollow shaft, C_2 is to be multiplied by $(1 - R^2)$

$$\alpha = \frac{Shrinkage\ allowance(mm)}{d_h} \times 10^3$$

R : Quotient obtained by dividing the inside diameter of the hollow shaft by its outside diameter
d_h : Diameter of the hole at shrinkage fit (*mm*)

$$r_s = \frac{External\ diameter\ of\ web(mm)}{d_h}$$

d_c : Required diameter of crankshaft determined by the formula in **2.3.1-1** (*mm*)

(2) The dimensions in fillets at the junctions of crank webs with crankpins of semi-built-up crankshafts are to comply with the requirements in **2.3.1-2**.

3 In cases of built-up crankshafts, the value of α used in **-2(1)** is to be within the following range:

$$\frac{1.1Y}{225} \le \alpha \le \left(\frac{1.1Y}{225} + 0.8\right)\frac{1}{1 - R^2}$$

Where:

Y : Specified yield point of crank web material (N/mm^2)
R : Quotient obtained by dividing the inside diameter of the hollow shaft by its outside diameter
α : Same as given in **-2(1)**

However, when the specified yield point of the crank web exceeds 390N/mm^2 or the value obtained by the following formula is less than 0.1, the value used for α is to be approved by the Society.

Where:

$$\frac{S-d_p-d_j}{2d_p}$$

S : Length of stroke (*mm*)

d_p : Diameter of the crankpin (*mm*)

d_j : Diameter of the journal (*mm*)

2.3.3 Shaft Couplings and Coupling Bolts

1 The diameter of coupling bolts at the joining face of the coupling between crankshafts, between a crankshaft and a thrust shaft, or between a crankshaft and a shaft mentioned in **2.2.4** is to be not less than the value obtained by the following formula.

$$d_b = 0.75\sqrt{\frac{(0.95d_c)^3}{nD}\left(\frac{440}{T_b}\right)}$$

Where:

d_b : Diameter of coupling bolts (*mm*)

n : Number of bolts

D : Diameter of pitch circle (*mm*)

d_c : Required diameter of crankshaft calculated by the formula in **2.3.1-1** when the values of K_m, K_s and K_h are replaced with 1.0 (*mm*).

T_b : Specified tensile strength of bolt material (N/mm^2)

When the specified tensile strength of the bolt material exceeds 1000N/mm^2, the value used for the formula is to be as considered appropriate by the Society.

2 Shaft couplings are to be of sufficient strength to withstand working stresses. The fillets of shaft couplings are to have enough of a radius to avoid any excessive stress concentration. Where shaft couplings are separate from the shafts, both the fitting method and the construction of the couplings are to be sufficient enough to resist astern pull. In cases where keys are used for fitting shaft couplings to shafts, the grooves for the keys are to be constructed so as to avoid any excessive stress concentration.

2.3.4 Detailed Evaluation for Strength

In cases where the crankshafts do not satisfy the requirements given in **2.3.1** and **2.3.2**, special considerations will be made provided that detailed data and calculations regarding the strength of crankshafts are submitted to the Society and are considered appropriate.

2.4 Safety Devices

2.4.1 Speed Governors and Overspeed Protective Devices

1 Each diesel engine used as main propulsion machinery in diesel ships is to be provided with a speed governor so adjusted to prevent the engine speed from exceeding the number of maximum continuous revolutions by more than 15%.

2 In addition to this speed governor, each diesel engine used as main propulsion machinery in diesel ships that has a continuous maximum output of 220*kW* or above, which can be declutched or which drives a controllable pitch propeller, is to be provided with a separate overspeed protective device. The overspeed protective device, including its driving gear, are to be independent from the governor required by **-1**, and be so adjusted that the engine speed may not exceed the number of maximum continuous revolutions by more than 20%.

3 Diesel engines used to drive generators are to be provided with governors specified in the requirements in **2.4.2, Part 8**. However, if a diesel engine which is used as main propulsion machinery for an electric propulsion ship drives a generator used to supply electrical power exclusively to propulsion motors, the requirements specified in **5.1.2-2, Part 8** are to be applied.

4 In addition to the speed governor, each diesel engine used as main propulsion machinery of electric propulsion ships and those diesel engines used to drive generators that have a maximum continuous output of 220*kW* or above are to be provided with a separate overspeed protective device. The overspeed protective device, including its driving gear, are to be independent from the governor required by **-3**, and be so adjusted that the engine speed may not exceed the number of maximum continuous revolutions by more than 15%.

2.4.2 Sentinel Valve for Overpressure in the Cylinders

Each cylinder of a diesel engine having a bore exceeding 230*mm* is to be provided with an effective sentinel valve for overpressure. This valve is to be adjusted so that it can operate at a maximum of 1.4 *times* the maximum pressure in the cylinder at maximum continuous power and does not pose a threat to crew members. However, in cases where another effective alarm for cylinder overpressure is provided, this sentinel valve may be omitted.

2.4.3 Protection against Crankcase Explosion

1 For diesel engines having a cylinder bore not less than 200*mm* or a crankcase with a gross volume not less than 0.6m^3 are to be provided with crankcase explosion relief valves of an approved type for preventing any overpressure in the event of an explosion within the crankcase. Crankcase explosion relief valves are to be in accordance with the following requirements:

(1) The valves are to be provided with lightweight spring-loaded valve discs or other quick-acting and self closing devices to relieve a crankcase of pressure in the event of an internal explosion and to prevent the inrush of air thereafter.

(2) The valve discs are to be made of ductile material capable of withstanding the shock of contact with stoppers at the full open position.

(3) The valves are to be designed and constructed to open quickly and be fully open at a pressure not greater than 0.02*MPa*.

(4) The valves are to be provided with a flame arrester that permits flow for crankcase pressure relief and prevents passage of flame following a crankcase explosion.

(5) The valves are to be provided with a copy of the manufacturer's installation and maintenance manual. This copy is to be provided on board ship.

2 The number and locations of the explosion relief valves specified in **-1** are to be in accordance with **Table 7.2.4**.

3 Additional explosion relief valves corresponding to **-1** above are to be fitted on separate spaces of crankcase such as gear or chain cases for camshaft or similar drives, when the gross volume of such spaces is not less than 0.6m^3.

4 The explosion relief valves given in **-1** and **-3** above are to conform to the following requirements **(1)** and **(2)**:

(1) The free area of each explosion relief valve is to be not less than 45cm^2.

(2) The combined free area of the valves fitted on an engine is to be not less than 115cm^2 per cubic metre of the crankcase or similar drive case specified in **-3** gross volume. The total volume of the stationary parts within the crankcase or separate space may be discounted in estimating the gross volume of the case.

Table 7.2.4 Number and Location of Explosion Relief Valves

Cylinder bore(*mm*)	Number and location of explosion relief valves
200 to below 250	At least one valve near each end, but, over 8 crankthrows, an additional valve is to be fitted near the middle of the engine.
250 to below 300	At least one valve in way of each alternate crankthrow, with a minimum of two valves.
300 and over	At least one valve in way of each crankthrow.

2.4.4 Protection against Scavenging Spaces

Scavenging spaces in open connection to the cylinders are to be provided with relief valves designed to prevent explosions that might be caused by the abnormal buildup of pressure. These devices are to be arranged so that any discharge from them does not pose any danger to the operators working in that space.

2.4.5 Crankcase Oil Mist Detection Arrangements

1 Crankcase oil mist detection arrangements are required for diesel engines of 2,250*kW* maximum continuous power and above or having cylinders of more than 300*mm* bore, and in cases of engine failure, the following means are to automatically be employed. However, in cases where alternative devices deemed appropriate by the Society are provided, such devices may be used instead of crankcase oil mist detection arrangements.

(1) In the case of crosshead engines, alarms are to activate and speeds be reduced. (However, in cases where alternative measures such as activating alarms to request such speed reductions are taken, the manual reduction of speeds may be accepted).
(2) In the case of trunk piston engines, alarms are to activate and diesel engines are to be stopped or have their fuel supply shut off.

2 The crankcase oil mist detection arrangements required in **-1** above are to be of an approved type and in accordance with the following requirements:

(1) Oil mist detection arrangements are to provide an alarm indication in the event of a foreseeable functional failure in the equipment and installation arrangements.
(2) Oil mist detection arrangements are to provide an indication that any lenses fitted in the equipment and used in determination of the oil mist level have been partially obscured to a degree that will affect the reliability of the information and alarm indication.
(3) Oil mist detection arrangements are to be capable of being tested on the test bed and board under engine standstill and engine running at normal operating conditions.
(4) Each engine is to be provided with independent oil mist detection and monitoring and a dedicated alarm. Oil mist detection and alarm information is to be able to be confirmed from a safe location away from the engine. In addition, in the case of ships which apply the **Rules for Automatic and Remote Control Systems**, the concentration of crankcase oil mist is also to be capable of being read by a monitoring panel.
(5) The layout of the arrangements, pipes and cables, pipe dimensions, the location of engine crankcase sample points, sample extraction rate and the way of maintenance and test are to be in accordance with the engine designer's and oil mist manufacturer's instructions.
(6) Where sequential oil mist detection arrangements are provided the sampling frequency and sampling time is to be as short as reasonably practicable.
(7) A copy of the maintenance and test manual is to be provided on board ship.

2.5 Associated Installations

2.5.1 Exhaust Driven Turboblowers

1 For main propulsion engine equipped with exhaust driven turboblowers, means are to be provided to ensure that the engine can be operated with sufficient power to give the ship a navigable speed in case of failure of one of the turboblowers.

2 Where the main propulsion engine can not be operable only with the exhaust driven turboblowers in case of starting or low speed range, an auxiliary of scavenging air system is to be provided. For the event of failure of such an auxiliary system, proper means are to be provided so that the main propulsion engine can be brought into the condition that its output increases enough as the exhaust driven turboblowers show their function.

2.5.2 Exhaust Gas Arrangements

1 Exhaust gas pipes with a surface temperature exceeding 220°*C* are to be water-cooled or sufficiently covered with thermal insulation. However, in case where no fire is likely to occur, the requirements may be dispensed with.

2 Exhaust gas arrangements are also to comply with the requirements specified in **11.15** in this Part.

2.5.3 Starting Arrangements

1 The starting air mains are to be protected against explosion caused by back fire from the cylinders or excessive temperature rise in the starting air manifold at the time of starting by the following arrangements **(1)** and **(2)**:

(1) An isolating non-return valve or equivalent thereto is to be provided at the starting air supply connection to each engine.
(2) An adequate rupture disc device or a flame arrester is to be fitted at the starting valve on each cylinder for direct reversing engines having a starting air manifold. At least one such device is to be fitted at the supply inlet to the starting air manifold for each non-reversing engine. However, the above mentioned device may be omitted for engines having cylinder bore not exceeding 230*mm*.

2 Where main propulsion engines are arranged for starting by compressed air, at least two starting air reservoirs are to be provided. These reservoirs are to be connected so that usage can be readily switched from one to the other. In this case, the total capacity of the starting air reservoirs is to be sufficient to provide, without replenishment, the number of consecutive starts not less than that specified in **(1)** to **(3)** below. Where the arrangements of the main propulsion engines and shafting systems are other than shown below, the required number of starts is to be as deemed appropriate by the Society.

(1) For direct reversible engines

$Z = 12C$

Where:

Z: Total number of starts of engine

C: Constant determined by the arrangement of main propulsion engines and shafting systems, where the following values are to be referred to as the standard;

C = 1.0 For single screw ships, where one engine is either coupled with the shaft directly or through reduction gears.

C = 1.5 For twin screw ships, where two engines are either coupled with the shafts directly or through reduction gear. Or, for single screw ships, where two engines are coupled with the shaft through declutchable coupling provided between engine and reduction gear.

C = 2.0 For single screw ships, where two engines are coupled with one shaft without any declutchable coupling between engine and reduction gear.

(2) For non-reversible type engines using a separate reversing gear or controllable pitch propeller, 1/2 of the total number of starts specified in **(1)** above may be accepted.

(3) For electric propulsion ships:

$Z = 6 + 3(k - 1)$

Where:

Z: Total number of starts of engine

k: Number of engines (In the case of more than 3 engines, the value of k to be used is 3.)

3 Where main propulsion engines are arranged for starting by battery, 2 sets of batteries are to be provided. The total capacity of the batteries is to be sufficient, without recharging, to provide the number of starts of the main propulsion engine required in **-2** within 30 *minutes*.

4 The starting arrangements of diesel engines which drive generators or auxiliaries are to be as deemed appropriate by the Society.

5 The starting air systems are also to comply with the requirements in **11.13**.

2.5.4 Fuel Oil Arrangements

1 Where a diesel engine is mounted on an elastic support, flexible joints approved by the Society are to be provided at the connections between the engine and the fuel oil supply pipe.

2 The fuel oil arrangements for diesel engines are additionally to comply with the requirements in **11.9** in this Part and **3.2.2, Part 9**.

2.5.5 Lubricating Oil Arrangements

1 The lubricating oil arrangements of diesel engines with a maximum continuous output exceeding 37*kW* are to be provided with alarm devices which give visible and audible alarming in the event of failure of the supply of lubricating oil or an appreciable reduction in lubricating oil pressure. Also, devices to stop the operation of the engine automatically by lower pressure after such alarms are to be provided.

2 Lubricating oil drain pipes from the engine crankcase sump to the sump tank are to be submerged at their outlet ends.

3 The lubricating oil drain pipes shown in **-4**, above of two or more engine units are not to be interconnected.

4 Arrangements for lubricating oil system are additionally to comply with the requirements in **11.10** in this Part and **3.2.3, Part 9**.

2.5.6 Cooling Arrangements

Cooling arrangements are to comply with the requirements in **11.12** in addition to the requirements in the following **(1)** and **(2)**:

(1) In engines having more than one cylinder, an adequate means is to be provided to make cooling uniform for each cylinder and piston.

(2) Drain cocks are to be fitted to water jackets and water pipe lines at their lowermost position.

2.6 Tests

2.6.1 Shop Tests

1 For components or accessories specified in **Table 7.2.5**, hydrostatic tests are to be carried out at the pressures shown in the Table.

2 For rotating assemblies of exhaust gas turboblowers, dynamic balancing tests are to be carried out after their assembly.

3 For the impellers and inducers of exhaust gas turboblowers, overspeed tests are to be carried out according to test procedures deemed appropriate by the Society.

4 For exhaust gas turboblowers, trial runs are to be carried out according to test procedures deemed appropriate by the Society.

5 For diesel engines, shop trials are to be carried out according to the test procedure deemed appropriate by the Society.

6 For diesel engines with novel design features or for those with no service records, in cases where it is deemed necessary by the Society, tests are to be carried out to verify their durability according to the procedure deemed appropriate by the Society.

Table 7.2.5 Hydrostatic Test Pressure

Part	Test Pressure(6)(MPa)
Cylinder cover, cooling space(1)	0.7
Cylinder liner, over the whole length of cooling space(2)	0.7
Cylinder jacket, cooling space	0.4(3) or 1.5P, whichever is greater
Exhaust valve, cooling space	0.4 or 1.5P, whichever is greater
Piston crown(1),(4)	0.7
Fuel injection system: Pump body (pressure side(5)), Valve(5), Pipe	1.5P or P +30, whichever is smaller
Scavenging pump cylinder	0.4
Turboblower, cooling space	0.4 or 1.5P, whichever is greater
Exhaust pipe, cooling space	0.4 or 1.5P, whichever is greater
Heat exchanger	0.4 or 1.5P, whichever is greater
Engine driven pumps	0.4 or 1.5P, whichever is greater
Piping system	Apply the requirements in **10.6**

Notes:

(1) For forged steel cylinder covers with cooling spaces that have been machined up without a welding procedure and for piston crowns, if the accurate gauging of thickness after being machined up on both the inside and the outside, and confirmed of being free from surface defects by the Surveyor, the results may be accepted as a substitution for the above hydrostatic test.

(2) Where cylinder liners are machine finished on both the inside and the outside, accurately gauged for thickness, and confirmed free from surface defects by the Surveyor, the above test pressure of cylinder liners may be reduced to 0.4MPa.

(3) For diesel engines having no cylinder liner, the hydrostatic test pressure is to be 0.7MPa.

(4) The cooling space of piston crowns of crosshead type diesel engines are to be hydrostatically tested after assembled with piston rods.

(5) Where fuel oil injection pumps and fuel injection valves are made of forged steel, the hydrostatic test may be omitted.

(6) P is the maximum working pressure (MPa).

Chapter 3 POWER TRANSMISSION SYSTEMS

3.1 General

3.1.1 Scope

The requirements of this Chapter apply to power transmission systems which transmit power from main propulsion machinery and prime movers driving generators and auxiliaries (hereinafter referred to in this Chapter as all auxiliaries excluding auxiliary machinery for specific use etc.).

3.1.2 Drawings and Data

Drawings and data to be submitted are generally as follows:

(1) Drawings:
- (a) Sectional assembly
- (b) Gears
- (c) Gear shafts
- (d) Couplings
- (e) Construction of main parts such as clutches and flexible shafts

(2) Data:
- (a) Specifications for materials used in power transmission parts (chemical compositions, heat treatment methods, mechanical properties and their test methods)
- (b) Transmitted power and number of revolutions per minute for each pinion at maximum continuous output
- (c) Particulars of each gear (number of teeth, module, pitch circle diameters, pressure angles of teeth, helix angles, face widths, centre distances, tool tip radius, backlash, amount of profile shift, amount of profile and tooth trace modification, finishing method of tooth flank, expected finishing accuracy of gears)
- (d) Welding methods of principal components (including tests and inspection)
- (e) Necessary data for the strength calculation of principal components of the power transmission systems.

3.2 Materials and Construction

3.2.1 Materials

1 Materials used for the following components (hereinafter referred to as "the principal components of the power transmission system") are to comply with the requirements in **Part K of the Rules for the Survey and Construction of Steel Ships**.

(1) Power transmission shafts and gears
(2) Power transmission parts of couplings
(3) Power transmission parts of clutches
(4) Coupling bolts

2 The principal components of power transmission systems (excluding coupling bolts, clutch discs and the like) are to have been subjected to the non-destructive tests specified in **5.1.10** and **6.1.10, Part K of the Rules for the Survey and Construction of Steel Ships**.

3.2.2 Welding

Where the principal components of power transmission systems are of welded construction, the requirements in **Chapter 9** are to be complied with.

3.2.3 General Construction of Gearings

1 Gears are to comply with the requirements in the following **(1)**, **(2)** and **(3)**.

(1) Where a gear rim is shrunk on the boss, the rim is to be thick enough to ensure sufficient strength and is to have enough shrinkage allowance against transmitted power. Where the shrinkage fit is made after tooth cutting, construction is to be such as to fully guarantee the accuracy of gearing, or the final tooth finishing is to be

carried out after the shrinkage fit.

(2) Where gears are of welded construction, they are to have sufficient rigidity and are to be stress-relieved before tooth cutting.

(3) Gears are not to be of a harmful unbalanced weight.

2 Gear casings are to have sufficient rigidity and their construction is to be such as to allow inspection and maintenance to be performed as easily as possible.

3 In cases where heavy articles are intended to be fitted onto the extended part of the pinion shaft, the construction of pinions is to be such that the whirling movement of the pinions and the deviation of the shaft centre may be minimized.

3.2.4 General Construction of Power Transmission Systems other than Gearings

1 Power transmission systems other than the gearings are to be of constructions and materials that have been previously approved by the Society, function safely and reliably and having sufficient strength against transmitted power. Where rubber couplings are used, they are to be appropriate for their conditions of use for heating due to hysteresis.

2 The construction of electro-magnetic slip couplings is to conform to the requirements in **2.4, Part 8** as well as to any other requirements deemed appropriate by the Society.

3 In cases where the clutch of the power transmission system for main propulsion is operated hydraulically or pneumatically, it is to comply with either the following **(1)** or **(2)**:

(1) At least two hydraulic pumps or two compressors of the same capacity are to be provided, the total capacity of which is to be sufficient enough to ensure the maximum continuous output of the main propulsion machinery. In addition, in cases where one pump fails, the total capacity of the remaining pumps is to be sufficient enough to ensure the navigable speed of the ship.

(2) Some other appropriate unit is to be provided in order to ensure the navigable speed of the ship in the case of hydraulic pump or compressor failure.

4 In cases where rubber couplings are used, consideration is to be given to the heat emission of the rubber elements and they are to be constructed so that inspections can be performed as easily as possible.

3.2.5 Lubricating Oil Arrangements

1 Lubricating oil arrangement is to comply with the requirements in **11.10**. Additionally, it is recommended to use strainers with magnets for gearings.

2 The lubricating oil arrangements of power transmission systems with the driving units above 37 *kW* are to be provided with alarm devices which give visible and audible alarms in the event of a failure of the supply of lubricating oil or an appreciable reduction in lubricating oil pressure.

3.3 Strength of Gears

3.3.1 Application

The requirements in **3.3** apply to external tooth cylindrical gears having an involute tooth profile. All other gears are to be as deemed appropriate by the Society.

3.3.2 General Requirements

1 The fillets between the roots of the teeth are to be as smooth and have as large of a radius as possible. It is recommended that the tooth tip and the both ends of the tooth trace are suitably chamfered.

2 Gears, which are subjected to a surface hardening process, are to have necessary flank hardness and depth of hardened zone.

3.3.3 Allowable Tangential Loads for Bending Strength

The tangential loads on gear-teeth are to satisfy the following condition for bending strength at the root section of gear-teeth:

$$P_{MCR} \leq 9.81(K_1 S_b - K_2) K_3 \left(4.85 - \frac{30.6}{Z}\right) m_n$$

Where:

P_{MCR} : Tangential load on gear-teeth at the maximum continuous output. Given by the following formula:

$$P_{MCR} = \frac{1.91H}{N_0 D_1 b} \times 10^6 \ (N/cm)$$

H : Output which the pinion shares at maximum continuous output (*kW*)

N_0 : Number of 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*)

Z : Number of teeth

m_n : Rectangular module of tooth

K_1 : External load magnification factor. Determined by the amount of fluctuating loads working on the gears and given by the following formula:

$$K_1 = \frac{1.10 P_{MCR}}{P_{MAX}}$$

P_{MAX} : Instantaneous maximum tangential load occurring within the service revolution range (*N/cm*).

Where, however, the value K_1 is unknown, the values in **Table 7.3.1** may be used.

K_2 : Internal load magnification value. This value depends on the accuracy of gears and their overlap ratio and can be derived either from the following formula or from **Fig. 7.3.1**.

$$K_2 = k_2 (Dn)^{0.8}$$

D : Pitch circle diameter of gears (*cm*)

n : Number of revolutions per minute of gears divided by 1,000.

k_2 : Value given in **Table 7.3.2**. In this case, ε_{sp} is the value derived from the following formula:

$$\varepsilon_{sp} = \frac{b_e \sin \beta_0}{0.1 \pi m_n}$$

b_e : Face width (in the case of double-helical gears, the face width is that of a single side) (*cm*)

β_0 : Helical angle

K_3 : Load magnification coefficient due to flexibility. This value depends on the face width and pitch circle diameter and is given either by the following formula or by **Fig. 7.3.2**.

$$K_3 = 1 - k_3 \left(\frac{b_t}{D_1} \right)^3$$

b_t : Total face width of pinions (in case of double-helical gears, the central gap is included) (*cm*)

D_1 : Pitch circle diameter of the pinion (*cm*)

k_3 : Value given in **Table 7.3.3**

S_b : This value depends mainly on the material of gears and is given by the following formula. However, in the case of ahead idle gears and astern gears, the values of S_b are to be 0.7 *times* and 1.2 *times* respectively. In this case, S_b is not to exceed 25.

a) In the case of gears, including bottom land, to which a surface hardening process was applied:

$$S_b = 0.83\sqrt{T}$$

b) In the case of other gears:

$$S_b = \frac{\dfrac{T+Y}{49}}{1 + (0.0096T - 2.4)\left(\dfrac{0.04}{r_0} + 0.02\right)(0.023 m_n + 0.75)}$$

T : Specified tensile strength of gear material (*N/mm*^{2})

Y : Specified yield strength of gear material (*N/mm*^{2})

r_0 : Ratio of tool tip radius to module

Table 7.3.1 Values of K_1 (3)(4)

Driving unit	Construction: Kind of coupling	Use: Gear for main propulsion	Use: Gear for auxiliaries
Steam turbine Gas turbine Electric motor	Single-stage reduction gear Multiple-stage reduction gear	1.00 1.00(1), 1.10(2)	1.15 1.15
Diesel engine	Hydraulic or electromagnetic coupling High elastic coupling Elastic coupling	1.00 0.90 0.80	1.15 1.05 0.95

Notes:

(1) Applicable only to gearing connected directly to the main propulsion shafting system.

(2) Applicable to gearing connected, through effective flexible couplings, to the propulsion shafting system.

(3) Where one pinion meshes with more than two wheels, 0.9 *times* these values may be used for the value of K_1.

(4) The value of K_1 for rigid couplings is to be approved by the Society.

Table 7.3.2 Values of k_2

Expected accuracy	$\varepsilon_{sp} \geq 1.25$	$\varepsilon_{sp} < 1.25$
Those correspond to finishing shaved or ground	0.044	0.088
Those correspond to finishing hobbed	0.11	0.22

Table 7.3.3 Values of k_3

	When one pinion meshes with one wheel	When two wheels mesh with one pinion in the positions forming a row
k_3	0.01	0.003

Fig. 7.3.1 Values of K_2

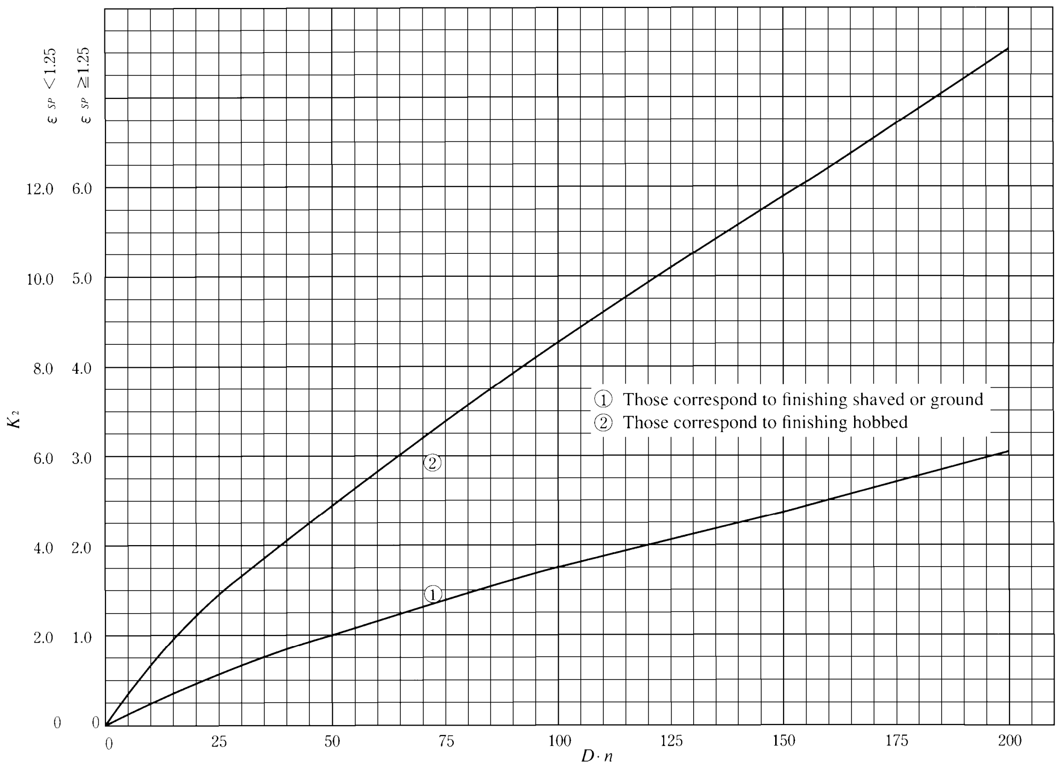
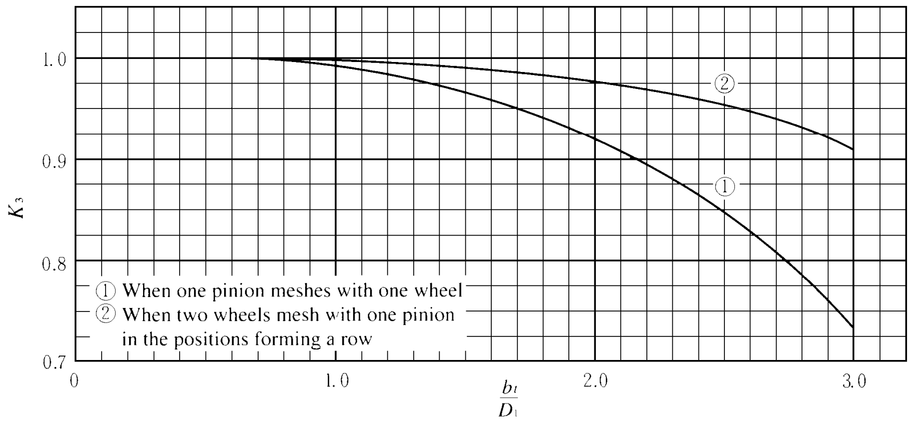


Fig. 7.3.2 Values of K_3



3.3.4 Tangential Loads for Surface Strength

The tangential loads on gear-teeth are to satisfy the following condition for limiting tooth surface strength, but these do not apply to astern gears.

$$P_{MCR} \leq 9.81(K_1 S_S - K_2) K_3 K_4 \frac{i}{1+i} D_1$$

Where:

S_S : The value related mainly to the material of gears, given by the following formula:

a) Combination of hardened gear

$$S_S = 2.23\sqrt{T_w}$$

b) Combination of other gears

$$S_S = (0.005 \frac{H_{BP}}{H_{BW}} + 0.007) T_w + 7.5$$

H_{BP} : Hardness of the tooth face of the pinion (Brinell hardness)

H_{BW} : Hardness of the tooth face of the wheel (Brinell hardness)

T_w : Specified tensile strength of wheel material (N/mm^2)

K_4 : Lubricating coefficient. This value depends on the pitch circle diameter and the number of revolutions per minute and is given either by the following formula or by **Fig. 7.3.3**. However, in the case of a combination of hardened gears, K_4 = 0.53

$$K_4 = 0.3(Dn)^{\frac{1}{6}}$$

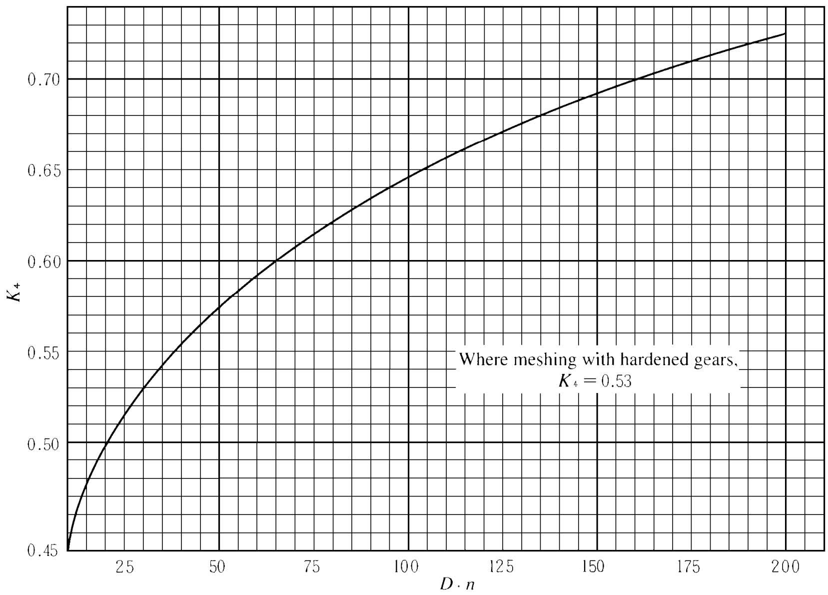
i : Gear ratio (the number of teeth of the wheel divided by the number of teeth of the pinion)

Other symbols are same as in **3.3.3**.

3.3.5 Detailed Evaluation for Strength

Special consideration will be given to the gearing devices, notwithstanding the requirements in **3.3.3** and **3.3.4**, provided that detailed data and calculations on their strength are submitted to the Society and considered appropriate.

Fig. 7.3.3 Values of K_4



3.4 Gear Shafts and Flexible Shafts

3.4.1 Gear Shafts

1 The diameter of gear shafts is to comply with the following requirements specified in **(1)** to **(3)**:

(1) The diameter of a gear shaft by which power is transmitted is not to be less than the value given by the formula in **4.2.2**. In this case, *H* and *R* in the formula represent respectively the output and the number of revolutions per minute of the shaft at the maximum continuous rating.

(2) The diameter of the pinion shaft between the pinion shaft bearings is to have sufficient rigidity against the bending force generated by the meshing of gears.

(3) The diameter of the wheel shaft between the wheel shaft bearings is not to be less than 1.16 *times* the value specified in **(1)**, when one pinion is gearing, or two pinions which are arranged at an angle less than 120° are gearing and not to be less than 1.10 *times* the value specified in **(1)** when two pinions, which are arranged at an angle more than 120°, are gearing.

2 Special consideration will be given to the gear shaft, notwithstanding the requirements in **-1**, provided that detailed data and calculations on the strength are submitted to the Society and considered appropriate.

3.4.2 Flexible Shafts

The diameter of a flexible shaft is not to be less than the value given by the following formula:

$$d = 93\sqrt[3]{\frac{560H}{N_0(T+160)}}$$

Where:

d : Diameter of the flexible shaft (*mm*)

H : Output which the flexible shaft shares at maximum continuous output (*kW*)

N_0 : Number of revolutions of the flexible shaft at maximum continuous output (*rpm*)

T : Specified tensile strength of the shaft material (*N/mm*^{2})

3.4.3 Couplings and Coupling Bolts

The dimensions of couplings and coupling bolts are to be of values not less than those obtained from the formula given in **4.2.12-1** in this Part. Furthermore, in cases where they support heavy materials in cantilever style, couplings and coupling bolts are to be designed so as to have sufficient strength to resist such weight. In addition, in the formula referred to above, d_o is the value of the shaft diameter that has been calculated according to each kind of shaft.

3.5 Tests

3.5.1 Shop Tests

1 For the parts subjected to surface hardening process, the measurement of the hardened depth is to be carried out on sample materials.

2 For parts subjected to a surface hardening process, hardness tests and non-destructive tests by suitable procedures are to be carried out.

3 For gears, accuracy tests to examine the machining accuracy of finish are to be carried out.

4 In the case of gears where the value given by the following formula exceeds 50, dynamic balancing tests are to be carried out.

$$\frac{DN_0}{1000}$$

Where:

D : Pitch circle diameter of gear (*cm*)
N_0 : Number of rotations of gear (*rpm*)

5 The contact marking of the teeth of all gearings is to be tested with a thin uniform coat of suitable paint under an appropriate load.

Chapter 4 SHAFTINGS

4.1 General

4.1.1 Scope

The requirements of this Chapter apply to propulsion shafting systems (excluding propellers) and shafting systems which transmit power from prime movers to drive generators and auxiliaries (hereinafter referred to in this Chapter as all auxiliaries excluding auxiliary machinery for specific use etc.). For torsional vibrations, the requirements in **Chapter 6** are to be complied with.

4.1.2 Drawings and Data

Drawings and data to be submitted are generally as follows:

(1) Drawings for approval (including specifications of material)
- (a) Shafting arrangement
- (b) Thrust shaft
- (c) Intermediate shaft
- (d) Stern tube shaft
- (e) Propeller shaft
- (f) Stern tube
- (g) Stern tube bearing
- (h) Stern tube sealing device
- (i) Shaft bracket bearing
- (j) Shaft couplings and coupling bolts
- (k) Shafts which transmit power to generators or auxiliaries

(2) Data for reference
- (a) Data for the calculations of shafting strength specified in this Chapter
- (b) Data which is deemed necessary by the Society

4.2 Materials, Construction and Strength

4.2.1 Materials

1 Materials used for the following components (hereinafter referred to as “the principal components of shafting”) are to be of steel forgings conforming to the requirements specified in **6.1 of Part K of the Rules for the Survey and Construction of Steel Ships**; of stainless steel forgings conforming to the requirements specified in **6.2 of Part K of the Rules for the Survey and Construction of Steel Ships**; of rolled stainless steel bars approved for shaft use conforming to the requirements specified in **3.5.1-2 of Part K of the Rules for the Survey and Construction of Steel Ships** (hereinafter, stainless steel forgings and rolled stainless steel bars are to be referred to as “stainless steel forgings, etc.”); or of material specially approved for shaft use by the Society under **1.1.1-2 of Part K of the Rules for the Survey and Construction of Steel Ships**. Built-up type shaft couplings may be of steel castings that conform to the requirements in **Part K of the Rules for the Survey and Construction of Steel Ships**.

(1) Thrust shafts
(2) Intermediate shafts
(3) Stern tube shafts
(4) Propeller shafts
(5) Shafts which transmit power to generators or auxiliaries
(6) Shaft couplings
(7) Coupling bolts

2 Depending on the type of material being used, the principal components of shafting, excluding the coupling bolts, are to have been subjected to the non-destructive tests specified either in **5.1.10**, **6.1.10** or in **6.2.10 of Part K**

of the Rules for the Survey and Construction of Steel Ships.

3 The specified tensile strength of the shaft materials is generally to be between 400 and 800 N/mm^2 and to be between 500 and 800N/mm^2 for shafts experiencing torsional vibration stress that exceeds 85 % of the value for τ_2 given in **6.2.2**.

Steel forgings with a specified tensile strength exceeding 800 N/mm^2 are not to be used for any shafts unless specially approved by the Society.

4.2.2 Intermediate Shafts

1 The diameter of the intermediate shafts of steel forgings (excluding stainless steel forgings, etc.) is not to be less than the value given by the following formula:

$$d_0 = F_1 k_1 \sqrt[3]{\frac{H}{N_0}\left(\frac{560}{T_s + 160}\right)} K$$

Where:

d_0 : Required diameter of intermediate shaft (*mm*)

H : Maximum continuous output of engine (*kW*)

N_0 : Number of revolutions of intermediate shaft at maximum continuous output (*rpm*)

F_1 : Factor given in **Table 7.4.1**

k_1 : Factor given in **Table 7.4.2**

T_s : Specified tensile strength of intermediate shaft material (N/mm^2)

The upper limit of the value of T_S used for the calculation is to be 760 N/mm^2 for carbon steel forgings and 800 N/mm^2 for low alloy steel forgings.

K : Factor for hollow shaft and given by the following formula. In cases where $d_i \le 0.4 d_a$, it may be considered that K = 1

$$K = \frac{1}{1 - \left(\frac{d_i}{d_a}\right)^4}$$

d_i : Inside diameter of hollow shaft (*mm*)

d_a : Outside diameter of hollow shaft (*mm*)

2 The diameter of the intermediate shaft of material other than specified in **-1** above is to be deemed appropriate by the Society.

Table 7.4.1 Values of F_1

For steam turbine installation, gas turbine installation, diesel installation with slip type coupling[(1)], electric propulsion installation	For all other diesel installations than those noted in the left hand column
95	100

Note:

(1) Slip type coupling signifies hydraulic coupling, electromagnetic coupling or the equivalent.

Table 7.4.2 Values of k_1

Shaft with integral flange coupling	Shaft with flange coupling either shrink fit, push fit or cold fit [(1)]	Shaft with keyway [(2)]	Shaft with transverse hole [(3)]	Shaft with longitudinal slot [(4)]	Shaft with splines [(5)]
1.0	1.0	1.1	1.1	1.2	1.15

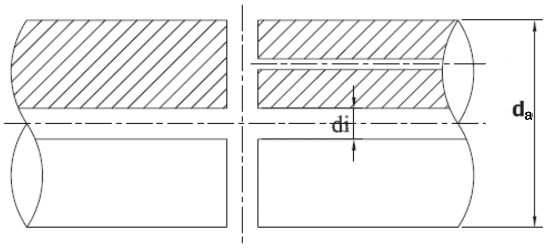
Notes:

(1) In cases where shafts, during continuous operation, experience torsional vibration stress exceeding 85 % of τ_1 given in **6.2.2-1(1)** , an increase of 1 to 2 % in diameter to the fit diameter and a blending radius nearly equal to the change in diameter are to be provided.

(2) After a length of not less than 0.2 d_0 from the end of the keyway, the diameter of a shaft may be reduced progressively to the diameter calculated with k_1=1.0.

The fillet radius in the transverse section of keyway bottom is to be 0.0125 d_0 or more.

(3) The diameter of the hole is not to be more than 0.3 d_0. When a transverse hole intersects an eccentric axial hole (*See* below), the value is to be determined by the Society based on the submitted data in each case.



(4) The shape of the slot is to be in accordance with the following: any edge rounding other than by chamfering is to be avoided in principle; the number of slots is to be 1, 2 or 3 and they are to be arranged 360, 180 or 120 degrees apart from each other respectively.

(a) $l < 0.8d_a$

(b) $d_i < 0.8d_a$

(c) $0.1d_a < e \leqq 0.2d_a$

(d) $r = e / 2$

Where:

l: slot length

d_a: outside diameter of the hollow shaft

d_i: inside diameter of the hollow shaft

e: slot width

r: end rounding of the slot

(5) The shape of the spline is to conform to *JIS B* 1601 or the equivalent thereof.

4.2.3 Thrust Shafts

1 The diameter of the thrust shaft transmitting the torque of main propulsion machinery, and which is made of steel forgings (excluding stainless steel forgings, etc.), on both sides of the thrust collar, or in way of the axial bearing where roller bearings are used as thrust bearings, is not to be less than the value given by the following formula:

$$d_t = 1.1F_1 \sqrt[3]{\frac{H}{N_0}\left(\frac{560}{T_s + 160}\right)K}$$

Where:

d_t : Required diameter of thrust shaft (*mm*)

Other symbols used here are the same as those used in **4.2.2-1**.

2 In cases where the required diameter of the thrust shaft given by **-1** above is larger than the diameter of the intermediate shaft, the diameter of the thrust shaft may be reduced gradually at either fwd or aft of the thrust block by multiplying the required diameter of the thrust shaft given by **-1** by 0.91.

3 The diameter of the thrust shaft of material other than specified in **-1** above is to be deemed appropriate by the Society.

4.2.4 Propeller Shafts and Stern Tube Shafts

1 The diameters of propeller shafts and stern tube shafts made of carbon steel forgings or low alloy steel forgings are not to be less than the value given by the following formula. However, in cases where the propeller shaft is Kind 2 or the stern tube shaft is Kind 2, the diameters are to be deemed appropriate by the Society.

$$d_s = 100k_2 \sqrt[3]{\frac{H}{N_0}\left(\frac{560}{T_s + 160}\right)K}$$

Where:

d_s : Required diameter of propeller shaft or stern tube shaft (*mm*)

k_2 : Factor concerning shaft design. Values given in **Table 7.4.3**

T_s : Specified tensile strength of shaft material (N/mm^2)

The upper limit of the value of T_S used in this calculation is to be 600 N/mm^2

Other symbols used here are the same as those used in **4.2.2-1**

2 The diameters of propeller shafts and stern tube shafts made of stainless steel forgings, etc. are not to be less than the value given by the following formula:

$$d_s = 100 k_3 \sqrt[3]{\frac{H}{N_0}}$$

k_3 : Factor concerning the shaft material and shaft portion, which is given in **Table 7.4.4**. Material other than that specified in the table is to be determined by the Society in each case.

Other symbols used here are the same as those used in **4.2.2-1**.

3 The diameters of propeller shafts and stern tube shafts other than those prescribed in **-1** and **-2** are to be deemed appropriate by the Society.

Table 7.4.3 Values of k_2

	Application		k_2
1	The portion between the big end of the tapered part of propeller shaft (in cases where the propeller is fitted with a flange, the fore face of the flange) and the fore end of the aftermost stern tube bearing, or 2.5 d_S , whichever is greater	For a shaft carrying a keyless propeller, or where the propeller is attached to an integral flange	1.22
		For a shaft carrying a keyed propeller	1.26
2	Excluding the portion given in 1 above, the portion up to the fore end of the fwd stern tube seal in the direction of the bow		$1.15^{(1)}$
3	Stern tube shaft		$1.15^{(1)}$
4	The portion located forward of the fore end of the fwd stern tube seal		$1.15^{(2)}$

Notes:

(1) At the boundary, the shaft diameter is to be reduced with either a smooth taper or a blending radius nearly equal to the change in diameter.

(2) The shaft diameter may be reduced by either a smooth taper or a blending radius nearly equal to the change in diameter to the diameter calculated by the formula given in **4.2.2**.

Table 7.4.4 Values of k_3

	Application	*KSUSF* 316 *KSUS*316-*SU*	*KSUSF* 316*L* *KSUS*316*L*-*SU*
1	The portion between the big end of the tapered part of propeller shaft (in cases where the propeller is fitted with a flange) and the fore end of the aftermost stern tube bearing, or 2.5 d_S , whichever is greater	1.28	1.34
2	Excluding the portion given in 1 above, the portion up to the fore end of the fwd stern tube seal in the direction of the bow	$1.16^{(1)}$	$1.22^{(1)}$
3	The portion located forward of the fore end of the fwd stern tube seal	$1.16^{(2)}$	$1.22^{(2)}$

Notes:

(1) At the boundary, the shaft diameter is to be reduced with either a smooth taper or a blending radius nearly equal to the change in diameter.

(2) The shaft diameter may be reduced by either a smooth taper or a blending radius nearly equal to the change in diameter to the diameter calculated by the formula given in **4.2.2-1** considering T_S =400.

4.2.5 Other Shafts

The diameter of shafts transmitting power to generators or essential auxiliary machinery is, in principle, to conform to the requirements in **4.2.2**.

4.2.6 Detailed Evaluation for Strength

Special consideration will be given to the shaft diameters, notwithstanding the requirements in **4.2.2**, **4.2.3**, **4.2.4** and **4.2.5**, provided that the detailed data and calculations are submitted to the Society and considered appropriate.

4.2.7 Corrosion Protection of Propeller Shafts and Stern Tube Shafts

1 Propeller shafts Kind 1 and stern tube shafts Kind 1 are to be effectively protected against corrosion by water with one of the means specified below.

(1) To effectively protect the propeller shafts and stern tube shafts against any contact with water by the means approved by the Society.

(2) To use *KSUSF*316, *KSUSF*316*L*, *KSUS*316-*SU* or *KSUS*316*L-SU* specified in **Part K of the Rules for the Survey and Construction of Steel Ships** for shafts.

(3) To use corrosion resistant materials approved by the Society other than those specified in **(2)** above.

2 Effective means are to be provided to prevent water from having access to the part between the aft end of propeller shaft sleeve or the aft end of the aftermost stern tube bearing and the propeller boss.

3 Spaces between the propeller cap or propeller boss and the propeller shaft are to be filled up with tallow, or provided with other effective means to protect the shaft against corrosion by water.

4.2.8 Propeller Shaft Sleeves and Stern Tube Shaft Sleeves

The sleeves to be fitted to a propeller shaft and a stern tube shaft are to comply with the requirements in the following **(1)** to **(3)**:

(1) The thickness of the sleeve is not to be less than the value given by the following formula:

$$t_1 = 0.03 d_S + 7.5$$

$$t_2 = \frac{3}{4} t_1$$

Where:

t_1 : Thickness of sleeve in way of stern tube bearing or shaft bracket bearing in contact with the bearing face (*mm*)

t_2 : Thickness of sleeve of other parts than the above (*mm*)

d_S : Required diameter of propeller shaft given by the formula in **4.2.4** (*mm*)

(2) Sleeves are to be of bronze or equivalent thereof and to be free from porosity and other defects.

(3) Sleeves are to be fitted to the shafts by a method free from stress concentration such as shrinkage fit, etc.

4.2.9 Fixing of Propellers to Shafts

1 In cases where propellers are force fitted onto the propeller shaft, the fixing part is to be of sufficient strength against the torque to be transmitted.

2 In cases where a key is provided to the fixing part, ample fillets are to be provided at the corners of the keyway and key is to have a true fit in the keyway. The fore end of keyway on the propeller shaft is to be rounded smoothly in order to avoid any excessive stress concentration.

3 In cases where the propeller and propeller shaft flange are connected with bolts, the bolts and pins are to be of sufficient strength.

4 The thickness of the aft propeller shaft flange at the pitch circle is not to be less than 0.27 *times* the diameter of the intermediate shaft (calculated with $k_1 = 1.0$, $K = 1.0$ and $T_S = 400$) in **4.2.2**.

4.2.10 Stern Tube Bearings and Shaft Bracket Bearings

1 The aftermost stern tube bearing or shaft bracket bearing which supports the weight of propeller is to comply with the following requirements **(1)**, **(2)** and **(3)**:

(1) In the case of water-lubricated bearings of lignumvitae.

(a) The bearing length is not to be less than four *times* the required diameter of the propeller shaft given by the formula in **4.2.4-1** or **-2**, or three *times* the actual shaft diameter, whichever is greater.

(b) Adequate means are to be provided to supply ample amount of clean water for lubrication and cooling.

(2) In the case of oil-lubricated bearings of white metal.

(a) The length of the bearing is not to be less than 2 *times* the required diameter of the propeller shaft given by the formulae in either **4.2.4-1** or **-2**, or 1.5 *times* the actual diameter, whichever is greater. However, where special consideration is given on the construction and arrangement in accordance with provisions specified elsewhere and specially approved by the Society, the length of the bearing may be fairly shorter than that specified above.

(b) The stern tube is to be always filled with oil. Adequate means are to be provided to measure the temperature of oil in the stern tube.

(c) In cases where a gravity tank supplying lubricating oil to the stern tube bearing is fitted, it is to be located above the designed maximum load line and provided with a low level alarm device. However, in cases where the lubricating system is designed to be used under the condition that the static oil pressure of the gravity tank is lower than the water pressure, the tank is not required to be above the designed maximum load line.

(d) The lubricating oil is to be cooled by submerging the stern tube in the water of the after peak tank or by some other suitable means.

(3) In cases where bearing materials other than **(1)** and **(2)** above are intended to be used, the materials, construction and arrangement are to be approved by the Society. The length of these bearings is to comply with the following requirements in **(a)** and **(b)**:

(a) In the case of oil-lubricated bearing of synthetic materials;
For bearings of synthetic rubber, reinforced resin or plastics materials which are approved for use as oil-lubricated stern tube bearings, the length of the bearing is to be not less than 2 *times* the required diameter of the propeller shaft given by the formulae in either **4.2.4-1** or **-2**, or 1.5 *times* the actual diameter, whichever is greater. However, for bearings having a construction and arrangement specially approved by the Society, the length of the bearing may be fairly shorter than that specified above.

(b) In the case of water-lubricated bearings of synthetic materials;
For bearings of synthetic materials which are approved for use as water-lubricated stern tube bearings such as rubber or plastics, the length of the bearing is to be not less than 4 *times* the required diameter of the propeller shaft given by the formulae in either **4.2.4-1** or **-2**, or 3 *times* the actual diameter, whichever is greater. However, for bearings having a construction and arrangement specially approved by the Society, the length of the bearing may be fairly shorter than that specified above.

2 Sealing devices, other than gland packing type water sealing devices, are to be approved by the Society with regards to materials, construction and arrangement.

4.2.11 Shaft Couplings and Coupling Bolts

1 The diameter of coupling bolts at the joining face of the couplings is not to be less than the value given by the following formula:

$$d_b = 0.65\alpha\sqrt{\frac{{d_0}^3(T_s + 160)}{nDT_b}}$$

Where:

d_b : Bolt diameter (*mm*)

d_0 : Diameter (*mm*) of intermediate shaft calculated with k_1 = 1.0 and K = 1.0 in **4.2.2**

n: Number of bolts

D : Pitch circle diameter (*mm*)

T_S : Specified tensile strength of intermediate shaft material taken for the calculation in **4.2.2**

T_b : Specified tensile strength of bolt material (*N/mm*^{2}), while generally $T_S \le T_b \le 1.7T_S$; and, the upper limit of the value of T_b used for the calculation is to be 1,000 *N/mm*^{2}

α : Coefficient concerning vibratory torque given by the following formula or to be taken as 1.0, whichever is greater.
However, α =1.0 may be accepted for coupling bolts used for shafting systems which transmit power from prime movers to drive generators and auxiliaries.

$$\alpha = 0.95\sqrt[3]{\frac{Q_a}{Q_m}}$$

Q_a : Torsional vibratory torque acting on the joining face of the couplings rotating at resonant critical speed in all conditions (*N-m*)

Q_m : Nominal rated torque given by the following formula (*N-m*)

$$Q_m = 9549\frac{H}{N_0}$$

H : Maximum continuous output of engine (*kW*)
N_0 : Rate of revolutions of intermediate shaft at the maximum continuous output (*rpm*)

2 The thickness of the coupling flange at the pitch circle is not to be less than the required diameter of the coupling bolt calculated by the formula in **-1** for the material having the same tensile strength as the corresponding shaft. However it is not to be less than 0.2 *times* the required diameter of the corresponding shaft.

3 The fillet radius at the base of the flange is not to be less than 0.08 *times* the diameter of the shaft, where the fillet is not to be recessed in way of nuts and bolt heads.

4 In cases where the shaft couplings are not integral with the shaft, the couplings are to have sufficient strength against the torque to be transmitted to the shaft and also the astern pull. In this case, consideration is to be taken so as not to cause an excessive, stress concentration.

4.2.12 Shaft Alignment

For the main propulsion shafting having an oil-lubricated propeller shaft of which diameter is not less than 400 *mm*, the shaft alignment calculation including bending moments, bearing loads and deflection curve of the shafting is to be carried out for approval.

4.3 Tests

4.3.1 Shop Tests

The following components are to be subjected to hydrostatic tests at pressures specified below

(1) Stern tubes:
0.2 *MPa*

(2) Propeller shaft sleeves and stern tube shaft sleeves:
0.1 *MPa* (tests are to be carried out before shrinkage fit)

4.3.2 Tests after Installation on Board

1 The sealing devices specified in **4.2.10-2** are to be tested for leakage under working oil pressure after installation on board.

2 For the main propulsion shafting (excluding those of waterjet propulsion systems or azimuth thrusters), confirmation tests relating to shaft alignment are to be carried out.

Chapter 5 PROPELLERS

5.1 General

5.1.1 Scope

The requirements in this Chapter apply to screw propellers.

5.1.2 Drawings and Data

Drawings and data to be submitted are generally as follows:

(1) Drawings
- (a) Propeller
- (b) Operating oil piping diagram of controllable pitch propeller indicating pipe materials, pipe sizes and service pressure
- (c) Blade fixing bolts of controllable pitch propeller

(2) Data
- (a) Particulars of propeller (maximum continuous output and number of maximum continuous revolutions per minute of main propulsion machinery, details of blade profile, diameter, pitch, developed area, propeller boss ratio, rake or rake angle, number of blades, mass, moment of inertia, material specifications, etc.)
- (b) Calculation sheet of propeller pull-up length (where it is proposed to fit keyless propellers)

5.1.3 Materials

1 The materials of propellers and the blade fixing bolts of controllable pitch propellers are to comply with the requirements in **Part K of the Rules for the Survey and Construction of Steel Ships**.

2 Propellers are to have been subjected to non-destructive tests on their principal parts.

5.2 Construction and Strength

5.2.1 Thickness of Blade

1 The thickness of the propeller blades at a radius of 0.25 *R* and 0.6 *R* for solid propellers and at a radius of 0.35 *R* and 0.6 *R* for controllable pitch propellers is not to be less than the values given by the following formula. The thickness of the highly skewed propeller blades is to conform with the provisions specified elsewhere.

$$t = \sqrt{\frac{K_1}{K_2}\frac{H}{ZN_0\ell}SW}$$

Where:

t : Thickness of blades (excluding the fillet of blade root) (*cm*)

H : Maximum continuous output of main propulsion machinery (*kW*)

Z : Number of blades

N_0 : Number of maximum continuous revolutions per minute divided by 100 (*rpm* /100)

ℓ : Width of blade at radius in question (*cm*)

K_1 : Coefficient of the radius in question given by the following formula:

$$K_1 = \frac{30.3}{\sqrt{1+k_1\left(\frac{P'}{D}\right)^2}}\left(k_2\frac{D}{P}+k_3\frac{P'}{D}\right)$$

D : Diameter of propeller (*m*)

k_1, k_2, k_3 : Values given in **Table 7.5.1**

P' : Pitch at radius in question (*m*)

P : Pitch at radius of 0.7 *R* (*m*), (*R* = Radius of propeller (*m*))

K_2 : Coefficient given by the following formula:

$$K_2 = K - \left(k_4 \frac{E}{t_0} + k_5 \right) \frac{D^2 N_0^2}{1000}$$

k_4, k_5 : Values given in **Table 7.5.1**

E : Rake at the tip of the blade (Measuring from face side base line and taking positive value for backward rake) (*cm*)

t_0 : Imaginary thickness of blade at propeller shaft centreline (t_0 may be obtained by drawing the each side line which connects the blade tip thickness with the thickness at 0.25 *R* (or 0.35 *R* for controllable pitch propeller), in the projection of the blade section along the maximum blade thickness line.) (*cm*)

K : Value given in **Table 7.5.2**

S : Coefficient concerning the increase in stress during times of bad weather. Where S >1.0 or S <0.8, the value of S is to be taken as 1.0 or 0.8 respectively.

$$S = 0.095 \left(\frac{D_S}{d_S} \right) + 0.677$$

D_S : Depth of ship for strength computation (*See* **2.1.8, Part 1**)

d_S : Load draught (*See* **2.1.13, Part 1**)

W : Coefficient concerning alternate stress, given by the following formula or to be taken as 2.80, whichever is greater.

$$W = 1 + 1.724 \left(\frac{A_2 A_3 + A_4 A_1 P'/D}{A_3 + A_4 P'/D} \right)$$

$$A_1 = \frac{\Delta\omega}{\omega + C_1}$$

$$A_2 = \frac{\Delta\omega}{\omega + C_2}$$

$$A_3 = \frac{(C_1 + 1)(C_2 + \omega)}{C_3 (C_2 + 1)(C_1 + \omega)}$$

$$A_4 = \begin{cases} 3.52 (0.25R) \\ 2.41 (0.35R) \\ 1.26 (0.6R) \end{cases}$$

$$C_1 = \frac{D}{0.95P} \left\{ \frac{P}{D} \left(1.3 - \frac{2a_e}{Z} \right) + 0.22 \right\} - 1$$

$$C_2 = \frac{D}{0.95P} \left(1.1 \frac{P}{D} - \frac{1.19 a_e}{Z} + 0.2 \right) - 1$$

$$C_3 = 0.122 \frac{P}{D} + 0.0236$$

a_e : Expanded area ratio of propeller

ω : Nominal mean wake in the propeller disc

$\Delta\omega$: Peak to peak value of wake fluctuation in the propeller disk at a radius of 0.7 *R*. The values of ω and $\Delta\omega$ are to be calculated by using the following formulae, except in the case of multi-screw ships or when expressly approved by the Society.

$$\Delta\omega = 7.32 \left\{ 1.56 - 0.04 \left(\frac{B}{D} + 4 \right) \sqrt{\frac{B}{d_S}} - C_b \right\} \omega$$

$$\omega = 0.625 \left\{ 0.04 \left(\frac{B}{D} + 4 \right) \sqrt{\frac{B}{d_S}} + C_b \right\} - 0.527$$

B : Breadth of ship (*m*)

C_b : Block coefficient of ship

2 The fillet radius between the root of a blade and the boss of the propeller, on the pressure side at the maximum blade thickness part, is to be not less than the value of R_0 given by the following formula:

$$R_0 = t_r + \frac{(e - r_B)(t_0 - t_r)}{e}$$

R_0 : Required radius of the fillet (*cm*)

t_r : Required thickness of blades at a radius of 0.25 *R* (or 0.35 *R* for a controllable pitch propeller) specified in **-1** (*cm*)

t_0 : Same as that used in **-1**

r_B : Boss ratio of propeller

e : 0.25 (or 0.35 for a controllable pitch propeller)

3 Special consideration will be given to the thickness of the blades or the radius of the fillet, notwithstanding the requirements in **-1** or **-2** above, provided that detailed data and calculations are submitted to the Society and considered appropriate.

Table 7.5.1 Values of k_1, k_2, k_3, k_4 and k_5

Radial position	k_1	k_2	k_3	k_4	k_5
0.25*R*	1.62	0.386	0.239	1.92	1.71
0.35*R*	0.827	0.308	0.131	1.79	1.56
0.6*R*	0.281	0.113	0.022	1.24	1.09

Table 7.5.2 Values of *K*

Material		*K*
Copper alloy casting	*KHBsC*1	1.15
	*KHBsC*2	
	*KAlBC*3	1.3
	*KAlBC*4	1.15

Notes:

(1) For the blades of materials different from those specified in the above Table, the value of *K* is to be determined in each case.

(2) For propellers having a diameter of 2.5 *metres* or less, the value of *K* may be taken as the value in the above Table multiplied by the following factor:

$2 - 0.4D$ for $2.5 \geq D > 2.0$

1.2 for $2.0 \geq D$

5.2.2 Controllable Pitch Propellers

1 The thickness of the controllable pitch propeller blade is to be in accordance with the requirements specified in **5.2.1**.

2 The diameter of blade fixing bolts of controllable pitch propellers is not to be less than the value calculated by the following formula:

$$d = 0.55\sqrt{\frac{1}{\sigma_a n}\left(\frac{AK_3}{L} + F_c\right)}$$

Where:

d : Required diameter of blade fixing bolt (*mm*) (*See* **Fig. 7.5.1**)

A : Value given by the following formula, where *H*, N_0 and *Z* are the same as those specified in **5.2.1-1**:

$$A = 3.0 \times 10^4 \frac{H}{N_0 Z}$$

K_3 : Value given by the following formula:

$$K_3 = \left\{\left(\frac{D}{P}\right)^2 \times (0.622 - 0.9x_0)^2 + (0.318 - 0.499x_0)^2\right\}^{\frac{1}{2}}$$

x_0 : Ratio of the radius at the boundary between blade flange and pitch control gear to the propeller radius (*See* **Fig. 7.5.1**). Where x_0>0.3, the ratio is to be taken as 0.3.

L : Mean value of $L_1$and L_2 (*cm*)

L_1 and L_2 are the lengths of lines constructed from the centre of the bolts located on the edge of each side that are perpendicular to the line passing through the rotating centre of the flange at a pitch angle of β.

(*See* **Fig. 7.5.2**)

F_c : Centrifugal force (*N*) of propeller blade given by the following formula:

$$F_c = 1.10 \times mR'N_0^2$$

m : Mass of one blade (*kg*)

R' : Distance between the centre of gravity of the blade and the centre line of the propeller shaft (*cm*)

n : Number of bolts on the face side of blade

σ_a : Allowable stress of bolt material given by the following formula (N/mm^2):

$$\sigma_a = 34.7 \times \left(\frac{\sigma_B + 160}{600} \right)$$

σ_B : Specified Tensile strength of bolt material (N/mm^2)

Where σ_B >800 N/mm^2, it is to be taken as 800 N/mm^2.

Other symbols are the same as those given in the formula of **5.2.1-1**.

3 For blade fixing bolts, corrosion-resistant materials are to be used, or special means precluding their direct contact with water are to be provided.

4 The thickness of the flange for fitting the blade to the pitch control gear (the thickness as measured from the seat of fixing bolt or nut to the boundary face between the flange and the pitch control gear) is to be not less than the value calculated by the following formula:

$$t_f = 0.9d$$

Where:

t_f : Thickness of flange (*mm*) (*See* **Fig. 7.5.1**)

d : equired diameter of bolt calculated by the formula specified in **-2** (*mm*)

5 Blade fixing bolts are to be fitted tightly into the pitch control gear and provided with effective means for locking.

6 In cases where recesses for bolts are provided on the fillet at the root of the blades, the design blade section determined by the requirements for blade thickness in **5.2.1** is not to be reduced for the recess.

7 The face of the flange of the blade is to be fitted tightly to the face of pitch control gear and the circumferential clearance of the edge of flange is to be minimized.

8 In cases where pitch control gears are operated by hydraulic oil pumps, they are to comply with either the following **(1)** or **(2)**:

(1) At least two hydraulic pumps of the same capacity are to be provided, the total capacity of which is to be sufficient enough to ensure the maximum continuous output of the main propulsion machinery. In addition, in cases where one pump fails, the total capacity of the remaining pumps is to be sufficient enough to ensure the navigable speed of the ship.

(2) Some other appropriate unit is provided in order to ensure the navigable speed of the ship in the case of hydraulic pump failure.

9 The operating oil piping arrangement is to comply with the requirements in **11.10**.

5.2.3 Blade fitting of Built-up Propeller

The blade fixing bolts and the flanges for fitting the blade of built-up propellers are to so designed as to comply with the requirements concerning to those for controllable pitch propellers specified in **5.2.2**.

Fig. 7.5.1 Measuring Method of Blade Fixing Bolt Dimensions

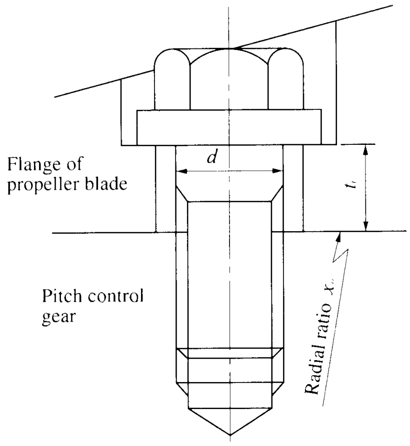
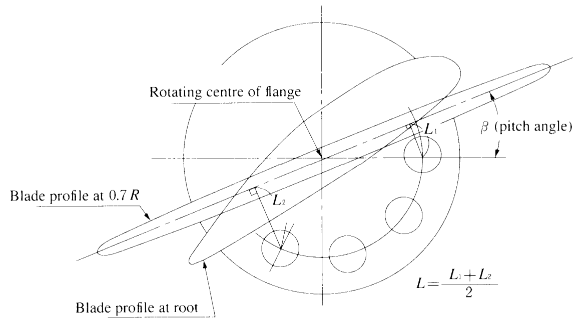


Fig. 7.5.2 Determination of L



5.3 Force Fitting of Propellers

5.3.1 Pull-up Length

1 In cases where a propeller is force fitted onto a propeller shaft without the use of a key, the lower and upper limits of pull-up length are to be as given by the following formulae. For a taper of more than 1/15, these limits of pull-up length are to be subject to the satisfaction of the Society:

$$L_1 = PK_E + K_C(C_b - C_0)$$

$$L_2 = K_E K_W \frac{(K_{R1}{}^2 - 1)}{\sqrt{(3K_{R1}{}^4 + 1)}} + K_c(C_b - C_0)$$

$$L_3 = 19.6K_E(K_{R1}{}^2 - 1) + K_c(C_b - C_0)$$

L_1 : Lower limit of pull-up length (*mm*)

L_2 : Upper limit of pull-up length (*mm*) (in cases other than the case of L_3 shown below)

L_3 : Upper limit of pull-up length (*mm*) (in cases where the material of boss is manganese bronze casting and K_{R1} <1.89)

K_W :The value given by **Table 7.5.3**. In cases where the material of propeller boss is other than those specified in **Table 7.5.3**, the value is to be determined by the Society in each case.

K_{R1} :Rate of R_1 to R_0 (R_1/R_0)

K_{R2} :Rate of R_2 to R_0 (R_2/R_0)

R_0 : Radius of the propeller shaft at the midpoint of taper in the axial direction (*mm*)

R_1 : Radius of propeller boss at the determinant point of the propeller boss ratio (*mm*)

R_2 : Inner radius at the section corresponding to R_0 in the case of a hollow propeller shaft (*mm*)

C_b : Temperature of propeller boss at time of fitting propeller (°*C*)

C_0 : Reference temperature: 35°*C* for L_1, 0°*C* for L_2 and L_3

P : Value given by the following formula (*N/mm*^{2}):

$$P = \frac{2.8T}{SB}\left\{-2.8\tan\alpha + \sqrt{0.0169 + B\left(\frac{F_V}{T}\right)^2}\right\}$$

S : Contact area between propeller shaft and propeller boss on the drawing (*mm*^{2})

α : Half angle of the taper at the propeller shaft cone part (*rad*)

B : $0.0169 - 7.84tan^2\alpha$

T : Thrust force given by the following formula (N);

$T = 1.76 \times 10^3 (H / V_s)$

V_s : Ship speed at maximum continuous output (kt)

F_V : Tangential force acting on contact surface given by the following formula (N);

$$F_V = \frac{9.55cH}{N_0 R_0} \times 10^4$$

c : 1.0 for turbine ships;

For diesel ships, 1.2 or the value given by the following formula, whichever is greater. However, where a detailed report on the maximum torque acting on the fitted portion of the propeller under all operating conditions including transient conditions has been submitted to the satisfaction of the Society, it may comply with the provisions specified otherwise.

$$(0.194 \ln D + 0.255) \left\{ \left(\frac{N_C}{N_0} \right)^2 + 1.047 \frac{Q_v N_0}{H} \times 10^{-2} \right\}$$

Q_V : Torsional vibratory torque acting on the fitted portion of the propeller at a rotational speed of resonant critical within the range of above 25% of the number of maximum continuous revolutions (N-m)

H, N_0, D : Same as those specified in **5.2.1-1**, However, D is to be taken as 2.6 m for D <2.6 m and as 10.2 m for D >10.2 m.

N_c : Number of revolutions (rpm) at resonant critical divided by 100

K_E : Value given by the following formula (mm^3/N):

$$K_E = \frac{R_0}{\tan \alpha} \left\{ \left(\frac{{K_{R1}}^2 + 1}{{K_{R1}}^2 - 1} \right) K_4 + 4.85 \left(\frac{1 + {K_{R2}}^2}{1 - {K_{R2}}^2} \right) + K_5 \right\} \times 10^{-6}$$

In cases where the material of the propeller shaft is other than forged steel or the material of propeller boss is other than specified in **Table 7.5.3**, the value is to be determined by the Society as considered appropriate.

K_4 and K_5 : Values given in **Table 7.5.3**

K_C : Value given by the following formula (mm /°C):

$$K_C = \left(K_6 + K_7 \frac{C_b - C_s}{C_b - C_0} \right) \left(\ell_0 - \frac{R_0}{\tan \alpha} \right) \times 10^{-5}$$

In cases where the material of the propeller shaft is other than forged steel or the material of propeller boss is other than specified in **Table 7.5.3**, the value is to be determined by the Society as considered appropriate.

C_S : Temperature of propeller shaft at time of fitting propeller (°C).

ℓ_0 : Half length of the tapered part in the propeller boss hole in the axial direction (mm)

K_6 and K_7 : Values given in **Table 7.5.3**

2 In cases where propeller is force fitted on the propeller shaft with the use of a key, the strength of the fitted part is to be such that it is sufficient for the torque to be transmitted.

5.3.2 Propeller Boss

1 In cases where a propeller is force fitted onto a propeller shaft, the edge at the fore end of the tapered hole of the propeller boss is to be appropriately rounded off.

2 Propeller boss is not to be heated locally to a high temperature at the time of forcing on or drawing out.

5.4 Tests

5.4.1 Shop Tests

Propellers are to be subjected to static balancing tests.

5.4.2 Tests after Installation on Board

When a propeller is force-fitted onto a propeller shaft, irrespective whether it is done with or without a key, a force-fitting test is to be carried out to measure and record the pull-up length. This test may be carried out as a Shop Test.

Table 7.5.3 Values of K_4, K_5, K_6, K_7 and K_w

Material of propeller boss	K_4	K_5	K_6	K_7	K_w
*KHBsC*1	9.27	1.65	0.55	1.20	123
*KHBsC*2	9.27	1.65	0.55	1.20	123
*KAlBC*3	8.49	1.40	0.55	1.20	172
*KAlBC*4	8.49	1.40	0.55	1.20	193

Chapter 6 TORSIONAL VIBRATION OF SHAFTINGS

6.1 General

6.1.1 Scope

1 The requirements of this Chapter apply to power transmission systems for propulsion and propulsion shafting systems (except propellers), shafting systems for transmitting power from main propulsion machinery to generators, crankshafts of diesel engines used as main propulsion machinery and shafting systems of generating plants using diesel engines.

2 The requirements of this Chapter apply mutatis mutandis to the shafting systems of auxiliaries (hereinafter referred to in this Chapter as all auxiliaries excluding auxiliary machinery for specific use etc.) driven by diesel engines.

6.1.2 Data to be Submitted

1 Torsional vibration calculation sheets covering the following items are to be submitted for approval:

(1) Natural frequency calculation tables for one node and two nodes vibration, and also for more nodes vibrations if necessary

(2) Calculation results of the torsional vibration stress at each resonant critical within a speed range up to 120% of the number of maximum continuous revolutions; and, in cases of diesel installations, those of the torsional vibration stress for the flank appearing in the speed range from 90 to 120% caused by a resonance of the first major order (i.e., the *n* th or *n*/2 th order where *n* denotes the number of cylinders) having its critical speed above 120% of the number of maximum continuous revolutions.

(3) Arrangement of crank throws and firing order (in cases of diesel installations)

(4) For propulsion shafting systems intended to be continuously operated under one cylinder misfiring condition, calculation results of the torsional vibration stress with any one cylinder misfiring giving rise to the highest torsional vibration stress.

2 Notwithstanding the requirements specified in **-1**, submission of torsional vibration calculation sheets may be omitted in the following cases provided that approval of the Society is obtained:

(1) In cases where the shafting system is of the same type as previously approved one.

(2) In cases where there is a slight alternation in the specifications of the vibration system, and the frequency and torsional vibration stress can be deduced with satisfactory accuracy on the basis of the previous results of calculations or measurements.

6.1.3 Measurements

Torsional vibration measurements are to be carried out to confirm the correctness of the estimated values of calculation results if deemed necessary by the Society; for example, cases where the torsional vibration calculations indicate the possibility of dangerous critical speeds in the operating speed range, etc.

6.2 Allowable Limit

6.2.1 Crankshafts

The torsional vibration stresses on the crankshafts of diesel engines used as main propulsion machinery of diesel ships are to be in accordance with the following requirements **(1)** through **(4)**:

(1) For continuous operation, when the number of revolutions is within the range of 80% to 100% of the number of maximum continuous revolutions, the torsional vibration stresses are not to exceed τ_1 given in following:

(a) For 4-stroke cycle in-line diesel engines or 4-stroke cycle Vee type diesel engines with firing intervals of 45° or 60°, the value of τ_1 is given by the following formula:

$$\tau_1 = 45 - 24\lambda^2$$

(b) For 2-stroke cycle diesel engines or 4-stroke cycle Vee type diesel engines other than shown in **(a)** above, the value of τ_1 is given by the following formula:

$$\tau_1 = 45 - 29\lambda^2$$

τ_1 : Allowable limit of torsional vibration stresses for the range of $0.8 < \lambda \leq 1.0$ (N/mm^2)

λ : Ratio of the number of revolutions to the number of maximum continuous revolutions

(2) When the number of revolutions is within the range of 80% and below the number of maximum continuous revolutions, the torsional vibration stresses are not to exceed τ_2 given below. Furthermore, in cases where the stresses exceed the value calculated by the formula of τ_1 in **(1)**, the barred speed ranges specified in **6.3** are to be imposed.

$$\tau_2 = 2\tau_1$$

τ_2 : Allowable limit of torsional vibration stresses for the range of $\lambda \leq 0.8$ (N/mm^2)

λ : Ratio of the number of revolutions to the number of maximum continuous revolutions

(3) When the number of revolutions is within the range of the number of maximum continuous revolutions to 115%, the torsional vibration stresses are not to exceed τ_3 given in the following:

(a) For 4-stroke cycle in-line diesel engines or 4-stroke cycle Vee type diesel engines with firing intervals of 45° or 60°, the value of τ_3 is given by the following formula:

$$\tau_3 = 21 + 237(\lambda - 0.8)\sqrt{\lambda - 1}\ (1 < \lambda \leq 1.15)$$

(b) For 2-stroke cycle diesel engines or 4-stroke cycle Vee type diesel engines other than shown in **(a)** above, the value of τ_3 is given by the following formula:

$$\tau_3 = 16 + 237(\lambda - 0.8)\sqrt{\lambda - 1}\ (1 < \lambda \leq 1.15)$$

τ_3 : Allowable limit of torsional vibration stresses for the range of $1.0 < \lambda \leq 1.15$ (N/mm^2)

λ : Ratio of the number of revolutions to the number of maximum continuous revolutions

(4) In cases where the tensile strength of the shaft material exceeds 440 N/mm^2, and its yield strength exceeds 225 N/mm^2, the values of τ_1, τ_2 and τ_3 given in **(1)**, **(2)** and **(3)** may be increased by multiplying the factor f_m given in the following formula:

(a) For τ_1 and τ_3

$$f_m = 1 + \frac{2}{3}\left(\frac{T_s}{440} - 1\right)$$

(b) For τ_2

$$f_m = \frac{Y}{225}$$

Where:

f_m : Correction factor for allowable limit of torsional vibration stress concerning the shaft material

T_s : Specified tensile strength of the shaft material (N/mm^2). However, the value of T_s for calculating f_m is not to exceed 760 N/mm^2 for carbon steel forgings, and 1080 N/mm^2 for low alloy steel forgings.

Y : Specified yield strength of the shaft material (N/mm^2)

6.2.2 Intermediate Shafts, Thrust Shafts, Propeller Shafts and Stern Tube Shafts

1 For diesel ships, the torsional vibration stresses on the intermediate shafts, thrust shaft, propeller shafts and stern tube shafts made of steel forgings (excluding stainless steel, etc.) are to be in accordance with the following requirements **(1)** and **(2)**. However, those shafts classified as either propeller shafts Kind 2 or stern tube shafts Kind 2 are to be deemed appropriate by the Society.

(1) For continuous operation, when the number of revolutions is within the range of 80% to 105% of the number of maximum continuous revolutions, the torsional vibration stresses are not to exceed τ_1 given in the following formulae:

$$\tau_1 = \frac{T_s + 160}{18} C_K C_D (3 - 2\lambda^2)\ (\lambda \leq 0.9)$$

$$\tau_1 = 1.38 \frac{T_s + 160}{18} C_K C_D\ (0.9 < \lambda)$$

τ_1 : Allowable limit of torsional vibration stresses for the range of $0.8 < \lambda \leq 1.05$ (N/mm^2)

λ : Ratio of the number of revolutions to the number of maximum continuous revolutions

T_s : Specified tensile strength of shaft material (N/mm^2)

However, the value of T_s for using in the formulae is not to exceed 800N/mm^2 (600N/mm^2 for carbon steels in general) in intermediate shafts and thrust shafts, and 600 N/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 no effective means against corrosion by water, the value of T_s for use in the formulae is to be as deemed appropriate by the Society.

C_K : Coefficient concerning to the type and shape of the shaft, given in **Table 7.6.1**.

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) When the number of revolutions is within the range of 80% and below the number of maximum continuous revolutions, the torsional vibration stress (including those in one cylinder misfiring conditions if intended to be continuously operated under such conditions) are not to exceed τ_2 given below. Furthermore, in cases where the stresses exceed the value calculated by the formula of τ_1 for the range of $\lambda \le 0.9$ in **(1)**, the barred speed ranges specified in **6.3** are to be imposed.

$$\tau_2 = 1.7\tau_1 / \sqrt{C_K}$$

Where:

τ_2 : Allowable limit of torsional vibration stresses for the range of $\lambda \le 0.8$ (N/mm^2)

Other symbols used here are the same as in **(1)**

2 For diesel ships, the torsional vibration stresses on the propeller shafts and stern tube shafts made of stainless steel forgings, etc. are to be in accordance with the following requirements **(1)** and **(2)**.

(1) For continuous operation, when the number of revolutions is within the range of 80% to 105% of the number of maximum continuous revolutions, the torsional vibration stresses are not to exceed τ_1 given in the following formulae:

$$\tau_1 = A - B\lambda^2 \ (\lambda \le 0.9)$$

$$\tau_1 = C \ (0.9 < \lambda)$$

τ_1 : Allowable limit of torsional vibration stresses for the range of $0.8 < \lambda \le 1.05$ (N/mm^2)

λ : Ratio of the number of revolutions to the number of maximum continuous revolutions

A, B, C: Values determined by the materials used, given in **Table 7.6.2**. For the materials other than specified in the Table, however, the values are to be deemed appropriate by the Society.

(2) When the number of revolutions is within the range of 80% and below the number of maximum continuous revolutions, the torsional vibration stress are not to exceed τ_2 given below. Furthermore, in cases where the stresses (including those in one cylinder misfiring conditions if intended to be continuously operated under such conditions) exceed the value calculated by the formula of τ_1 for the range of $\lambda \le 0.9$ in **(1)**, the barred speed ranges specified in **6.3** are to be imposed.

$$\tau_2 = 2.3\tau_1$$

τ_2 : Allowable limit of torsional vibration stresses for the range of $\lambda \le 0.8$ (N/mm^2)

Other symbols used here are the same as in **(1)**.

3 The allowable limits of torsional vibration stresses on the shafts made of materials other than specified in **-1** and **-2**, and the allowable limits of torsional vibration stresses on the intermediate shafts, thrust shafts, propeller shafts and stern tube shafts for steam turbine ships, gas turbine ships, and electric propulsion ships, or for diesel ships which have electromagnetic slip couplings between main propulsion machinery and main propulsion systems are to be deemed appropriate by the Society.

Table 7.6.1 Values of C_K (5)

Intermediate shaft with						Thrust shaft		Propeller shaft and stern tube shaft	
integral flange coupling	flange couplings either shrink fit, push fit or cold fit	keyway, tapered connection	keyway, cylindrical connection	transverse hole(1)	longitudinal slot(2)	on both sides of thrust collar	in way of part subjected to axial load of roller bearing	near the big end of the tapered part of propeller shaft(3)	excluding the portion given in the left column(4)
1.0	1.0	0.6	0.45	0.50	0.30	0.85	0.85	0.55	0.80

Notes:

(1) To be in accordance with **note (3) of Table 7.4.2**.

(2) To be in accordance with **note (4) of Table 7.4.2**.

(3) The portion between the big end of the tapered part of the propeller shaft (in cases where the propeller is fitted with a flange, the fore face of the flange) and the fore end of the aftermost stern tube bearing, or 2.5 d_s, whichever is greater. In this case d_s is the required diameter of the propeller shaft or stern tube shaft.

(4) The portion in the direction of the bow up to the fore end of the fwd stern tube seal.

(5) Any value of C_K other than those above is to be determined by the Society based on the submitted data in each case.

Table 7.6.2 Values of A, B and C

	A	B	C
KSUSF316 *KSUS316-SU*	40.7	30.6	15.9
KSUSF316L *KSUS316L-SU*	37.6	28.3	14.7

6.2.3 Shafting System of Generating Plants

1 The torsional vibration stresses on the crankshafts of diesel engines used for generating plants (hereinafter referred to in **6.2.3** and **6.2.5** as including propulsion generating plants used for electric propulsion ships) are to be in accordance with the following requirements **(1)** and **(2)**:

(1) When the number of revolutions is within the range of 90% to 110% of the number of maximum continuous revolutions, the torsional vibration stresses are not to exceed τ_1 given in the following:

(a) For 4-stroke cycle in-line diesel engines or 4-stroke cycle Vee type diesel engines with firing intervals of 45° or 60°, the value of τ_1 is given by the following formula:

$$\tau_1 = 21 \quad (N/mm^2)$$

(b) For 2-stroke cycle diesel engines and 4-stroke cycle Vee type diesel engines other than shown in **(a)** above, the value of τ_1 is given by the following formula:

$$\tau_1 = 16 \quad (N/mm^2)$$

(2) When the number of revolutions is within the range of 90% and below the number of maximum continuous revolutions, the torsional vibration stresses are not to exceed τ_2 given below. Furthermore, in cases where the stresses exceed the value of τ_1 given in **(1)**, the barred speed ranges specified in **6.3** are to be imposed.

$$\tau_2 = 90 \quad (N/mm^2)$$

2 The torsional vibration stresses on the generator shafts of generating plants using diesel engine are to be in accordance with the following requirements **(1)** and **(2)**:

(1) When the number of revolutions is within the range of 90% to 110% of the number of maximum continuous revolutions, the torsional vibration stresses are not to exceed τ_1 given in the following:

$$\tau_1 = 31 \quad (N/mm^2)$$

(2) When the number of revolutions is within the range of 90% and below the number of maximum continuous revolutions, the torsional vibration stresses are not to exceed τ_2 given below. Furthermore, in cases where the

stresses exceed the value of τ_1 given in **(1)**, the barred speed ranges specified in **6.3** are to be imposed.

$\tau_2 = 118$ (N/mm^2)

3 In cases where the tensile strength of the shaft material exceeds 440 N/mm^2, and its yield strength exceed 225 N/mm^2, the values of τ_1 and τ_2 given in **-1** and **-2** may be increased by multiplying the factor f_m given in **6.2.1(4)**.

6.2.4 Power Transmission Systems

1 The torsional vibration torques on gearings are to be in accordance with the following requirements **(1)** and **(2)**:

(1) Within the range of the allowable limits for τ_1 specified in **6.2.1**, **6.2.2** and **6.2.3**, the amplitudes of the torsional vibration torques are not to exceed the mean of the transmitting torque of the systems.

(2) Within any range other than that specified in **(1)**, the barred speed ranges specified in **6.3** are to be imposed in cases where the amplitudes of the torsional vibration torques exceed the mean transmitting torque.

2 The torsional vibration stresses on the gear shafts are to comply with the requirements for the intermediate shafts specified in **6.2.2**.

3 The allowable limits of the torsional vibration torques, stresses or amplitudes for the power transmission systems (including shaft couplings) other than gearings are to comply with the provisions specified elsewhere.

6.2.5 Avoidance of Major Criticals

The major criticals of one node vibration (e.g. the *n* th and *n*/2 th order for 4-stroke cycle and the *n* th order for 2-stroke cycle where *n* denotes the number of cylinders) in in-line diesel engines are not to exist, except when approval of the Society is specifically obtained, within the following speed ranges:

For main propulsion shafting system $0.8 \le \lambda \le 1.1$

For shafting system of generating plants $0.9 \le \lambda \le 1.1$

Where:

λ: Ratio of the number of revolutions at the major critical to the number of maximum continuous revolutions

6.2.6 Detailed Evaluation for Strength

Special consideration will be given to allowable limits of torsional vibration stresses that do not comply with the requirements in **6.2.1**, **6.2.2** and **6.2.3**, provided that detailed data and calculations are submitted to the Society and considered appropriate.

6.3 Barred Speed Range

6.3.1 Barred Speed Range for Avoiding Continuous Operation

1 In cases where the torsional vibration stresses exceed the allowable limit τ_1 specified in **6.2**, barred speed ranges are to be marked with red zones on the engine tachometers and these ranges are to be passed through as quickly as possible. In this case, barred speed ranges are to be imposed in accordance with the following:

(1) The barred speed ranges are to be imposed between the following speed limits.

$$\frac{16N_c}{18-\lambda} \le N_0 \le \frac{(18-\lambda)N_c}{16}$$

Where:

N_0: 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 number of maximum continuous revolutions

(2) For controllable pitch propellers, both full and zero pitch conditions are to be considered.

(3) Restricted speed ranges in one cylinder misfiring conditions are to enable safe navigation even where the ship is provided with only one propulsion engine.

2 In cases where the range in which the stresses exceed the allowable limit τ_1 specified in **6.2** is verified by measurements, such range may be taken as the barred speed range for avoiding continuous operation, notwithstanding the required range specified in **-1**, having regard to the tachometer accuracy.

3 For engines where clearing the barred speed range for avoiding continuous operation specified in **-1** and **-2**

above is not readily available, transferring of the resonant points of torsional vibrations and other necessary measures are to be taken.

Chapter 7 BOILERS, ETC. AND INCINERATORS

7.1 General

7.1.1 Scope

The requirements in this Chapter apply to boilers excluding those given in the following **(1)** and **(2)**, thermal oil heaters and incinerators:

(1) Steam boilers with a design pressure not exceeding 0.1 *MPa* and heating surface not exceeding 1 m^2

(2) Hot water boilers with a design pressure not exceeding 0.1 *MPa* and heating surface not exceeding 8 m^2

7.1.2 Terminology

Terms used in this Part are defined as follows:

(1) "Boilers" are plants which generate steam or hot water by means of flame, combustion gases or other hot gases and include superheaters, reheaters, economizers and exhaust gas economizers, etc.

(2) "Essential auxiliary boilers" are boilers which supply steam necessary for the operation of auxiliary machinery essential for main propulsion, auxiliary machinery for manoeuvring and safety as well as for generators.

(3) "Exhaust gas boilers" are boilers which generates steam or hot water using only exhaust gases from diesel engines, have independent steam spaces or hot wells and have outlets for steam or hot water.

(4) "Exhaust gas economizers" are those equipment which generates steam or hot water using only exhaust gases from diesel engines and do not have independent steam spaces or hot wells.

(5) "Heating surfaces of boilers" are those areas calculated on combustion gas side surfaces where one side is exposed to combustion gas and the other side to water. Unless specified otherwise, the heating surfaces of superheaters, reheaters, economizers or exhaust gas economizers are excluded.

(6) "Approved working pressures of boilers" and "nominal pressure of boilers with built-in superheaters" are as defined in **2.1.22** and **2.1.23**, **Part 1**.

(7) "Design pressures" are those pressure used in the calculations made to determine the scantlings of each component and are the maximum permissible working pressure of a component. Design pressures of boiler drums are not to be less than the approved working pressure of their respective boilers.

7.1.3 Drawings and Data to be Submitted

Drawings and data to be submitted are generally as follows:

(1) Drawings (with materials and scantlings)
   - (a) General arrangement of the boiler
   - (b) Details of shells and headers (including the internal fittings)
   - (c) Details of the seats for boiler fittings and nozzles
   - (d) Arrangement and details of the boiler tubes
   - (e) Arrangement and details of the tubes for the superheater and reheater
   - (f) Details of the internal desuperheater
   - (g) Arrangement and details of the tubes for the economizer or exhaust gas economizer
   - (h) Details of the air preheater
   - (i) Arrangement and details of the boiler fittings
   - (j) Arrangement of the safety valves (including principal particulars)
   - (k) Details of the bursting disk (where fitted)
   - (l) Other drawings considered necessary by the Society

(2) Data
   - (a) Particulars of the boiler
   - (b) Welding specifications (including welding procedures, welding consumables and welding conditions)
   - (c) Operating instructions (for shell type exhaust gas economizers only)
   - (d) Other data considered necessary by the Society

7.2 Construction etc. of Boilers

7.2.1 General

1 Boilers with design pressures that do not exceed 0.35 *MPa* (hereinafter referred to as the "small boilers") are to comply with the requirements specified in **7.2.2** and **7.2.3**.

2 Boilers, excluding those given in **-1** above, are to comply with the requirements specified in **9.2** through **9.10, Part D of the Rules for the Survey and Construction of Steel Ships**.

7.2.2 Materials, Construction, Strength and Accessories of Small Boilers

1 The materials, construction and strength and accessories of small boilers are to comply with the requirements in recognized standard.

2 Small boilers are to be provided with safety valves or pressure relief piping of sufficient capacity.

3 Small boilers are to be provided with the following safety devices:

(1) Prepurging system for preventing the explosion of furnace gas.

(2) Fuel oil shut-off system which activates in cases of flame vanishing, automatic ignition failure or draught fan stoppage.

(3) Fuel oil shut-off system which activates when the pressure is not exceeding the approved working pressure of the boiler.

(4) Fuel oil shut-off system for preventing any overheating due to a lack of water supply.

7.2.3 Tests

1 Shop Tests

The pressure parts are to be subjected to hydrostatic tests at a pressure 2 *times* the design pressure or at 0.2 *MPa*, whichever is greater.

2 Tests after Installation on Board

Function tests for the safety devices of small boilers that are specified, in **7.2.2-3** above are to be carried out after the boiler has been installed on board.

7.3 Construction of Thermal Oil Heaters

7.3.1 General

Thermal oil heaters heated by flame or combustion gas are to comply with the relevant requirements specified in **7.1** in this Part and **9.2** through **9.10, Part D of the Rules for the Survey and Construction of Steel Ships** (in this case, the term "boiler" is to be read as "thermal oil heater") as well as the requirements in **7.3**.

7.3.2 Safety Devices, etc. for Thermal Oil Heaters Heated by Flame

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 always be kept 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 valves or pressure relief pipes of sufficient capacity are to be provided.

4 Discharge pipes from the safety valve of the pressure relief pipe specified in **-3** are to have their open ends in the thermal oil tank that is of sufficient capacity.

5 The following safety devices are to be provided:

(1) Prepurging system for preventing the explosion of the furnace gas.

(2) Fuel oil shut-off systems which operate in the following cases:

  (a) When there is an abnormal increase in the thermal oil temperature.

  (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 there is an abnormal fall in the thermal oil level of the expansion tank.

7.3.3 Safety Devices, etc. for Thermal Oil Heaters Directly Heated by the Exhaust Gas of Engines

1 Safety devices etc. are to comply with the requirements in **7.3.2-1**, **-3** and **-4**.

2 The master valve of an expansion tank is to normally be kept open and an interlocking device that prevents exhaust gas from entering into the heater when the master valve is closed is to be provided.

3 A shut-down device for exhaust gas is to be provided at the exhaust gas inlet of a thermal oil heater. In addition, it is to be so arranged that the engine can be operable even when the supply of the exhaust gas to the heater is shutdown.

4 Means are to be provided to prevent the leakage of any oil from thermal oil heaters and to prevent water used for firefighting or others from flowing into the exhaust gas duct of the engine.

5 Stop valves are to be provided at the inlet and outlet of the thermal oil heater.

6 An audible-visual alarm is to be provided to warn on the following occasions and relayed any such warning to the monitoring-station.

(1) When a fire breaks out in the thermal oil heater.

(2) When the temperature of the thermal oil becomes abnormally high.

(3) When the thermal oil leaks within the thermal oil heater.

(4) 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 decreases.

(5) When the liquid level in the expansion tank drops

7 A fixed fire extinguishing and cooling system as deemed appropriate by the Society is to be provided.

7.3.4 Thermal Oil Systems

The thermal oil systems for the thermal oil heaters are to comply with the requirements in **11.11**.

7.4 Incinerators

7.4.1 General

1 Notwithstanding the requirements in **7.2** and **7.3**, incinerators are to comply with the requirements in **7.4**. However, the requirements in **7.4** do not apply to the incinerators with maximum capacity less than 34.5kW.

2 Notwithstanding **-1**, incinerators for oil or rubbish other than those produced by normal ship operation or the like will be specially considered.

7.4.2 Drawings and Data to be Submitted

Notwithstanding the requirements in **7.1.3**, drawings and data to be submitted are as follows:

(1) Drawings
- (a) General arrangement of the incinerator
- (b) Arrangement of the incinerator fittings
- (c) Other drawings considered necessary by the Society

(2) Data
- (a) Particulars
- (b) Instruction manuals of safety devices
- (c) Operation manual of the incinerator
- (d) Other data considered necessary by the Society

7.4.3 Construction and Fittings

The construction and fittings of incinerators are to comply with the requirements in the following **(1)** to **(9)**.

(1) Major parts of the combustion chamber are to be constructed out of effective material.

(2) Combustion chambers are to be so constructed as to ensure that harmful combustion gas or drainage will not leak.

(3) Uptakes from combustion chambers are to satisfy the following **(a)** to **(c)**:
- (a) They are not to be connected to the exhaust gas pipes from diesel engines and gas turbines.
- (b) They are not to lead to such positions where any combustion gas might leak inboard.
- (c) When connected to the uptakes from boilers, thermal oil heaters or other incinerators, they are to be subject to the recognition of the Society.

(4) Temperature measuring devices for combustion gas are to be provided.

(5) Fire doors for rubbish are to be arranged so that back-firing from the combustion chamber is prevented.

(6) Over-pressure preventive devices are to be provided to the water jackets of any incinerators equipped with a

water jacket.

(7) Waste oil piping systems are to comply with the relevant requirements in **11.9**.

(8) Burning systems are to satisfy the following **(a)** to **(d)**:

(a) They are to be arranged so that the combustion chamber is prepurged by air before ignition.

(b) They are to be arranged so that the fuel valve does precede the ignition spark in cases where automatic ignition system is adopted.

(c) They are to be capable of controlling the amount of fuel supplied in cases where an automatic fuel supply system is provided.

(d) They are to comply with the requirements in **14.4.2-2(1)**, **(2)** and **(3)** in cases where an automatic combustion control device is provided.

(9) The location of the remote shut-off device for the incinerators is to comply with the requirements in **4.1.2-4**, **Part 9**.

7.4.4 Safety Devices and Alarm Devices

1 Incinerators fitted with automatic fuel or waste oil supply systems are to be provided with a safety device to automatically stop the supply of fuel and waste oil to the burners in the following cases **(1)** and **(2)**:

(1) When the maximum working temperature of the furnace is exceeded

(2) When the flame vanishes

2 Incinerators are to be provided with alarm devices which operate in the following cases:

(1) When the approved working temperature of the furnace is exceeded

(2) When the flame vanishes

(3) When the power supply to the alarm device stops

(4) When cooling system, if any, stops

(5) When the waste oil supply pressure to the furnace falls, in the case of pressure atomizing

(6) When the fuel supply pressure to the furnace falls, in the case of pressure atomizing

(7) When combustion air supply system, if any, stops

7.4.5 Tests

Operation tests of the safety devices and the alarm devices s specified in **7.4.4** as well as a burning test are to be carried out.

Chapter 8 PRESSURE VESSELS

8.1 General

8.1.1 Scope

1 The requirements in this Chapter apply to all liquid or gas containing vessels in which the internal pressure at the top of the vessel exceeds atmospheric pressure. These vessels include heat exchangers, but exclude those exposed to flame, combustion gas or hot gas.

2 For heat exchangers, etc. whose internal pressure does not reach atmospheric pressure, the relevant requirements in this Chapter apply. In this case a negative gauge pressure of the vessel is to be substituted for by a positive gauge pressure of the same value.

8.1.2 Design Pressures

The design pressure used for the strength calculations of the materials used for pressure vessels is not to be less than the following, whichever is the greatest:

(1) Approved working pressure specified in **2.1.22, Part 1**.

(2) Maximum working pressure at maximum temperature (maximum working temperature) as designed by the manufacturer

(3) For pressure vessels of liquefied gases that are stored under a pressurized condition that is at or near atmospheric temperature, the following pressure requirement, whichever is the greatest, is to apply:

  (a) Vapour pressure of the gas at 45°*C*

  (b) Maximum working pressure

  (c) 0.7 *MPa*

8.1.3 Classification of Pressure Vessels

1 Pressure vessels are classified into the following three groups in accordance with the thickness of their shell plates and their service conditions.

(1) Pressure vessels, Group I (*PV*-1)

  Pressure vessels which conform to either one of the following:

  (a) Shell plates exceeding 38 *mm* in thickness (*See* Note 1.)

  (b) Design pressure exceeding 4 *MPa* (*See* Note 1.)

  (c) Maximum working temperature exceeding 350°*C*

  (d) Steam generators with a design pressure exceeding 0.35 *MPa*

  (e) Vessels which contain inflammable high pressure gases having a vapour pressure not less than 0.2 *MPa* at 38°*C* (*See* Note 2.)

  Notes:

  1. Pressure vessels which have shell plates that exceed 38 *mm* in thickness and/or a design pressure that exceeds 4 *MPa* are classified into "*PV*-2" provided that they are only subjected to hydraulic oil or water pressure at atmospheric temperature.
  2. The requirements for "*PV*-2" apply to materials, construction and welding, when the pressure vessel has a capacity of 500 *litres* or less.

(2) Pressure vessels, Group II (*PV*-2)

  Pressure vessels which conform to either one of the following:

  (a) Shell plates exceeding 16 *mm* in thickness

  (b) Design pressure exceeding 1 *MPa*

  (c) Maximum working temperature exceeding 150°*C*

  (d) Steam generators with a design pressure not exceeding 0.35 *MPa*

(3) Pressure vessels, Group III (*PV*-3)

  Pressure vessels not included in Group I and II

2 The classification of those pressure vessels used for dangerous substances not specified in **-1** will be determined on a case by case basis, in accordance with the property of the substance, the service condition, etc.

8.1.4 Drawings and Data

Drawings and data to be submitted are generally as follows. However, for pressure vessels of Group III, no submission is required unless it is specifically requested by the Society.

(1) Drawings (with type and dimensions of materials specified)
  - (a) General arrangement
  - (b) Details of the shells
  - (c) Arrangement of the pressure relief devices
  - (d) Details of the washers for fittings and nozzles
  - (e) Other drawings considered necessary by the Society

(2) Data
  - (a) Principal particulars
  - (b) Welding specifications (with welding procedures, welding consumables and welding conditions)
  - (c) Other data considered necessary by the Society

8.2 Materials and Welding

8.2.1 Materials

1 The materials used for the construction of the pressure parts of pressure vessels are to be adequate for their service conditions and are to comply with the requirements in the following **(1)** to **(3)**. However, when special materials are intended to be used, sufficient information related to the design and usage of these materials is to be submitted to the Society for approval.

(1) Pressure vessels, Group I (*PV*-1)
All materials are to comply with the requirements in **Chapter 3** to **Chapter 7, Part K of the Rules for the Survey and Construction of Steel Ships** and they are to be tested in accordance with the requirements in **Chapter 1** and **Chapter 2** of the said Part.

(2) Pressure vessels, Group II (*PV*-2)
Same as those for Group I. However, for those pressure vessels which conform to either one of the following conditions, materials may be in accordance with the requirements in **(3)**.
  - (a) Design pressure below 0.7 *MPa*.
  - (b) Design pressure not exceeding 2 *MPa*, a maximum working temperature not exceeding 150°*C* and an internal capacity not exceeding 500 *litres*.

(3) Pressure vessels, Group III (*PV*-3)
Materials complying with the requirements on the recognized standards are to be used.

2 Notwithstanding the requirements in **-1(1)** and **(2)**, the materials used for fittings such as valves, nozzles, etc. that are to be fitted to pressure vessels of Group I and Group II may be in accordance with the requirements in **-1(3)**, where approved by the Society with consideration given to their dimensions and service conditions.

8.2.2 Service Limitations of Cast Iron

1 Grey cast iron is not to be used for the shells of the following pressure vessels:

(1) Those that have a maximum working temperature which exceeds 220°*C* or a design pressure which exceeds 1 *MPa*.

(2) Those that contain or handle flammable or toxic substances.

2 Special cast iron such as nodular graphite cast iron, etc. may be used, when approved by the Society, for those pressure vessels that have a maximum working temperature not exceeding 350°*C* and a design pressure not exceeding 1.8 *MPa*.

8.2.3 Service Limitations of Materials Used for Fittings

The service limitation of materials to be used for fittings is to comply with the requirements in **9.9.1, Part D of the Rules for the Survey and Construction of Steel Ships**. For the fittings of pressure vessels used to contain or to handle flammable or toxic substances, no cast iron is to be used unless approved by the Society.

8.2.4 Heat Treatment of Steel Plates

In cases where a heat treatment such as hot forming or stress relieving is to be carried out on steel plates during the manufacturing process, the manufacturer of the pressure vessels is to make clear this intention when ordering the materials. What is expected of the manufactures of steel plates in these cases is specified in **3.3.4, Part K of the Rules for the Survey and Construction of Steel Ships**.

8.2.5 Heat Treatment of Materials subjected to Cold-forming

In cases where cold-forming is considered harmful to materials of the pressure vessels which are intended for use in an environment where things such as stress corrosion cracking, etc. are expected, suitable measures such as heat treatment are to be taken.

8.2.6 Non-destructive Testing for Cast Steels and Cast Irons

1 Cast steel and cast iron used for the shells of pressure vessels of Group I subject to internal pressure are to be subjected to radiographic testing or ultrasonic testing as well as magnetic particle testing or dye penetrant testing in order to confirm that they are free from detrimental defects.

2 Cast steel and cast iron used for the shells of pressure vessels of Group II subject to internal pressure are to be subjected to adequate non-destructive testing in order to confirm that they are free from detrimental defects.

8.2.7 Welding

The workmanship of the welding of pressure vessels are to comply with the requirements in **Chapter 9**.

8.3 Design Requirements

8.3.1 Symbols

Unless expressly specified otherwise, the symbols used in this Chapter are as follows:

f : Allowable stress (*N/mm*^{2}) conforming to the requirements in **8.4.1-1**, **-2** or **10.2.1**

a : Corrosion allowance (*mm*) conforming to the requirements in **8.4.3**

T_r : Required thickness (*mm*) calculated by using design pressure. The allowable pressure means the pressure obtained by substituting the actual thickness for the required thickness

P : Design pressure (*MPa*)

J : Minimum value of the efficiency specified in **8.4.2**

R : Inside radius of the shell (*mm*)

R_{20} : Specified tensile strength at room temperature for the material concerned (*N/mm*^{2})

E_{20} : Specified minimum yield point (or 0.2% proof stress) at room temperature of material concerned (*N/mm*^{2})

8.3.2 Design Loads

1 The design of a pressure vessel is to take the following loads, in addition to any internal pressure, into account when it is considered to be necessary:

(1) Static head of contained fluid

(2) External pressure

(3) Dynamic loads caused by ship motion

(4) Thermal stress

(5) Loads from fittings

(6) Loads due to reactions exerting on supporting structure

(7) Hydrostatic test pressure loads

(8) Other loads or external forces exerted on the actual pressure vessels

2 If deemed necessary, fatigue analysis and crack propagation analysis are to be carried out in consideration of the loads specified in **-1**.

8.3.3 Pressure Vessels of Unusual Shapes

In cases where, due to the unusual shape of the part being subject to pressure, it is not appropriate to design a pressure vessel according to the requirements in **8.5** and **8.6**, any strain or deformations under a suitable load are to be measured with the approval by the Society. The Society will consider them as complying with the requirements in **8.5** and **8.6** after taking account of the results of these measurements.

8.3.4 Design Considerations

1 Pressure vessels for low temperature service are to have sufficient notch toughness for the lowest service temperature involved.

2 Pressure vessels used in an extremely corrosive environment are to be provided with effective corrosion control means.

3 Heat exchangers are to be provided with an effective sealing mechanism at the joints between tubes and tube plates as well as at joints between tube plates and the shell so as to prevent the two types of heat exchanging fluid from mixing together.

8.3.5 Considerations for Installation

1 Pressure vessels are to be so installed as to minimize the effects of ship motion, vibrations from the machinery installations, external forces exerted by piping and supports as well as thermal expansion due to temperature variation.

2 Pressure vessels and their fittings are to be installed at positions convenient for operation, repair and inspection.

8.4 Allowable Stress, Efficiency and Corrosion Allowance

8.4.1 Allowable Stress

1 The allowable stress of materials used at room temperature is to be determined by the following:

(1) Excluding cast steels, the allowable stress (f) of carbon steels (Including carbon manganese steel. Hereinafter, this definition applies throughout this Chapter) and low alloy steels, is to be the value obtained from the following formulae, whichever is smaller. For pressure vessels used for liquefied gas, the values of the denominators for f_1 and f_2 are to be 3.0 and 2.0, respectively.

$$f_1 = \frac{R_{20}}{2.7}, \quad f_2 = \frac{E_{20}}{1.6}$$

(2) The allowable stress of electric resistance welded steel tubes, except where they are used for the shells of pressure vessels, is to be the value specified in **(1)** when subjected to ultrasonic testing or any other compatible flaw detection approved by the Society for the entire length of the weld. In other cases, a value that is 85% of the value specified in **(1)** is to be used.

(3) The allowable stress of cast steel is to be the value obtained by **(1)** multiplied by the coefficients given in **Table 7.8.1**.

(4) The allowable stress of cast iron is to be 1/8 of the specified minimum tensile strength.
However, the allowable stress of any special cast iron approved by the Society may be 1/6 of the specified minimum tensile strength.

(5) The allowable stress (f) of austenitic steel is to be obtained from the following f_1 or f_2, whichever is smaller.

$$f_1 = \frac{R_{20}}{3.5}, \quad f_2 = \frac{E_{20}}{1.6}$$

(6) The allowable stress (f) of aluminum alloy is to be obtained from the following f_1 or f_2, whichever is smaller.

$$f_1 = \frac{R_{20}}{4.0}, \quad f_2 = \frac{E_{20}}{1.5}$$

Table 7.8.1 Coefficients to be Multiplied to the 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 a radiographic test or alternative testing is carried out	0.8
When the above tests are carried out all parts	0.9

2 For the allowable stress of materials used for pressure vessels for high temperature service, the requirements in **9.4.1, Part D of the Rules for the Survey and Construction of Steel Ships** or the values deemed appropriate by the

Society apply.

3 Allowable tensile stress is to conform to the requirements in **-1** and **-2**. However, the allowable tensile stress of bolts is to comply with the following requirements:

(1) In cases where bolts are used at room temperature, the value is to be obtained from the following **(a)** or **(b)**, whichever is 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) $\dfrac{E_{20}}{4.0}$

(2) In cases where bolts are used at high temperatures, the value will be considered by the Society on a case by case basis.

4 Allowable bending stress is to comply with the following requirements:

(1) In cases where the materials are used at room temperature, the requirements in **-1** are to be complied with. However, for cast iron or cast steel, the value used is to be 1.2 *times* thereof.

(2) In cases where the materials are used at high temperatures, the value will be considered by Society on a case by case basis.

5 The allowable shearing stress for the mean primary shearing stress in the section subjected to shearing loads is to be a value that is 80% of the allowable tensile stress.

6 The allowable compression stress in the cylindrical shell of pressure vessels used at room temperature that are subject to a load causing compression stress in the longitudinal direction is to be obtained from the following **(1)** or **(2)**, whichever is smaller:

(1) The value specified in **-1**

(2) The allowable buckling stress by the following formula:

$$\sigma_z = \frac{0.3ET_0}{D_m(1+0.004\dfrac{E}{E_{20}})}$$

Where:

σ_z : Allowable buckling stress (*N/mm*^{2})

E : Modulus of longitudinal elasticity at room temperature (*N/mm*^{2})

T_0 : Net thickness of a shell plate excluding any 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 shells of pressure vessels formed by a rotating unit when detailed calculations are carried out may be as follows:

$$P_m \le f$$

$$P_L \le 1.5f$$

$$P_b \le 1.5f$$

$$P_L + P_b \le 1.5f$$

$$P_m + P_b \le 1.5\ f$$

$$P_L + P_b + Q \le 3\ f$$

Where:

P_m : Equivalent primary general membrane stress (*N/mm*^{2})

P_L : Equivalent primary local membrane stress (*N/mm*^{2})

P_b : Equivalent primary bending stress (*N/mm*^{2})

Q : Equivalent secondary stress (*N/mm*^{2})

8.4.2 Efficiencies of Joints

The efficiency of joints is to be as follows:

(1) Seamless shells: 1.00

(2) Welded shells: As given in **Table 7.8.2**

(3) Where electric resistance welded steel tubes are used for the shell: As given in item (1), **Table 7.8.2**

Table 7.8.2 Joint Efficiency of Welded Joints

Type of joint	Type of radiographic testing		
	Full radiographic testing carried out	Partial radiographic testing carried out	No radiographic testing carried out
(1) Double-welded butt joints or those butt welded joints considered by the Society to be equivalent	1.00	0.85	0.75
(2) Single-welded butt joints where the backing strip is left unremoved or those single-welded butt joints considered by the Society to be equivalent	0.90	0.80	0.70
(3) Single-welded butt joints other than those in (1) and (2) above	-	-	0.60
(4) Double-welded full fillet lap joints	-	-	0.55

Note:
Radiographic testing may be substituted for by ultrasonic testing if approved by the Society.

8.4.3 Corrosion Allowance

1 The corrosion allowance of materials used for strength calculation, except where they are subjected to extreme corrosion or wear and tear, is to be not less than 1.0 *mm* or 1/6 of the required thickness without the corrosion allowance for the inner surface, whichever is smaller. In cases where corrosion resistance materials are used and effective corrosion control measures are taken or when there is no possibility of corrosion, this value may be reduced accordingly.

2 In cases where the outer surface of a pressure vessel which may suffer corrosion is provided with thermal insulation that prevents external inspection, an appropriate amount of corrosion allowance is also to be provided on the outer surface of the pressure vessel.

8.5 Strength

8.5.1 Minimum Thickness of Each Component

1 The thickness of shell plates and end plates is not to be less than 5 *mm* except where specifically approved by the Society with consideration given to the diameter, pressure, temperature, materials, etc. The thickness of formed end plates, except for full hemispherical end plates, is not to be less than the required thickness (calculated by assuming that the efficiency is 1.00) of the shell to which the end plate is welded.

2 The thickness of nozzles welded to pressure vessels is to comply with the following requirements. These requirements will be modified where approved by the Society with consideration given to the dimensions or shape, materials, etc.

(1) The thickness is not to be less than either the value 2.5 *mm* added to 1/25 of the outside diameter of the nozzle or the value calculated by the formula in **8.5.2-2**. However, this value need not be more than the thickness of the shell at which the nozzle is welded.

(2) Notwithstanding the requirement in **(1)**, for Groups II and III pressure vessels the value need not be more than 4 *mm*, if it is not less than the value calculated by the formula in **8.5.2-2**.

8.5.2 Strength of Shell Plates, End Plates and Flat Plates subjected to Internal Pressure

1 General

Shell plates, end plates and flat plates without stays or other supports (excluding the tube plates of heat exchangers) subjected to internal pressure are to comply with the requirements specified in **-2** to **-7**. However, the strength of the shell plates of pressure vessels is to be calculated in accordance with suitable formulae considered appropriate by the Society under the following conditions.

(1) Cylindrical pressure vessels

$$\frac{T_r}{D} > 0.25 \quad \text{or} \quad P > \frac{fJ}{2.5}$$

(2) Spherical pressure vessels

$$\frac{T_r}{D} > 0.185 \quad \text{or} \quad P > \frac{fJ}{1.5}$$

2 Required thickness of cylindrical shell plates subjected to internal pressure

The required thickness of cylindrical shell plates subject to internal pressure is to be calculated by the following formula. However, in the case of cylindrical shell plates having openings for which reinforcement is required, openings are to be reinforced in accordance with the requirements in **8.6.3**.

$$T_r = \frac{PR}{fJ - 0.5P} + a$$

3 Required thickness of spherical shell plates subjected to internal pressure

The required thickness of spherical shell plates subject to internal pressure is to be calculated by the following formula. However, in the case of spherical shell plates having openings for which reinforcement is required, the openings are to be reinforced in accordance with the requirements in **8.6.3**.

$$T_r = \frac{PR}{2fJ - 0.5P} + a$$

4 Required thickness of formed end plates subjected to pressure on the concave side without stays or other supports

(1) The required thickness of end plates having no openings is to be calculated by the following formula:

(a) Dished and hemispherical end plates

$$T_r = \frac{PR_1W}{2fJ - 0.5P} + a$$

Where:

$$W = \frac{1}{4}\left(3 + \sqrt{\frac{R_1}{r}}\right) \quad \text{for dished end plates}$$

W = 1 for hemispherical end plates

R_1 : Inside crown radius

It is to be less than the outside diameter of the skirt of the end plate.

r : Inside knuckle radius

It is not to be less than 6% of the outside diameter of the skirt of the end plate or 3 *times* the actual thickness of the end plate, whichever is greater.

(b) Semi-ellipsoidal end plates (in cases where the inside minor radius of the end plate is not less than 1/2 of the inside major radius of the end plate)

$$T_r = \frac{PR}{fJ - 0.25P} + a$$

(2) The required thickness of end plates having openings is to comply with the following requirements in **(a)**, **(b)** or **(c)**:

(a) In cases where no reinforcement for openings is necessary according to the requirements in **8.6.2**, or the openings are reinforced in accordance with the requirements in **9.6.3-3** to **-5, Part D of the Rules for the Survey and Construction of Steel Ships**, the required thickness is to be calculated by the formula specified in **(1)** above.

(b) In cases where an end plate has a flanged-in manhole or an access opening with a maximum diameter exceeding 150 *mm* and the flanged-in reinforcement complies with the requirement in **9.6.3-7, Part D of the Rules for the Survey and Construction of Steel Ships**, the thickness is to be calculated as follows:

i) 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 3 *mm*) of the required thickness calculated by the formula specified in **(1)(a)**. 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 end plates having two manholes in accordance with **i)**, the distance between the two manholes is not to be less than 1/4 of the outside diameter of the end plate.

ii) Semi-ellipsoidal end plates

The requirements in **(1)(a)** are to be applied, however, in this case R_1 is to be 0.80 *times* the inside diameter of shell, and W is to be 1.77.

(c) The required thickness, where the openings are not reinforced in accordance with the requirements in **(a)** or **(b)**, is to be calculated by the following formula. However, this thickness is not to be less than the value obtained by the formula given in **(1)**.

$$T_r = \frac{PD_0}{2f} K + a$$

Where:

D_0 : Outside diameter of the end plate (*mm*)

K : As shown in **Fig. D9.6, Part D of the Rules for the Survey and Construction of Steel Ships**. However, this is applicable to end plates complying with the following conditions:

Hemispherical end plates:

$0.003D_0 \le T_e \le 0.16D_0$

Semi-ellipsoidal end plates:

$0.003D_0 \le T_e \le 0.08D_0$

$H \ge 0.18D_0$

Dished end plates:

$0.003D_0 \le T_e \le 0.08D_0$

$r \ge 0.1D_0$

$r \ge 3T_e$

$R_1 \le D_0$

$H \ge 0.18D_0$

or $0.01D_0 \le T_e \le 0.03D_0$

$r \ge 0.06D_0$

$H = 0.18D_0$

or $0.02D_0 \le T_e \le 0.03D_0$

$r \ge 0.06D_0$

$0.18D_0 \le H \le 0.22D_0$

T_e : Actual thickness of the end plate (*mm*)

H : Depth of the end plate measured on its external surface from the plane of junction of the dished part with the cylindrical part (*mm*)

R_1 and r : As specified in **(1)(a)**

5 Required thickness of formed end plates subjected to pressure on their convex side

The required thickness of formed end plates subjected to pressure on their convex sides is not to be less than the thickness calculated on the assumption that their concave sides are subjected to a pressure at least 1.67 *times* the design pressure.

6 Required thickness of flat end plates and cover plates, etc. without stays or other supports

(1) In cases where flat end plates and cover plates without stays or other supports are welded to shell plates, the required thickness is to be calculated by the following formulae:

(a) Circular plates

$$T_r = C_1 d \sqrt{\frac{P}{f}} + a$$

(b) Non-circular plates

$$T_r = C_1 C_2 d \sqrt{\frac{P}{f}} + a$$

Where:

C_1 : Constant shown in **Fig. D9.9, Part D of the Rules for the Survey and Construction of Steel Ships**

$C_2 = \sqrt{3.4 - 2.4\frac{d}{D'}}$ but need not be over 1.6

d : Diameter shown in **Fig. D9.9, Part D of the Rules for the Survey and Construction of Steel Ships** (for circular plates), or the minimum length (for non-circular end plates) (*mm*)

D' : Long span of non-circular end plates or covers measured perpendicular to the short span (*mm*)

(2) In cases where flat cover plates without stays are bolted to the shell plate, the required thickness is to be calculated by the following formulae:

(a) In cases where full face gaskets are used

For circular plates

$$T_r = d\sqrt{\frac{C_3 P}{f}} + a$$

For non-circular plates

$$T_r = d\sqrt{\frac{C_3 C_4 P}{f}} + a$$

(b) In cases where moment due to gasket reaction is to be taken into account;

For circular plates

$$T_r = d\sqrt{\frac{C_3 P}{f} + \frac{1.78 W h_g}{f d^3}} + a$$

For non-circular plates

$$T_r = d\sqrt{\frac{C_3 C_4 P}{f} + \frac{6 V h_g}{f L d^2}} + a$$

Where:

C_3 : Constant determined by the bolting methods as shown in **Fig. D9.10, Part D of the Rules for the Survey and Construction of Steel Ships**

$C_4 = 3.4 - 2.4\frac{d}{D'}$ but need not be over 2.5

d : Diameter shown in **Fig. D9.10, Part D of the Rules for the Survey and Construction of Steel Ships** (for circular plates, or the minimum length (for non-circular plates) (*mm*)

D' : Long span of non-circular end plates or covers measured perpendicular to the short span (*mm*)

W : Mean load (*N*) of bolt loads necessary for the watertightness and the allowable load for the bolt actually used

L : Total length of the circle passing through the bolt centres (*mm*)

h_g : Arm length of moment due to the gasket reaction shown in **Fig. D9.10, Part D of the Rules for the Survey and Construction of Steel Ships** (*mm*)

7 Steam heated steam generators

For steam heated steam generators, the required thickness of flat end plates with stays or other supports, and the required dimensions of the stays are to comply with the requirements in **9.5.7**, **9.5.13** and **9.5.14, Part D of the Rules for the Survey and Construction of Steel Ships**.

8.5.3 Required Thickness of Tube Plates for Heat Exchangers

The thickness of tube plates for heat exchangers without tube stays is to comply with the following requirements:

(1) Except for floating head, the required thickness of flat tube plates without tube stays for the heat exchangers and the like is to be either of the values calculated by the following formulae, whichever is greater:

$$T_r = \frac{C_5 D}{2}\sqrt{\frac{P}{f_b}} + a$$

$$T_r = \frac{PA}{\tau L} + a$$

Where:

f_b : Allowable bending stress of the material (N/mm^2)

τ : Allowable shearing stress of the material (N/mm^2)

C_5 : Factor determined by the supporting method of tube and tube plate. In cases where the tube plates are not integral with the shell, when straight tubes are used this value is to be 1.0. When *U*-tubes are used this value is to be 1.25. In cases where the tube plates are integral with the shell, the value shown in **Fig. 7.8.1** is to be used.

D : Diameter of outer circle of tube end plate (*mm*). In cases where the tube end plate is bolted to flange, D is the diameter of a circle passing through the positions to which gasket reaction is acted; where the tube plate is fixed to the shell, the inside diameter of the shell (corrosion allowance is to be deducted) is to be taken.

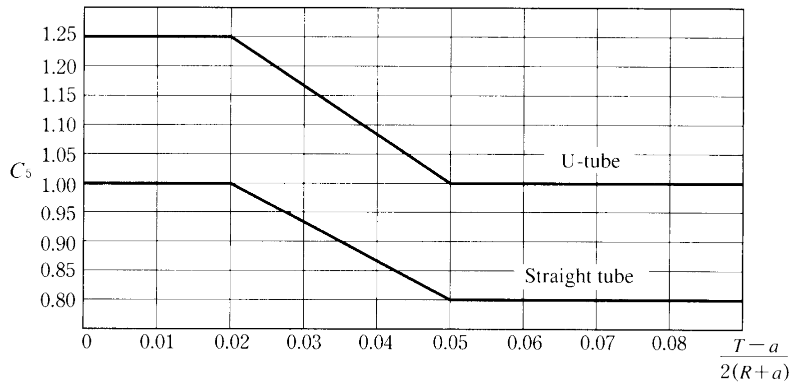
A : Area of a polygon obtained by connecting the centres of the outermost tube holes (*See*, **Fig. 7.8.2**) (mm^2)

L : Length obtained by deducting the sum of the tube hole diameters of the outermost tubes from the length of the outer periphery of the aforementioned polygon (*mm*)

a : Corrosion allowance (*mm*). In cases where a groove for the partition plate or a gasket groove with a depth greater than the corrosion allowance specified in **8.4.3** is provided, a is to be taken to the depth of such groove.

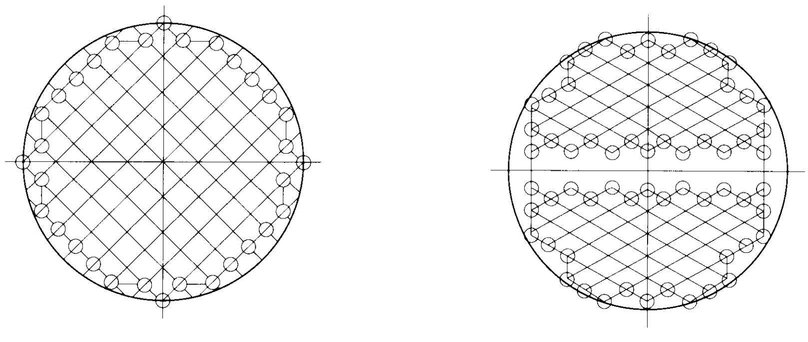
(2) The calculation of T_r in **(1)** is to be carried out on both sides by using the values for P, C_5 and D. However, in cases where a differential pressure calculation is carried out, approval will be given by the Society on a case by case basis.

Fig. 7.8.1 Value of C_5



T = Actual thickness of shell plate (*mm*)

Fig. 7.8.2 Polygon used for Tube Plate Calculation



8.5.4 Required Thickness of Tubes for Heat Exchangers

1 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:

$$T_r = \frac{PD_0}{2f} + a$$

Where:

D_0 : Outside diameter of the tube (*mm*)

a : 1.5 *mm* for steel tube; 0.1*T* for copper or copper alloy tube

T : Actual thickness of the tube (*mm*)

f : As given in **8.4.1** or **Table 7.8.3**

2 The thickness of the bent pipes for *U*-tube type heat exchangers is to be sufficient and take into account any thickness reduction caused by bending.

Table 7.8.3 Values of the Allowable Stress of Copper and Copper Alloy Pipes (f)

Kind of materials (Grade)	Design Temperature (°*C*)										
	50 or less	75	100	125	150	175	200	225	250	275	300
For phosphorous deoxidized copper seamless pipes and tubes (N/mm^2)											
*C*1201 *C*1220	41	41	40	40	34	27.5	18.5	-	-	-	-
For brass seamless pipes and tubes for condensers and heat exchangers (N/mm^2)											
*C*4430	68	68	68	68	68	67	24	-	-	-	-
*C*6870 *C*6871 *C*6872	78	78	78	78	78	51	24.5	-	-	-	-
For copper nickel seamless pipes and tubes for condensers and heat exchangers (N/mm^2)											
*C*7060	68	68	67	65.5	64	62	59	56	52	48	44
*C*7100	73	72	72	71	70	70	67	65	63	60	57
*C*7150	81	79	77	75	73	71	69	67	65.5	64	62

Note:

Intermediate values are to be determined by interpolation.

8.5.5 Strength of Pressure Vessels subjected to External Pressure

In cases where the internal pressure of pressure vessels may become lower than the external pressure, strength calculations are to be carried out for buckling.

8.5.6 Fatigue Analysis

For pressure vessels subjected to dynamic loads or excessive cyclic external loads, fatigue analysis is to be carried out. The degree of cumulative fatigue in these cases is to comply with the following formula. However, the value on the right side of the formula may be increased to a value considered appropriate by the Society according to the *S-N* curve used in the calculation, but is not to exceed 1.0.

$$\sum \frac{n_i}{N_i} \leq 0.5$$

Where:

n_i : Number of cycles at each stress level

N_i : Number of cycles to fracture for the respective stress level given by the *S-N* curve of material used

8.5.7 Considerations for Secondary Stress

In cases where deemed necessary by the Society, consideration is to be given to the strength against secondary stress.

8.5.8 Considerations for Thermal Stress

For pressure vessels which may be subject to excessive thermal stress or which contain fluid with a boiling point below -55°*C*, consideration is to be given to the strength against thermal stress.

8.5.9 Strength Calculation by Special Method

Even in cases where the dimensions of each component of pressure vessels do not conform to the requirements in **8.5**, if detailed strength calculation sheets are submitted, the Society will examine the data and approve the pressure vessels provided that the results are acceptable to the Society.

8.6 Manholes, Other Openings for Nozzle, etc. and their Reinforcements

8.6.1 Manholes, Cleaning Holes and Inspection Holes

1 Pressure vessels are to be provided with manholes, cleaning holes and inspection holes on the shell plates or end plates for inspection and maintenance in accordance with **Table 7.8.4**. However, where considered appropriate by the Society, the number and dimensions of these openings may be reduced.

2 The standard dimensions of manhole, cleaning holes and inspection holes are given in **Table 7.8.5**.

3 The construction of holes and covers is to comply with the requirements in **9.6.1-2, Part D of the Rules for the Survey and Construction of Steel Ships**.

Table 7.8.4 Number of Manholes, Cleaning Holes and Inspection Holes

Inside diameter of shell	Number of manholes, cleaning holes and inspection holes	
	Vessels with internal volume of not more than 100*l* and with internal length of not more than 1.5*m*.	All other vessels than those listed in the left hand column
300*mm* or below	One or more inspection holes	Two or more inspection holes
More than 300*mm* up to and including 500*mm*		Two or more cleaning holes; or, one or more each of cleaning holes and inspection holes
More than 500*mm* up to and including 750*mm*	-	One or more manholes; or, two or more cleaning holes; or, one or more each of cleaning holes(1) and inspection holes
More than 750*mm*	-	One or more manholes(2)

Notes:

(1) The dimensions of cleaning holes are generally to comply with the values for cleaning holes required by the shell with an internal diameter more than 750 *mm* by the **Table 7.8.5**

(2) Pressure vessels such as heat exchangers, etc. which are not considered necessary to be provided with manholes for reasons of shape, purpose, etc. may be provided with two or more cleaning holes instead of any manholes.

Table 7.8.5 Dimensions of Holes

Type of hole	Inside diameter of the shell	Dimensions
Manholes	For all dimensions	Oval : 400*mm*×300*mm* Circular : 400*mm*
Cleaning holes	More than 750*mm*	Oval : 150*mm*×100*mm* Circular : 150*mm*
	750*mm* and less	Oval : 100*mm*×75*mm* Circular : 100*mm*
Inspection holes	For all dimensions	50*mm*

8.6.2 Reinforcement of Opening

In cases where manholes, other openings for nozzles, etc. are provided in the shell, openings are to be reinforced. However, this reinforcement may be omitted for single openings shown in the following:

(1) Openings having a maximum diameter (in a threaded opening, the diameter of the root) of not more than 60 *mm* or more than 1/4 of the inside diameter of the shell or of the flanged part of the end plate.
(2) Openings provided on the shell plate having a maximum diameter not exceeding the value shown in **Fig. D9.7, Part D of the Rules for the Survey and Construction of Steel Ships**. In this case, no unreinforced opening is to exceed 200 *mm* in diameter.
(3) Openings provided on end plates complying with the requirement in **8.5.2-4(2)(c)** where no reinforcement is required due to the increased thickness of the end plates.

8.6.3 Reinforcing Procedures of Openings

The reinforcing procedures for openings provided in shell plates and end plates subjected to internal pressure are to comply with the requirements in **9.6.3, Part D of the Rules for the Survey and Construction of Steel Ships**. However, the reinforcement of the following openings will be considered by the Society on a case by case basis.
(1) Openings provided in the shell plate and having a diameter not less than 1/2 of the inside diameter of the shell.
(2) Openings whose outer extremity is at a distance of one-tenth of the shell outside diameter from the outer surface of the shell.
(3) Multiple openings which are provided in close proximity of each other.

8.7 Joints and Connections of Each Member

8.7.1 Welded Joints

1 The dimension and shape of edge preparation and the method of tapering plates of unequal thickness are to comply with the requirements in **9.8.1-1** and **-2, Part D of the Rules for the Survey and Construction of Steel Ships**.
2 The welded joints of the shells of the pressure vessels of Group I are to comply with the following requirements:
(1) Longitudinal joints
To be double-welded butt joints or other butt welded joints considered by the Society to be equivalent.
(2) Circumferential joints
To be in accordance with **(1)** above. However, when approved by the Society, the double-welded butt joint may be replaced by a single-welded butt joint with a backing strip or another butt welded joint considered by the Society to be equivalent may be used.
3 The welded joints of the shells of the pressure vessels of Group II are to comply with the following requirements:
(1) Longitudinal joints
To be in accordance with **-2(1)**.
(2) Circumferential joints
In addition to those in **(1)**, single-welded butt joints with backing strips or other butt welded joints considered by the Society to be equivalent. However, for plates of not more than 16 *mm* in thickness, a single-welded butt joint may be used.
4 The welded joints of the shells of the pressure vessels of Group III are to comply with the following requirements:
(1) Longitudinal joints
(a) For plates over 9 *mm* in thickness
Same as those in **-3(1)**. However, single-welded butt joints with backing strips or other butt welded joints considered by the society to be equivalent may be used.
(b) For plates of not more than 9 *mm* in thickness
Same as those in **(a)** above. However, a double-welded full fillet lap joint may be used.
(c) For plates of not more than 6 *mm* in thickness
Same as those in **(b)** above. However, a single-welded butt joint may be used.
(2) Circumferential joints
Same as those in **(1)(c)**. However, a one-sided welded full fillet lap joint may be used.

8.7.2 Shape of Welded Joint and Connection

The shape of welded joints and connections are to be as shown in **Fig. D9.9, Part D of the Rules for the**

Survey and Construction of Steel Ships, or be a shape which is considered by the Society to be equivalent.

8.7.3 Construction of Bolted Cover Plates

The construction of unstayed flat cover plates bolted to the shell is to comply with the requirements in **9.8.3, Part D of the Rules for the Survey and Construction of Steel Ships**.

8.8 Fittings, etc.

8.8.1 Materials of Fittings

The materials for nozzles, flanges or distance pieces attached directly to the shell of pressure vessels of Group I and Group II are to be equivalent to the material of the shell. However, this requirement may be dispensed with for flanges that are to be bolted or where approved by the Society.

8.8.2 Construction of Fittings

1 Fittings such as valves, flanges as well as bolts, nuts, gaskets, etc. are to be of a construction and have dimensions conforming to the recognized standards. They are also to conform to the service conditions specified in such standards.

2 Fittings are to be attached to the shells of pressure vessels of Group I and Group II by flanged joints or by welding. However, in cases where the thickness of the shell is over 12 *mm* or in cases where a seat for screwing is fitted to the shell, fittings of not more than 32 *mm* in nominal diameter may be attached to the shell by screws.

8.8.3 Installation of Pressure Relief Devices

1 Pressure vessels in which pressure may exceed the design pressure under working conditions are to be provided with relief valves. These relief valves are to be set at a pressure not exceeding the design pressure and be capable of preventing the pressure from exceeding the design pressure by more than 10%.

2 In cases where the exposure of a pressure vessel to fire or some other unexpected source of external heat may create a dangerous condition, a pressure relieving device is to be provided to prevent the pressure from exceeding the design pressure by more than 1.2 *times*. However, if an air reservoir which is not used for a general emergency alarm system required by Regulation 6, Chapter III, the Annex to *SOLAS* Convention is provided with a fusible plug that has a melting point, not exceeding 150*°C*, to release pressure automatically in the case of a fire, such a pressure relieving device may be omitted.

3 Heat exchangers or other similar pressure vessels, where internal pressure may exceed design pressure due to a failure of the heat exchanging tubes, tube plates, partition plates and other internals are to be provided with a suitable relief valve.

4 Steam generators belonging to Group I are to be provided with the safety valve specified in **9.9.3, Part D of the Rules for the Survey and Construction of Steel Ships**.

5 No stop valve is to be provided between a pressure vessel and a relief valve or other pressure relieving devices, except where means are provided in such a way that the function of the pressure relieving device is not impaired during the use of the pressure vessels.

6 A rupture disc may be provided between a pressure vessel and a relief valve or at the discharge line of a relief valve. In this case, the bursting pressure of the rupture disc is not to exceed the set pressure of the relief valve. In addition, the discharge capacity of the rupture disc is not to be less than the discharge capacity of the relief valve.

8.8.4 Pressure and Temperature Measuring Devices

Pressure and temperature measuring devices are to be provided on pressure vessel where considered necessary.

8.8.5 Fittings of Air Reservoir

1 Pressure relieving devices for air reservoirs are to comply with the requirements in **8.8.3**.

2 Air reservoirs are to be provided with effective drainage systems.

3 Air reservoirs are to be provided with pressure measuring devices.

8.9 Tests

8.9.1 Shop Tests

1 Tests for welds are to conform to the requirements in **Chapter 9** of this Part.

2 Pressure vessels and their fittings are to be subjected to hydrostatic tests according to the following requirements after being manufactured:

(1) Shells of pressure vessels

(a) Pressure vessels of Group I and Group II are to be subjected to hydrostatic tests at a pressure equal to 1.5 *times* their design pressure.

However, when the primary general membrane stress of the shell is expected to exceed 90% of the specified yield point of the material by this test pressure, the test pressure is to be lowered to such a pressure that the stress becomes 90% of the specified yield point of the material.

(b) Pressure vessels of Group III are to be subjected to hydrostatic tests in accordance with the requirements in **(a)** above when considered necessary by the Society.

(2) Fittings of pressure vessels

The fittings of pressure vessels of Group I and Group II are to be subjected to hydrostatic tests at a pressure equal to 2 *times* their design pressure.

(3) Hydrostatic tests of heat exchangers which are not specified in **(1)** and **(2)** and other special pressure vessels as well as their fittings will be considered by the Society on a case by case basis.

Chapter 9 WELDING FOR MACHINERY INSTALLATIONS

9.1 General

9.1.1 Scope

1 The requirements in this chapter apply to welding for machinery installations.

2 As for matters other than those specified in this Chapter, the requirements in **Part M of the Rules for the Survey and Construction of Steel Ships** are to apply.

9.1.2 Base Metals

1 Base metals used in welding work are to be those suitable for welding. And, the carbon content is not to exceed 0.23% for carbon steel and low alloy castings and forgings, or 0.35% for other carbon steel and low alloy steel. However, in cases where the Society has, after considering the welding conditions, given its approval, the carbon content may be increased to the Society approved value.

2 The upper limit of the carbon equivalent for high tensile steels is to be as deemed appropriate by the Society.

9.2 Welding Procedure Qualification Tests

9.2.1 Requirements for Tests

1 Manufacturers are to conduct welding procedure qualification tests, if they plan to carry out for the first time the following welding work:

(1) Welding work for boilers, pressure vessels of Group I and Group II

(2) Welding work for the principal components of prime movers, etc. (these principal components are specified in **Table 7.2.1** and **3.2.1-1**; hereinafter, this definition applies throughout this Chapter)

(3) Welding work using special materials

(4) Welding work using special welding procedures

2 Except for minor changes in welding conditions, in cases where any part of a welding procedure approved by an approval test as specified in **-1** is modified, a welding procedure qualification test is to be carried out.

3 Whenever manufacturers conduct an approval test for a welding procedure, they are to submit detailed data in connection with this welding work to the Society for approval.

9.2.2 Kinds of Tests

1 The types of tests are as follows:

(1) Mechanical tests
  - (a) Butt welding
    - i) Tensile test for joints
    - ii) Guided bend test or rolled bend test
    - iii) Impact test (the middle welded part, the boundary between the base metal and the welded part as well as the heat affected zone)
  - (b) Fillet weldings
    Fracture test

(2) Visual inspection and hardness test

(3) Macroscopic and microscopic examinations (the middle part of weld metal, the boundary between the base metal and the welded part as well as the heat affected zone)

(4) Radiographic examination

2 In cases where welding is made to a base metal which has no impact value requirement, the impact test may be omitted subject to Society approval.

3 In the case of fillet weldings, microscopic examinations and radiographic examinations may be omitted.

4 For welding procedure qualification tests on materials used at high temperatures, the Society may require a creep test or a high temperature tensile test.

5 In cases where special materials are used, or special welding procedures are employed, the Society may require other tests matching the specific requirements of such special materials or special welding procedures.

9.2.3 Welding of Test Assemblies

1 The shape and dimensions of test assemblies are to be as specified in **Fig. 7.9.1**.

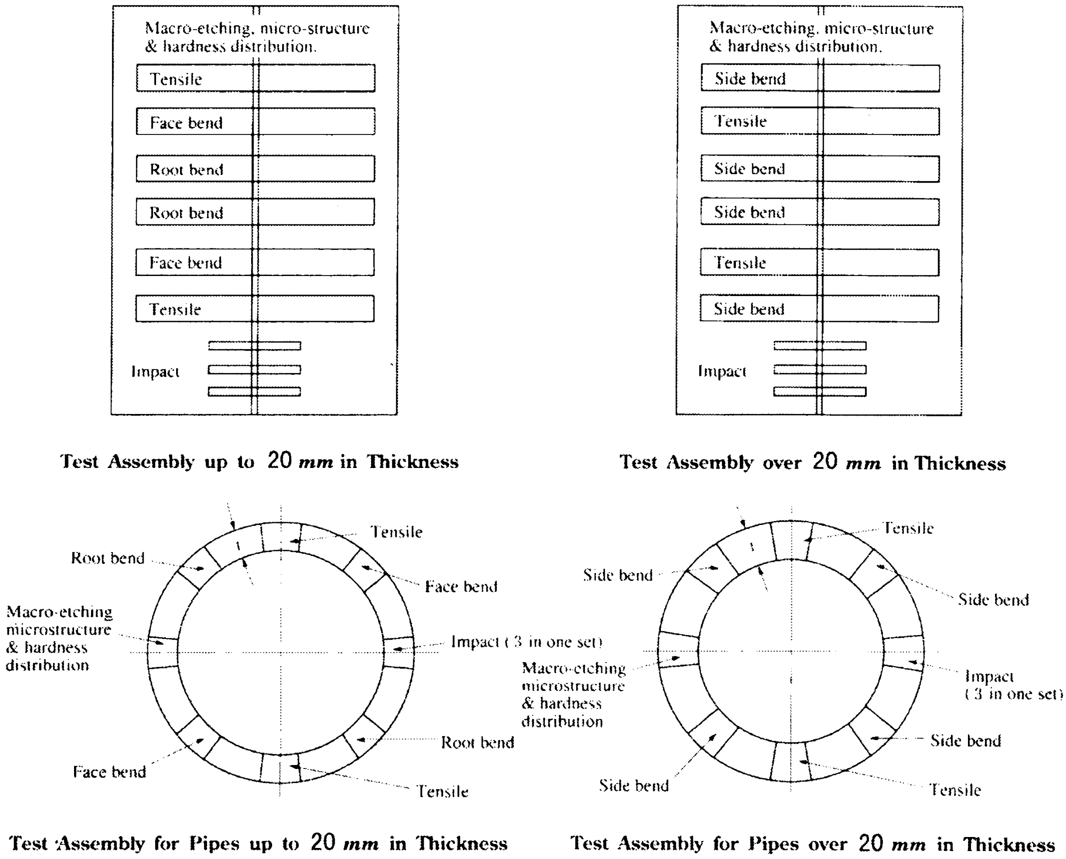
2 Test assemblies are to be of the same or equivalent material used in actual welding work.

3 In cases where the test assemblies of rolled steel plates for low temperature service are butt welded, the direction of the welding generally is to be in parallel with the direction of the rolling.

4 In general, the thickness of the test assemblies for welding procedure qualification tests is to be equal to the maximum thickness of the materials to be used in the actual welding work.

5 The welding of test assemblies is to be carried out under the same or similar conditions experienced in the actual work.

Fig. 7.9.1 Welding Procedure Qualification Test Assemblies



9.2.4 Test Specimens and Test Procedures

The shape and dimensions of test specimens and test procedures are to comply with the requirements in **Chapter 3, Part M of the Rules for the Survey and Construction of Steel Ships**. However, the requirements of other appropriate Codes or Standards may be applied subject to Society approval.

9.2.5 Retests

1 In cases where a tested part fails to meet the requirements, a retest may be performed by testing multiple test specimens of the same part. If all these additional tests are satisfactory, the part is considered to have passed the test.

2 Test specimens for retests are to be taken from either the same test assembly as the first test or from a test assembly newly welded under the same welding conditions as the first test assembly.

3 In cases where a retested part also fails to meet the requirements, tests may be performed over again after changing the welding conditions. In this case, where all of the tests specified for the test assembly have been carried out and their results are in compliance with the requirements, the tests are to be accepted as successful.

9.2.6 Test Records

Test results are to be summarized and be submitted to the Society as the test records.

9.2.7 Omission of Tests

In cases where test records, deemed appropriate by the Society, are available and the test results are considered to be satisfactory, a part or all of the tests may be omitted.

9.3 Post Weld Heat Treatment

9.3.1 Procedure of Post Weld Heat Treatment

1 Stress-relieving procedures of the post weld heat treatment for welds using carbon steel, carbon manganese steel and low alloy steel as the base metal are to be as follows:

(1) Furnace heating method
- (a) The temperature of the furnace is to be less than 400°*C* at the time the object is placed in or taken out of it.
- (b) The rates of heating and cooling above 400°*C* are to be as follows:
  - i) The heating rate $\leq 220 \times 25/t$ (°*C* /*hr*), but under any circumstances not more than 220 (°*C* /*hr*)
  - ii) The cooling rate $\leq 275 \times 25/t$ (°*C* /*hr*), but under any circumstances not more than 275 (°*C* /*hr*)

  Where:

  t: Maximum weld thickness (*mm*)
- (c) The holding temperature of the furnace is to be as given in **Table 7.9.1**. The furnace is to be kept at this temperature for a period of one hour per 25 *mm* thickness of the welded part and then cooled slowly. When Society approval has been obtained, the furnace temperature may be reduced to that given in **Table 7.9.2**.
- (d) During heating and cooling periods, temperature variation throughout the portion being heated shall not be a greater than 130°*C* within any 4500 *mm* interval of length. During the holding period, the difference between the highest and lowest temperature of each portion being heated shall not be greater than 80°*C*.
- (e) The maximum heating temperature for each portion of the object is to be less than 20°*C* below the final temperature of the heat treatment for the material of the portion.

(2) Local heating methods
- (a) In post-heating processing, the temperature gradient between the heating and non-heating areas is to be made smooth so that the materials will not suffer any harmful effects.
- (b) The heating band is to be greater than such an area with a length of 6 *times* or more the plate thickness as measured from the centre of the weld for each side respectively. In circumferential joints, the heating band may be 3 *times* the plate thickness (2 *times* in the case of pipes) on the outer side of the welding bead at the maximum width.
- (c) Heating and cooling rates at temperatures of 400°*C* or above are to conform to the requirements in **(1)(b)**.
- (d) The holding temperature and the period of the post weld heat treatment are to conform to the requirements in **(1)(c)**. Throughout the holding period, or the heating and cooling periods, the entire band is to be brought up to the required temperature as uniformly as possible.

2 For post weld heat treatment procedures on materials other than those specified in **-1**, the requirements shall be specially considered by the Society according to the type of base metal, the welding materials and the welding procedures.

3 Post weld heat treatments of low alloy steels, alloy steels and other special steels are to be carried out with special consideration being given to avoiding any undue degrading of notch toughness of the material and any cracks in the material that are caused by the heat treatment.

Table 7.9.1 Post Weld Heat Treatment Temperature

Category	Kind of steel	Minimum holding temperature (°C)
1	Carbon steel Carbon manganese steel $0.5M_0$ steel $0.5\,C_r\;0.5M_0$ steel $1\,C_r\;0.5M_0$ steel $1\frac{1}{4}C_r\,0.5M_0$ steel	600
2	$2\frac{1}{4}C_r 1M_0$ steel $5C_r\,0.5M_0$ steel	680

Table 7.9.2 Temperature Reduction vs. Holding Time2)3)

Minimum holding temperature (°C)	Minimum holding time (*hour*)
T-30	2
T-60	3
T-90 1)	5

Notes:

1) Applicable to carbon steel and carbon manganese steel only.
2) Intermediate values are to be obtained by interpolation.
3) T is the minimum holding temperature in **Table 7.9.1**.

9.3.2 Temperature Measurements and Recordings during Post Weld Heat Treatment

In general, the temperature measurements are to be carried out automatically by a thermocouple. However, in cases where the temperature of each part of the heated object can be readily assumed on the basis of furnace temperature, such furnace temperature may be used in place of the temperature of the heated object.

When post weld heat treatments are carried out, the following items are to be recorded:

(1) Type and kind of furnace or heating equipment
(2) Holding temperature and period
(3) Heating and cooling rates
(4) Other items deemed necessary

9.4 Welding of Boilers

9.4.1 General

In cases where the pressure parts of boilers are fabricated by welding, this welding is to be carried out in accordance with the requirements in **9.4** of this Chapter.

9.4.2 Alignment of Joints and Out-of Roundness

1 For the alignment of butt welded joints, maximum offset is not to exceed the following limits:

(1) For longitudinal joints:
1 *mm* for plates with a thickness of 20 *mm* or less
5% of the plate thickness for plates with a thickness of more than 20 *mm* but less than 60 *mm*
3 *mm* for plates with a thickness of 60 *mm* or more

(2) For circumferential joints:
1.5 *mm* for plates with a thickness of 15 *mm* or less
10% of the plate thickness for plates with a thickness of more than 15 *mm* but less than 60 *mm*
6 *mm* for plates with a thickness of 60 *mm* or more

2 The difference between the maximum and minimum inside diameters (out-of roundness) at any cross section is not to exceed 1% of the nominal inside diameter at the cross section under consideration.

9.4.3 Post Weld Heat Treatment

1 Each boiler, including all mountings and fittings, is to be subjected to post weld heat treatment for stress relieving after the completion of all welding work. However, in cases where the thickness of the welded part is less than 19 *mm* for carbon steel or less than 13 *mm* for alloy steel, the Society, after taking into account the welding procedures as well as the preheating and post weld heating conditions of these parts, may deem the omission of such post weld heat treatment to be acceptable.

(1) Welded joints between tubes, tubes and tube flanges, and tubes and headers

(2) Circumferential joints of headers

(3) Welded parts specifically approved by the Society

2 In cases where minor fillet welding is carried out for the following items **(1)** or **(2)** on boilers subjected to post weld heat treatment, no post weld heat treatment is required after such welding work.

(1) Seal welding

(2) 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 more.

9.4.4 Production Weld Tests

1 For welded joints of boiler shells, production weld tests are to be carried out. The welded joints of furnace plates may be tested by any of the following production weld tests: a guided bend test, a roller bend test, or a radiographic test.

2 Test plates for workmanship tests are to be sampled in accordance with the following requirements:

(1) The test plates are to be attached to each shell in such a manner so that they are welded continuously and correspond to the edges of the longitudinal joint.

(2) The test plates for the circumferential joints of shells are to be made separately under the same welding conditions as those for the circumferential joint. However, test plates for circumferential joints are not required except where the shell has no longitudinal joints or the welding procedure for the circumferential joints is remarkably different from those for the longitudinal joints.

(3) Test plates are to be of the same specification, type and thickness as the base metal (where plates with different thickness are welded, test plates are to be taken from the thinner one), and no warping is to be caused by welding.

(4) Test plates are to be subjected to the same post weld heat treatment as in the actual welding and are not to be heated beyond the heating temperature and holding period as applied in the actual welding.

3 Tests for the welded joints of test plates, such as a tensile test, a bend test and a macro-etching test are to be carried out. Guided bend tests or roller bend tests may be accepted as the bend test. In this case, the number and dimensions of the test specimens are to be as given in **Table 7.9.3**.

4 Test methods and test standards are required to comply with the following requirements:

(1) Tensile tests for joints

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 shows no sign of defect in the welded joint; and, the tensile strength is not less than 95% of the minimum tensile strength specified for the base metal, the test results may be judged to be acceptable.

(2) Guided bend tests or roller bend tests

The test specimen is to be put on a bend test jig deemed appropriate by the Society and the center line of the welding part is to coincide with the center of the jig. For side bend tests, the test specimen is to be bent with one of its two sides in tension. For root bend tests, the test specimen is to be bent 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*. Cracks or any other defects exceeding 3 *mm* in length are not to be observed on the outer surface of the bent specimen on the welding part. However, any cracks in the corners of the test specimen may be considered irrelevant to the test results.

(3) Macro-etching tests

Cracks, lack of fusion, incomplete penetration or any other defect are not to be observed.

5 In cases where the tensile strength is not less than 90% of the values specified in the requirements, or in cases where a guided bend test or a roller bend test fails to meet the requirements from defects other than those in the welded parts, a retest will be allowed. In this case, two additional test specimens are to be taken from the same test plate for each failure and both of these two test specimens are required to satisfy the requirements.

Table 7.9.3 Number and Dimensions of Test Specimens

<table>
<tr><th colspan="2">Number of test specimens</th><th>Dimensions of test specimens</th></tr>
<tr><td colspan="2">Tensile test for joint : 1</td><td>As specified in Table M3.1, Part M of the Rules for the Survey and Construction of Steel Ships</td></tr>
<tr><td>Guided bend tests or roller bend tests</td><td>Face bend tests and root bend tests: 1 set
or
Side bend tests: 1</td><td>As specified in Table M3.2, Part M of the Rules for the Survey and Construction of Steel Ships</td></tr>
<tr><td colspan="2">Macro-etching tests: 1</td><td>—</td></tr>
</table>

Note:

For test plates not more than 20*mm* in thickness, face bend tests and root bend tests are to be conducted. For those over 20*mm* in thickness, side bend tests are to be conducted.

9.4.5 Radiographic Testing for Longitudinal and Circumferential Joints

1 For boiler shells (including headers), the entire length of both the longitudinal and the circumferential welded joints is to be subjected to radiographic testing.

2 The radiographic technique employed is to be such as to detect a defect as small as 2% of the welding depth and the wire of the penetrameter, corresponding to 2% of the thickness of the base metal, is to be clearly shown on the radiographic film.

3 Each radiograph film is to be clearly marked with respect to the relative position of the welds and the radiograph position.

4 The following items are to be included in the radiographic testing report:

(1) Thickness of the material (flush or reinforced)

(2) Distance from the radiation source to the weld surface

(3) Distance from the film to the weld surface

(4) Type of penetrameter used

5 Reinforcement of the welded joints, where radiographic testing is carried out, is to be evenly finished to ensure trouble free examination. In this case, the height of the reinforcement is to be in accordance with the following standards:

(1) Double-welded butt joints:
To be as given in **Table 7.9.4**

(2) Single-welded butt joints:
To be 1.5 *mm* or less, regardless of the plate thickness

6 Any defects found as a result of radiographic tests are to be dealt with according to the following requirements:

(1) In cases where there are defects such as crack, lack of fusion, incomplete penetration, etc., the defective part is to be chipped off and rewelded.

(2) Defects such as blow-holes and slag-inclusions are to be reconditioned in accordance with procedures deemed appropriate by the Society after taking into consideration the shape, dimensions and distribution of the defect.

7 In cases where repairs are carried out on welded joints, the repaired part of the joint is to be subjected to a radiographic test once again.

Table 7.9.4 Allowable Height of Reinforcements

Thickness of base metal (mm)	12 or less	Exceeding 12 but not more than 25	Exceeding 25
Allowable height of reinforcement (mm)	1.5	2.5	3.0

9.4.6 Non-destructive Testing for Other Welds

1 For important welds other than those specified in **9.4.5**, non-destructive tests are to be carried out as considered appropriate.

2 Radiographic test procedures are to comply with the requirements specified in **9.4.5-2** through **-7** and any other non-destructive testing procedures are to be appropriate for the type of tests employed.

9.5 Welding of Pressure Vessels

9.5.1 General

In cases where the pressure parts of pressure vessels are fabricated by means of welding, the welding is to be carried out in accordance with the requirements in **9.5** of this Chapter.

9.5.2 Alignment of Joints, Out-of Roundness and Angular Deflection

1 For the alignment of the butt welded joints, the maximum offset is not to exceed the following limits:

(1) For longitudinal joints, joints in end plates and joints between hemispherical end plates and shells:

(a) 1/4 t for plates with an actual thickness of 50 mm or less (t) (maximum: 3.2 mm)

(b) 1/16 t for plates with an actual thickness of more than 50 mm (t) (maximum: 9 mm)

(2) For circumferential joints:

(a) 1/4 t for plates with an actual thickness of 40 mm or less (t) (maximum: 5 mm)

(b) 1/8 t for plates with an actual thickness of more than 40 mm (t) (maximum: 19 mm)

(3) For welding joints of spherical shells and end plates and welding joints between hemispherical end plates and shells, the values for longitudinal joints are applied.

2 The out-of-roundness of shells subjected to internal pressure is to be in accordance with the requirements in **9.4.2**.

3 Welds are to be free from any remarkable angular deflection.

4 The out-of-roundness and angular deflection of shells subjected to external pressure are to be examined in each case in consideration of buckling strength.

9.5.3 Stress Relieving

1 Pressure vessels of Group I are to be subjected to post weld heat treatment for stress relieving after all fittings, such as flanges, nozzles and reinforcement plates, have been welded in place.

2 Pressure vessels of Group II corresponding to the following **(1)** or **(2)** are to be subjected to stress relieving heat treatment in accordance with the requirements in **-1**.

(1) The thickness of the shell plates exceeds 30 mm

(2) The thickness of the shell plate 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 : Inside diameter of shell (mm)

3 Notwithstanding the requirements in **-1** and **-2**, mechanical stress reliving by pressurizing for pressure vessels made of carbon steel or carbon manganese steel may be employed as an alternative to post weld heat treatment with the approval of the Society and subject to the following conditions **(1)** through **(4)**:

(1) Complicated welded pressure vessel parts such as nozzles are to be heat treated before they are welded to larger

parts of the pressure vessels.

(2) The plate thickness is not to exceed the value given by the standard acceptable to the Society.

(3) A detailed stress analysis is to be made to ascertain that the maximum primary membrane stress during mechanical stress relieving closely approaches, but does not exceed, 90% of the yield stress of the material. Strain measurements during stress relief pressurization may be required by the Society for verifying the calculations.

(4) The procedure for mechanical stress relieving is to be submitted to the Society for approval in advance.

4 In cases where materials having superior notch toughness are used, stress relieving may be omitted if approved by the Society.

5 In cases where the following welding is carried out on stress relieved pressure vessels, post weld stress relieving may be omitted:

(1) For carbon steels and carbon manganese steels

(a) When fittings with inside diameter not more than 50 *mm* are fitted by fillet welding with a throat thickness of not more than 12 *mm*

(b) When non-pressured fittings are fitted by fillet welding with a throat thickness of not more than 12 *mm*

(c) Stud welded parts

(2) Welds specifically approved by the Society for other materials except those specified in **(1)**. In this case, appropriate preheating is to be carried out during the welding.

9.5.4 Production Weld Tests

1 In cases where pressure vessels of Group I are of welded construction, production weld tests specified in **9.5.4** are to be carried out.

(1) Test plates are to be sampled in accordance with the following requirements:

(a) The test plates are to be attached to each shell in such a manner so that they are welded continuously and correspond to the edges of the longitudinal joint. Furthermore, any deformation of the test plates during their manufacture is to be restricted to a minimum as far as practicable.

(b) The test plates for the circumferential joints of shells are to be made separately under the same welding conditions as those for circumferential joints. However, test plates for circumferential joints are not required except where the shell has no longitudinal joints or the welding procedure for the circumferential joints is remarkably different from those for the longitudinal joints.

(c) As a general rule, test plates are to be taken from the same materials used for manufacturing the pressure vessels.

(2) Mechanical tests for test plates such as a tensile test for joints, a bend test and a Charpy impact test are to be carried out. Guided bend tests or roller bend tests may be accepted as the bend test. In this case, the number and dimensions of the test specimens are to be as given in **Table 7.9.5**.

(3) Test methods and test standards are required to comply with the following requirements:

(a) Tensile tests and guided bend tests as well as roller bend test for joints are required to comply with the requirements in **9.4.4-4(1)** and **(2)**.

(b) Impact tests

Impact test specimens are to be sampled from welded joint portions so that its longitudinal axis is at a right angle to the welding line and its surface is 5 *mm* inside the surface of the plate. Notches on test specimens are to coincide with the centres of weld lines and their surfaces are to be at right angles to the plate surface. The mean value of the absorbed energy of three test specimens is not to be less than the Society approved value.

2 Production weld tests of pressure vessels of Group II of welded construction are to be conducted in accordance with the requirements in **-1**. However, the guided bend tests or roller bend tests specified in **-1(2)** may be omitted.

Table 7.9.5 Number and Dimensions of Test Specimens

Number of test specimens		Dimensions of test specimens
Tensile test for joint : 1		As specified in **Table M3.1, Part M of the Rules for the Survey and Construction of Steel Ships**
Guided bend tests or roller bend tests	Face bend tests and root bend tests : 1 set or Side bend tests : 1	As specified in **Table M3.2, Part M of the Rules for the Survey and Construction of Steel Ships**
Charpy impact tests : 1 set		U4 type test specimens as specified in **2.2.4, Part K of the Rules for the Survey and Construction of Steel Ships**

Note:
For test plates not more than 20*mm* in thickness, face bend tests and root bend tests are to be conducted. For those over 20*mm* in thickness, side bend tests are to be conducted.

3 Retest is to be in accordance with the following:
(1) In cases where a tested part fails, a retest may be conducted. For tensile and bend tests, two additional test specimens are to be taken from the same test plate or from other test plates manufactured in the same lot of the original test plate for each failure. In retests, both of the test specimens are to conform to the requirements. For impact tests, 1 set (three specimens) of additional test specimens is to be taken from the same test plate or other test plates manufactured in the same lot; and, if the mean value of the test results on a total of 6 test specimens is higher than the required mean value, the test plates are to be judged acceptable.
(2) Retests are allowed in the following cases:
  (a) In cases where the results of tensile and impact tests are not less than 90% of the values specified in the requirements.
  (b) In the cases where the cause of failure in guided or roller bend tests is attributed to defects other than those in the welded parts.

4 Surveyors may modify and reduce the degree of a production weld tests for pressure vessels after taking into account past results.

9.5.5 Radiographic Testing for Welded Joints

1 The entire length of butt weld joints corresponding to the following **(1)** or **(2)** are to be subjected full radiographic testing.
(1) Longitudinal and circumferential weld joints of pressure vessels of Group I
(2) Weld joints whose joint efficiency has been determined by full radiographic testing.

2 For the pressure vessels whose joint efficiency has been determined by spot testing, radiographic testing is to be carried out in accordance with the following requirements.
(1) For welds that were welded by the same method and by the same welder, a length which is not less than 20% (minimum 300 *mm*) of the length of the longitudinal joint as well as the weld at the intersecting section of any circumferential joints with a longitudinal joint are to be spot radiographed.
(2) Locations to be spot radiographed are to be chosen by the Surveyor.

3 Radiographic testing procedures and disposal of test results are to conform to the requirements in **9.4.5**.

4 Notwithstanding the requirements specified in **-1** and **-2**, ultrasonic tests may be conducted in lieu of radiographic testing in cases where the Society specifically grants approval.

9.5.6 Non-destructive Testing for Other Welded Parts

1 The welds for fittings such as the openings and their reinforcements for the pressure vessels requiring full radiographic testing are to be subjected to radiographic testing or magnetic particle testing considered appropriate by the Society. However, in cases where the application of these testing methods is considered impractical or where, in consideration of the welding position and welding shape, the Society approval has been received, radiographic testing may be replaced with liquid penetrant testing, ultrasonic testing or other appropriate testing.

2 Welds at the fitted parts of fittings such as the openings and their reinforcements of the pressure vessels requiring radiographic spot testing are to be subjected to the non-destructive testing specified in **-1** according to the sampling method.
3 The requirements in **9.5.5** apply mutatis mutandis to non-destructive testing procedures and the disposal of defects, etc.

9.6 Welding of Piping

9.6.1 Scope

The requirements in **9.6** apply to the welding of pipes, valves and pipe fittings belonging to Group I and II specified in **Chapter 10**.

9.6.2 Alignment of Joints

The maximum offset of joints between pipes is not to exceed 1/4 of the pipe thickness.

9.6.3 Preheating of Welds

When welding of pipes, materials are to be suitably preheated depending on the kind and thickness of the material.

9.6.4 Post Weld Heat Treatment

1 After any welding, pipes of a thickness specified in **Table 7.9.6** are to be subject to post weld heat treatment for relieving any residual stress according to the grade of the material used.
2 Regarding the post weld heat treatment of pipes and piping systems that are made of materials other than those given in **-1** above, treatment is to be made in accordance to the grade of the base metals, the weld materials, the welding procedure, etc. as deemed appropriate by the Society.

Table 7.9.6 Pipes Requiring Post Weld Heat Treatment

Grade (Note 1)		Category in **Table 7.9.1**	Thickness of weld (t) (mm)
Grade 1, Grade 2 and Grade 3		1	$t \geq 15$
Grade 4	No.12	1	$t \geq 15$
	No.22 No.23	1	$t > 8$
	No.24	2	All (Note 2)

Notes:
1. Grades are as specified in **4.2, Part K of the Rules for the Survey and Construction of Steel Ships**.
2. This treatment may be omitted if the thickness is 8mm or less, the outside diameter is 100mm or less and the design temperature is 450°C or less.

9.6.5 Non-destructive Testing

1 Butt weld joints of Group I pipes having nominal diameters exceeding 65A are to be subjected to full radiographic testing.
2 Butt weld joints of Group I pipes having nominal diameters not more than 65A and Group II pipes having nominal diameters exceeding 90A are to be subjected to a radiographic examination by sampling in accordance with the instructions of the Surveyor.
3 The Society may approve other appropriate non-destructive testing in lieu of a radiographic examination.
4 The requirements in **9.4.5** are to be applied mutatis mutandis to radiographic examinations.
5 With respect to the fillet welding of Group I or Group II pipes, the Society, in consideration of the material, dimensions and service conditions of the pipes, etc., may require a magnetic particle examination or other suitable examination.

6 The Society, in consideration of the welding materials or the welding procedure, may require a special examination.

9.7 Welding of Principal Components of Prime Movers, etc.

9.7.1 General

1 Welding for the principal components of prime movers, etc. is to comply with the requirements in **9.7**.
2 In cases where the principal components of prime movers, etc. are of welded construction, approval is to be obtained from the Society for the shape and dimensions of the welded parts, welding materials, welding procedures, heat treatments and non-destructive testing requirements.

9.7.2 Alignments of Joints and Edge Preparations

1 Alignments in butt welded joints are to be in accordance with the following requirements:
(1) A maximum of 5 *mm* or 1/4 of the thickness for welded parts with a thickness of 40 *mm* or less
(2) A maximum of 19 *mm* or 1/8 of the thickness for welded parts with a thickness of more than 40 *mm*
2 In butt weldings between plates of different thickness, the end of the thicker plate is to be smoothly tapered down to that of the thinner plate.
3 Butt weldings and T-joint weldings of important strength members are to be subjected to back chipping or effectively controlled so as to avoid any defects at the roots of the welds.
4 In cases where fillet welding is carried out in areas subjected to bending stress, toe parts are to have a smooth finished.
5 Welding is to be carried out in such a way as to not cause any excessive distortion at the welds.

9.7.3 Preheating of Welds

1 Preheating is to be carried out on the welds in the case of welding of thick plates, steels or low alloy steels with a carbon content exceeding 0.23%, or alloy steels where deemed necessary by the Society.
2 The preheating method and the minimum preheating temperature are to be determined as considered appropriate by the Society according to the types of base metals and welding materials as well as the thickness of weld and the welding method.

9.7.4 Post Weld Heat Treatment

In cases where thick materials are used or restraint conditions are severe, etc., post weld heat treatments are to be carried out where it is recognized that a considerable degree of post welding residual stress with a detrimental effect on the strength of structure is expected.

9.7.5 Non-destructive Testing

For examining welds, the Society, taking into consideration the materials used, dimensions and service conditions, may require ultrasonic tests, magnetic particle tests, liquid penetrant tests and other non-destructive tests as deemed appropriate.

Chapter 10 PIPES, VALVES, PIPE FITTINGS AND AUXILIARIES

10.1 General

10.1.1 Scope

The requirements in this Chapter apply to the design, fabrication and testing of pipes, valves, pipe fittings and auxiliaries.

10.1.2 Terminology

1 Design Pressure

Design pressure is defined as the maximum working pressure of a medium inside pipes. However, it is not to be less than any of the following pressures given in **(1)** to **(4)**:

(1) For piping systems fitted with relief valves or some other overpressure protective devices, a pressure based upon the set pressures of the relief valves or overpressure protective devices. However, for steam piping systems connected to boilers or piping systems fitted to pressure vessels, the design pressure of the boiler shell (nominal pressure if the boiler has a superheater) or the design pressures for the shells of pressure vessels.

(2) For piping on the discharge side of pumps, a pressure based upon the delivery pressure of the pump when the valve on the discharge side is closed and the pump is running at rated speed. However, for pumps having relief valves or overpressure protective devices, a pressure based upon the set pressures of the relief valves or the set pressures of the over pressure protective devices.

(3) For the blow-off piping of boilers, a pressure which is not less than 1.25 *times* the design pressure of the boiler drum.

(4) For pipes, valves and fittings containing fuel oil, the maximum working pressure or 0.3 *MPa*, whichever is greater.

2 Design Temperature

Design temperature is the highest working temperature of a medium inside pipes at a designed condition.

3 Pipe Fittings

Pipe fittings in this Part are those pipes connecting fittings such as pipe flanges, mechanical joints, pipe pieces, expansion joints, flexible hose assemblies, etc. and any items provided in piping systems such as strainers and separators.

4 Flexible Hose Assemblies

Flexible hose assemblies are those flexible hoses with end fittings.

10.1.3 Classes of Pipes

1 Pipes are classified according to the type of medium, design pressure and design temperature as shown in **Table 7.10.1**. However, pipes having open ends (such as drain pipes, overflow pipes, exhaust gas pipes, exhaust pipes of safety valves) and steam relief pipes are classified into Group III regardless of their respective design temperature.

2 Piping systems for media other than those specified in **-1** will be classified by the Society after consideration has been given to the nature of the medium and the service conditions of the pipes.

Table 7.10.1 Classes of Pipes

Kind of Medium	Design Pressure (P) and Design Temperature (T)		
	Group I	Group II (Note)	Group III
Steam	P>1.6MPa or T>300°C	P≦1.6MPa and T≦300°C	P≦0.7MPa and T≦170°C
Thermal oil	P>1.6MPa or T>300°C	P≦1.6MPa and T≦300°C	P≦0.7MPa and T≦150°C
Fuel oil, lubricating oil and flammable hydraulic oil	P>1.6MPa or T>150°C	P≦1.6MPa and T≦150°C	P≦0.7MPa and T≦60°C
Air, carbon dioxide gas, water and non-flammable hydraulic oil	P>4.0MPa or T>300°C	P≦4.0MPa and T≦300°C	P≦1.6MPa and T≦200°C

Note: Excluding any pipes meeting the conditions for Group III

10.1.4 Materials

1 Materials used for auxiliary machinery are to be adequate for their service conditions. Materials used for any essential parts of auxiliary machinery are to comply with recognized standards.

2 Materials used for pipes, valves or cocks (hereinafter collectively referred to as "valves" in this chapter) and pipe fittings are to be adequate for their service conditions and are to comply with standards deemed appropriate by the Society.

3 Pipes, valves and pipe fittings for fire fighting systems are to be of corrosion resistance materials or to be protected effectively in order to prevent the fire fighting capability of the system from deteriorating due to inside corrosion.

10.1.5 Service Limitations for Materials

1 Pipes are, as a rule, to be made out of steel, copper, copper alloy or cast iron, and such materials are to comply with the requirements given below in addition to the service limitations specified in standards deemed appropriate by the Society according to design temperature, classification, service, etc., unless otherwise specified. However, for pipes which have an opening and are classified as Group III regardless of design temperature, service limitations regarding temperature do not apply.

(1) Cast iron pipes are not to be used for the following pipes:

   (a) Pipes of Group I and Group II for cast iron pipes that have an elongation that is less than 12%.

   (b) Pipes of Group I for cast iron pipes that have an elongation of 12% and over.

   (c) Pipes which are susceptible to water hammering as well as pipes subject to large deflection or vibrations.

(2) In addition to **(1)**, copper pipes, copper alloy pipes and cast iron pipes are to conform to the requirements in **Table7.10.2** according to their application. However, the requirements may be waived when deemed acceptable by the Society.

2 Valves and pipe fittings are, as a rule, to be made out of steel, copper alloy or cast iron, and such materials are to comply with the requirements given below in addition to the service limitations specified in standards deemed appropriate by the Society according to their design temperature, classification, application, etc., unless otherwise specified. However, for valves and pipe fittings which have an opening and are classified as Group III regardless of design temperature, service limitations regarding temperature do not apply.

(1) Valves and pipe fittings made of copper alloy are not to be used for valves and pipe fittings with a design temperature over 210°C. However, special bronze, when approved by the Society, can be used for valves and pipe fittings with a design temperature of 260°C or less.

(2) Cast iron products with an elongation less than 12% are not to be used for the following valves and pipe fittings:

   (a) Valves and pipe fittings with a design temperature over 220°C.

   (b) Valves and pipe fittings used for pipes of Group I and Group II (except steam pipes), except where deemed appropriate by the Society after consideration has been given to their construction and purpose.

   (c) Valves fitted on the external walls of fuel oil tanks or lubrication oil tanks that are subjected to the static head of internal fluid.

   (d) Valves, seats and distance pieces mounted on shell plating or sea chests.

   (e) Valves directly mounted onto collision bulkheads.

   (f) Valves and pipe fittings of boiler water blow-off piping systems.

   (g) Piping systems which are liable to receive water hammering as well as valves and pipe fittings of piping systems which are subject to large deflection or vibrations.

(h) Valves provided at the ship/shore connection of a flammable liquid cargo line.

(3) Cast iron products with an elongation of 12% or above are not to be used for valves and pipe fittings for pipes of Group I, except where deemed appropriate by the Society after consideration has been given to their construction and purpose.

Table 7.10.2 Service Limitations for Pipes According to Application

Pipe Application (Note 1)	Material		
	Copper	Copper alloy	Cast iron
Fuel oil pipes Lubricating oil pipes in machinery spaces Hydraulic oil pipes in machinery spaces Thermal oil pipes in machinery spaces Air pipes Sounding pipes outside of sounding areas	× (Note 2)	× (Note 2)	× (Note 3)
Overflow pipes Bilge pipes Ballast pipes Drain pipes opening outboard and sanitary pipes below the freeboard deck Pipes used for fire fighting aboard ship Pipes in danger of rupturing leading to flooding during a fire Boiler water blow off pipes	×	×	×
Control oil pipes in machinery spaces	○	×(Note 2)	×
Air pipes for the remote closing of tank suction stop valves Air pipes for the remote control of auxiliaries, valves, etc. used during a fire	○	×	×

Notes:

1. Pipes used for measurements, drain pipes and vent pipes are not included.
2. The portion of pipes which is inside a tank is usable.
3. Including those outside machinery spaces.

Remarks:

1○: Usable

2×: Use prohibited

10.1.6 Use of Special Materials

Notwithstanding the provisions in **10.1.5** above, special materials such as rubber hoses, plastic pipes, vinyl pipes, aluminum alloys, etc. may be used, after taking into account safety against fire and flooding as well as their service conditions, where approved by the Society.

10.2 Thickness of Pipes

10.2.1 Required Thickness of Pipes Subject to Internal Pressure

1 The required thickness of pipes subject to internal pressure is to be determined by the following formula:

$$t_r = t_0 + b + C$$

Where:

t_r : Required thickness of pipe (mm)

$$t_0 = \frac{PD}{2fJ + P}$$

P : Design pressure (*MPa*)

D : External diameter of the pipe (*mm*)

f : Allowable stress specified in **-3** (*N/mm*^{2})

J : Joint efficiency as given in the following:

Seamless pipes 1.00

Electric resistance welded pipes 0.85

(However, a value of 1.00 may be adopted in cases where an ultrasonic flaw test or an alternative flaw test, considered appropriate by the Society, is conducted for the entire length of the welded joint)

b : Allowance for bending as given in the following formula:

$$b = \frac{1}{2.5} \cdot \frac{D}{R} \cdot t_0$$

R: Mean radius of the bend (*mm*)

However, b need not be considered when it has been ascertained that the calculated membrane stress in the bend does not exceed the allowable stress.

C : Corrosion allowance specified in **-5** (*mm*)

2 Notwithstanding the requirements specified in **-1** above, the thickness of pipes having a negative tolerance in thickness is not to be less than value t_1 determined by the following formula:

$$t_1 = \frac{t_r}{1 - \frac{a}{100}}$$

Where:

t_r : Same as in **-1**.

a : Maximum negative tolerance (%)

3 The allowable stress of each material is to comply with the following requirements:

(1) The allowable stress (f) of carbon steel pipes and low alloy steel pipes is to be chosen as the lowest of the values given by the following formulae, or the value shown in **Table 7.10.3(1)**.

However, where the design temperature is not in the creep region of the material, the value of f_3 need not be considered.

$$f_1 = \frac{R_{20}}{2.7},\ f_2 = \frac{E_t}{1.6},\ f_3 = \frac{S_R}{1.6}$$

Where:

R_{20} : Minimum tensile strength of the material at room temperature (*N/mm*^{2})

E_t : Yielding point or 0.2% proof stress of the material at design temperature (*N/mm*^{2})

S_R : Average stress for material concerned to produce rupture after 100,000 *hours* at design temperature (*N/mm*^{2})

(2) The allowable stress of copper pipes, brass pipes and copper nickel pipes is to be the value shown in **Table 7.10.3(2)**

(3) The allowable stress of material other than those specified in **(1)** and **(2)** will be considered by the Society in each case.

4 For the steel pipes with a design temperature that does not exceed 250°*C*, in cases where the value for t_0 specified in **-1** is calculated by using an allowable stress to the value of 1/5 of the specified minimum tensile strength of the material at room temperature instead of using the value for allowable stress specified in **-3(1)**, the value for b required to be considered in the formula of t_r specified in **-1** and the increment for the negative tolerance required by **-2** need not be taken into consideration.

5 The corrosion allowance for steel pipes as well as copper and copper alloy pipes is to comply with **Table 7.10.4** and **Table 7.10.5** respectively.

Table 7.10.3(1) Values of Allowable Stress of Steel Pipes (f) (N/mm^2)

Material		Design Temperature (Material °C)													
		100 or less	150	200	250	300	350	375	400	425	450	475	500	525	550
Grade 1	No.2	123	114	105	96	87	78	-	-	-	-	-	-	-	-
	No.3	138	128	118	107	96	90	-	-	-	-	-	-	-	-
Grade 2	No.2	123	114	105	96	87	78	-	-	-	-	-	-	-	-
	No.3	138	128	118	107	96	90	-	-	-	-	-	-	-	-
	No.4	156	145	133	122	117	113	-	-	-	-	-	-	-	-
Grade 3	No.2	123	114	105	96	87	78	75	70	63	56	-	-	-	-
	No.3	138	128	118	107	96	90	87	84	71	57	-	-	-	-
	No.4	156	145	133	122	117	113	105	96	77	-	-	-	-	-
Grade 4	No.12	119	112	105	97	89	85	83	80	77	73	70	65	-	-
	No.22	121	116	111	105	99	93	91	89	85	80	76	71	55	38
	No.23	121	116	111	105	99	93	91	89	85	80	76	71	56	40
	No.24	121	116	111	105	99	93	91	89	85	80	76	71	56	41

Notes:

1. Intermediate values are to be determined by interpolation.
2. The materials of steel pipes shown in this Table are to comply with the requirements in **Part K of the Rules for the Survey and Construction of Steel Ships**.

Table 7.10.3(2) Values of Allowable Stress of Copper and Copper Alloy Pipes (f) (N/mm^2)

Kind of materials (Grade)	Design Temperature (Material °C)										
	50 or less	75	100	125	150	175	200	225	250	275	300
For phosphorous deoxidized copper seamless pipes and tubes (N/mm^2)											
C1201 C1220	41	41	40	40	34	27.5	18.5	-	-	-	-
For brass seamless pipes and tubes for condensers and heat exchangers (N/mm^2)											
C4430	68	68	68	68	68	67	24	-	-	-	-
C6870 C6871 C6872	78	78	78	78	78	51	24.5	-	-	-	-
For copper nickel seamless pipes and tubes for condensers and heat exchangers (N/mm^2)											
C7060	68	68	67	65.5	64	62	59	56	52	48	44
C7100	73	72	72	71	70	70	67	65	63	60	57
C7150	81	79	77	75	73	71	69	67	65.5	64	62

Note: Intermediate values are to be determined by interpolation.

Table 7.10.4 Corrosion Allowance for Steel Pipes(C)

Piping service		C (mm)
Superheated steam systems		0.3
Saturated steam systems	General service	0.8
	Steam coil systems in fuel oil tanks	1
Feed water systems for boilers	Open circuit systems	1.5
	Closed circuit systems	0.5
Blow-off systems for boilers		1.5
Compressed air systems		1
Lubricating and hydraulic oil systems		0.3
Fuel oil systems		1
Primary refrigerant systems for refrigerating plants		0.3
Fresh water systems		0.8
River water systems		3

Notes:

1. For pipes efficiently protected against the internal corrosion, the corrosion allowance in this Table may be reduced by 50% where approved by the Society.
2. In cases where special alloy steels with sufficient corrosion resistance are used, the corrosion allowance may be reduced to zero.
3. For river water steel pipes whose nominal diameter is 25A or below, the corrosion allowance may be reduced to 1.5mm.
4. Where it is difficult to apply this Table or where a medium not specified in this Table is used, the corrosion allowance will be considered by the Society in case taking into account the corrosion conditions.
5. In cases where pipes pass through tanks, consideration is to be given to any external corrosion; and, depending on the type of external medium, a corrosion allowance is to be added according to the figures given in this Table.

Table 7.10.5 Corrosion Allowance for Copper and Copper Alloy Pipes (C)

Kind of material	C (mm)
Phosphorous-deoxidized copper seamless pipes and brass seamless pipes specified in **Table 7.10.3(2)**	0.8
Copper nickel seamless pipes specified in **Table 7.10.3(2)**	0.5

Note:

For media without corrosive action in respect of the material employed, the corrosion allowance may be reduced to zero.

10.2.2 Minimum Thickness of Pipes

1 The thickness of steel pipes is to comply with the requirements in **10.2.1** and is not to be less than the value shown in **Table 7.10.6(1)** and **Table 7.10.6(2)** depending on the service and location of the pipes. However, where corrosion resistant alloy steel pipes are used in lieu of steel pipes, the minimum thickness of these pipes will be considered by the Society in each case.

2 For pipes efficiently protected against corrosion, the minimum thickness specified in **Table 7.10.6(2)** may be reduced by an amount up to but not more than 1mm except for steel pipes for CO_2 fire extinguishing.

3 In determining the thickness of pipes from **Table 7.10.6(2)**, no allowance need be made for any negative tolerance and reduction in thickness due to bending. However, for threaded pipes their minimum thickness is to be measured at the bottom of the thread, with the exception of the threaded portions for fitting the pipe head of air pipes, overflow pipes and sounding pipes as well as the threaded portions of pipes used for CO_2 fire extinguishing from the distribution station to the nozzles.

4 The minimum thickness of copper and copper alloy pipes is to be as shown in **Table 7.10.7**.

Table 7.10.6(1) Minimum Thickness of Steel Pipes

Services of pipes	Location of pipes	Minimum thickness of the encircled alphabets correspond to those in **Table 7.10.6(2)**
Bilge pipes	Passing through tanks	Ⓑ
	Not passing through tanks	Ⓔ
Ballast pipes	Passing through tanks (Note 1)	Ⓑ
	Not passing through tanks	Ⓔ
Air pipes, Overflow pipes, Sounding pipes	passing through tanks	Ⓑ
	For tanks forming a part of ship's structure	Ⓓ
Fuel oil pipes	Passing through tanks except for fuel oil tanks	Ⓑ
River water pipes	Passing through tanks	Ⓑ
	Not passing through tanks	Ⓔ
Fresh water pipes	Passing through tanks	Ⓑ
Cargo oil pipes	Passing through tanks	Ⓑ, but Ⓒ when $D \geqq 250A$
	Not passing through tanks	Ⓒ
Pipes for CO_2, fire extinguishing	From bottles to distribution station	Ⓕ
	From distribution station to nozzles	Ⓖ
Pipes other than the above		Ⓗ

Note:

1 Ⓓ is applied when a safe (dangerous) ballast pipe passes through a safe (dangerous) ballast tank.

A dangerous ballast pipe means a pipe for suction and discharge of the ballast in a dangerous ballast tank (a ballast tanks adjacent to a cargo oil tank or a ballast tank connected to a cargo oil tank through an open-ended pipe).

A safe ballast pipe means a pipe for suction and discharge of the ballast in a safe ballast tank (a ballast tank other than a dangerous ballast tank).

Table 7.10.6(2) Minimum Thickness of Steel Pipes[(1)(3)] (*mm*)

Nominal Dia. (A) \ Corresponding Alphabet	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ	Ⓕ (2)	Ⓖ (2)	Ⓗ
6	-	-	-	-	-	-	-	1.6
8	-	-	-	-	-	-	-	1.8
10	-	-	-	-	-	-	-	1.8
15	-	-	2.8	-	3.2	3.2	2.6	2.0
20	-	-	2.9	-	3.2	3.2	2.6	2.0
25	-	-	3.4	-	3.2	4.0	3.2	2.0
32	-	6.3	3.6	4.5	3.6	4.0	3.2	2.0
40	-	6.3	3.7	4.5	3.6	4.0	3.2	2.3
50	-	6.3	3.9	4.5	4.0	4.5	3.6	2.3
65	7.0	6.3	5.2	4.5	4.5	5.0	3.6	2.6
80	7.6	7.1	5.5	4.5	4.5	5.6	4.0	2.9
90	8.0	7.1	5.7	4.5	4.5	6.3	4.0	2.9
100	8.6	8.0	6.0	4.5	4.5	7.1	4.5	3.2
125	9.5	8.0	6.6	4.5	4.5	8.0	5.0	3.6
150	11.0	8.8	7.1	4.5	4.5	8.8	5.6	4.0
175	11.8	8.8	7.7	5.3	5.3	-	-	4.5
200	12.5	8.8	8.2	5.8	5.8	-	-	4.5
225	12.5	8.8	8.8	6.2	6.2	-	-	5.0
250	12.5	8.8	9.3	6.3	6.3	-	-	5.0
300	12.5	8.8	10.3	6.3	6.3	-	-	5.6
350	12.5	8.8	11.1	6.3	6.3	-	-	5.6
400	12.5	8.8	12.7	6.3	6.3	-	-	6.3
450	12.5	8.8	12.7	6.3	6.3	-	-	6.3

Notes:

1. In cases where the thickness of pipes specified in the standards does not comply with the minimum thickness in this Table, the standard pipe may be used if the difference is 0.4*mm* or less.
2. Pipes, except those fitted in the engine room, are at least to be galvanized on their insides.
3. For pipes with a nominal diameter other than that shown in this Table, their minimum diameter will be considered by the Society in each case.

Table 7.10.7 Minimum Thickness of Copper and Copper Alloy Pipes (*mm*)

Outside diameter	Copper pipes	Copper alloy pipes
8-10	1	0.8
12-22	1.2	1
25-45	1.5	1.2
50-76.2	2	1.5
80-120	2.5	2
130-190	3	2.5
200-270	3.5	3
280	4	3.5

10.3 Construction of Valves and Pipe Fittings

10.3.1 General

Valves, pipe fittings, gaskets and packings are to be suitable for their service conditions. They are also to be constructed according to standards deemed appropriate by the Society or be constructed in a manner considered equivalent thereto.

10.3.2 Special Valves and Pipe Fittings

Valves, pipe fittings, gaskets and packing used for pipes of Group I and Group II that are of a special construction or produced by a special manufacturing process are to be approved by the Society.

10.3.3 Mechanical Joints

1 Mechanical joints are to be of a Society approved type as well as be adequate for their intended service conditions and application. Their construction and type are to conform to the examples in **Fig. 7.10.1,** according to their respective application classifications shown in **Table 7.10.8** and **Table 7.10.9**.

2 Mechanical joints which in the event of damage could cause a fire or flooding are not to be used in piping sections directly connected to sea openings or tanks containing flammable fluids.

3 Piping which has been fitted with a mechanical joint is to be adequately adjusted, aligned and supported. Supports or hangers are not to be used to force the alignment of piping at the point of connection.

4 Slip-on joints are not to be used inside tanks except for those used for pipes for the same medium as in the tank. 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.

5 In cases where the application of mechanical joints results in any reduction in pipe wall thickness due to the use of bite type rings or other structural elements, this is to be taken into account in determining the minimum wall thickness of the pipe to withstand design pressure.

6 Mechanical joints are to be constructed so that any possibility of tightness failure due to pressure pulsation, piping vibration, temperature variation and other similar adverse effects occurring during operation on board is prevented.

7 The material of mechanical joints is to be compatible with the piping material and internal and external media.

8 Mechanical joints are to be designed to withstand internal and external pressure as applicable and in cases where they are used in suction lines; the joints are to be capable of operating under a vacuum.

9 The installation of mechanical joints is to be in accordance with the manufacturer's assembly instructions. In cases where special tools and gauges are required for installation of these joints, these are to be supplied by the manufacturer.

Fig 7.10.1 Examples of Mechanical Joints

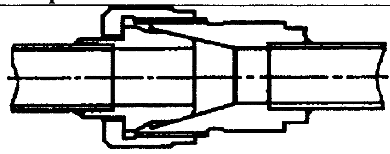
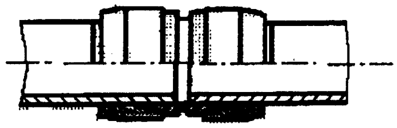
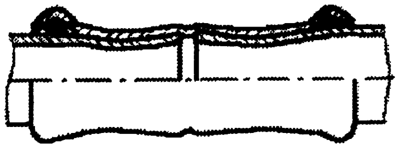
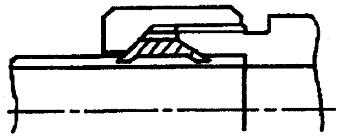
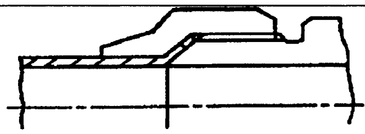
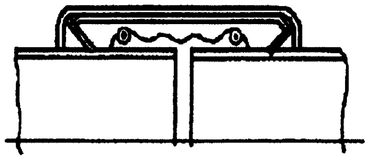
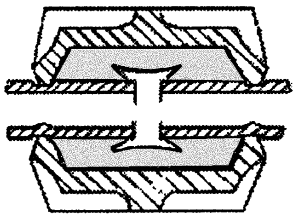
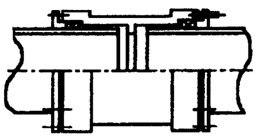
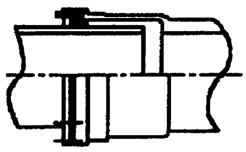
Pipe Unions	
Welded and Brazed Types	
Compression Couplings	
Swage Type	
Press Type	
Bite Type	
Flared Type	
Slip-on Joints	
Grip Type	
Machine Grooved Type	
Slip Type	 

Table 7.10.8 Application Classifications of Mechanical Joints[1]

Application Purpose	System	Kind of Connections		
		Pipe Union	Compression Coupling[6]	Slip-on Joint[9]
Flammable fluids[7] (Flash point > 60°*C*)	Fuel oil lines	+	+	+[3][4]
	Lubricating oil lines	+	+	+[3][4]
	Hydraulic oil	+	+	+[3][4]
	Thermal oil	+	+	+[3][4]
River water	Bilge lines	+	+	+[2]
	Fire main and water spray	+	+	+[4]
	Foam systems	+	+	+[4]
	Sprinkler systems	+	+	+[4]
	Ballast systems	+	+	+[2]
	Cooling water systems	+	+	+[2]
	Tank cleaning services	+	+	+
	Non-essential systems	+	+	+
Fresh water	Cooling water systems	+	+	+[2]
	Condensate returns	+	+	+[2]
	Non-essential systems	+	+	+
Sanitary/ Drains/ Scuppers	Deck drains (internal)	+	+	+[5]
	Sanitary drains	+	+	+
	Scuppers and discharges (overboard)	+	+	-
Sounding/Vents	Sounding/Vents for water tanks/cofferdam	+	+	+
	Sounding/Vents for oil tanks (f.p.> 60˚C)	+	+	+[3][4]
Miscellaneous	Starting/Control air[2]	+	+	-
	Service air (non-essential)	+	+	+
	Brine	+	+	+
	CO_2 systems[2]	+	+	-
	Steam	+	+	-[8]

Notes:

(1) +: Application is allowed; -: Application is not allowed

(2) Only Society approved fire resistant types may be used inside machinery spaces of category A.

(3) May not be used inside machinery spaces of category A or accommodation spaces. May be used in machinery spaces other than category A ones provided that the joints are located in easily visible and accessible positions.

(4) Only Society approved fire resistant types may be used.

(5) May only be used above the free board deck.

(6) If compression couplings include any components which readily deteriorate in case of fire, they are to be of a Society approved fire resistant type as required for slip-on joints.

(7) The number of mechanical joints in oil systems is to be kept to a minimum. In general, flanged joints which conform to recognized standards are to be used.

(8) Slip type joints as shown in **Fig. 7.10.1** may be used for pipes on deck with a design pressure of 1.0 *MPa* or less, provided that they are restrained on the pipes.

(9) The use of slip joints is to comply with the requirements specified in **11.2.4**.

Table 7.10.9 Application Classifications of Mechanical Joints Depending upon the Class of Piping[1]

Types of Joints		Classes of Piping Systems		
		Group I	Group II	Group III
Pipe Unions	Welded and brazed type	+[2]	+[2]	+
Compression Couplings	Swage type	+	+	+
	Bite type	+[2]	+[2]	+
	Flared type	+[2]	+[2]	+
	Press type	-	-	+
Slip-on joints	Machine grooved type	+	+	+
	Grip type	-	+	+
	Slip type	-	+	+

Notes:

(1) + Application is allowed, - Application is not allowed

(2) May be used for pipes of a nominal diameter of 50*A* or below.

10.3.4 Flexible Hose Assemblies

1 Flexible hose assemblies may be used for the following pipes:

(1) Fuel oil pipes (except fuel oil injection pipes)

(2) Lubricating oil pipes

(3) Hydraulic oil pipes

(4) Thermal oil pipes

(5) Compressed air pipes

(6) Bilge and ballast pipes

(7) Fresh water and river water pipes

(8) Steam pipes of Group III (metallic pipes only)

(9) Exhaust gas pipes (metallic pipes only)

2 Flexible hose assemblies, used for the pipes of Group I or II as well as for pipes likely to cause a fire or flooding in cases where they have been fractured, are to be approved by the Society.

3 Installation, design and construction of flexible hose assemblies are to comply with follows.

(1) Installation requirements

- (a) Flexible hoses are not to be subjected to torsional deflection (twisting) under normal operating conditions.
- (b) Flexible hoses are to be installed in clearly visible and readily accessible locations.
- (c) The number of flexible hoses is to be kept to a minimum.
- (d) Flexible hoses are to be limited to the necessary minimum length.
- (e) Any hose contact that could cause rubbing and abrasion is to be avoided.
- (f) The installation of flexible hoses is to take into account the allowable minimum bend radius.
- (g) In cases where flexible hoses are intended to be used for flammable oil pipes which are in close proximity to heated surfaces, the risk of ignition due to a failure of the hose assembly and the subsequent release of any fluids is to be mitigated by the use of screens or other similar protection.
- (h) Flexible hoses are to be installed in accordance with the manufacturer's instruction.

(2) Design requirements

- (a) The design of flexible hoses is to take into account ambient conditions, compatibility with fluids under working pressure and temperature conditions.
- (b) Hose clamps and other similar types of end fittings are not to be used for flexible hoses in pipes for steam, flammable oil, starting air and for river water where failure may result in flooding. For other pipes, the use of hose clamps may be accepted where the working pressure is less than 0.5*MPa* and provided there are double clamps at each end connection.
- (c) The design of flexible hoses, where pressure pulses and/or high levels of vibration are expected to occur during use, is to take into account the maximum expected impulse peak pressure as well as any other forces due to vibration.

(3) Construction requirements

Non-metallic flexible hoses are to conform to the following requirements:

(a) Non-metallic flexible hoses are to incorporate woven integral wire braid or other suitable material reinforcement where used for pipes specified in **10.3.4-1(1)** through **(6)**. Where specially approved by the Society, the reinforcement may be exempted.

(b) In cases where non-metallic flexible hoses are to be used for fuel oil supply lines to burners, they are to have external wire braid protection in addition to **(a)**.

(c) Non-metallic flexible hoses used for flammable oil and river water pipes, where failure may result in flooding, are to be of a fire resistant type except in cases where such hoses are installed on exposed open decks.

4 The end fittings of flexible hose assemblies are to have flanges or to comply with **10.3.3** or **10.4.2**.

10.4 Connection and Forming of Piping Systems

10.4.1 Welding of Piping Systems

The welding for piping systems is to comply with the requirements in **Chapter 9**.

10.4.2 Direct Connection of Pipe Lengths

1 Direct connection of pipe lengths belonging to Group I or II is to be of a butt welded type. However, for steel pipes having a nominal diameter of not more than 80*A*, slip-on sleeve welded joints may be used.

2 Threaded pipe joints (only tapered threads where used for pipes in Group I and Group II) are not to be used for the following pipes. However, the Society may allow use for pipes specified in **(3)** and **(4)** after considering the service of the pipes.

(1) Pipes conveying flammable media, except for pipes with small diameter used for instrumentation.

(2) Pipes for CO_2 systems, except inside protected spaces and in CO_2 cylinder rooms.

(3) Pipes belonging to Group I with a nominal diameter exceeding 25*A*.

(4) Pipes belonging to Group II and Group III with a nominal diameter exceeding 50*A*.

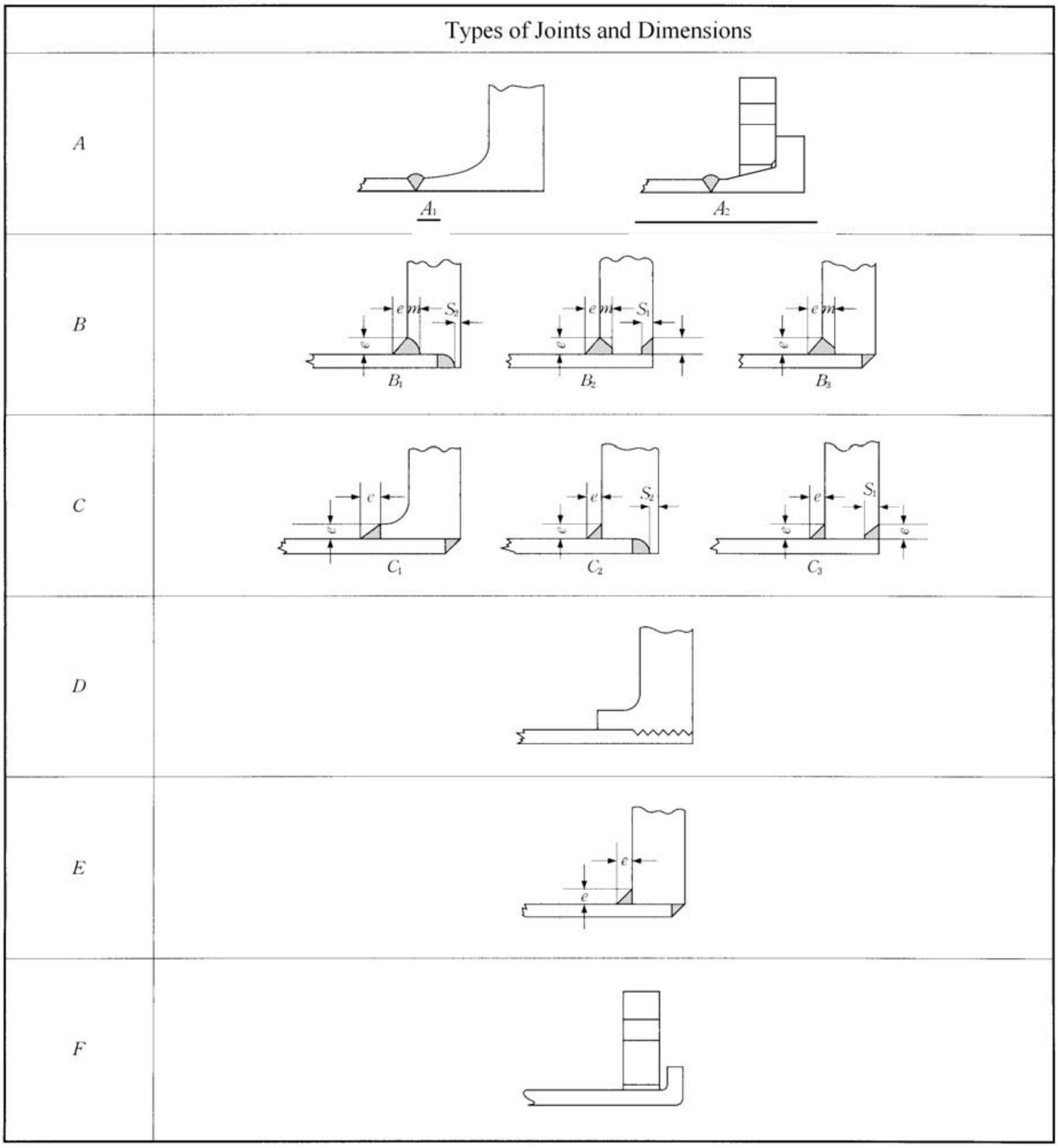
10.4.3 Connection of Pipes with Pipe Fittings

1 Joints between pipes and pipe flanges are to be adequate for their service conditions, and their construction and strength are to conform to the requirements in **Fig. 7.10.2** according to their application classification shown in **Table 7.10.10**, or other type of joints as deemed appropriate by the Society.

2 Valves and pipe fittings made of non-ferrous metal may be mounted on non-ferrous metal pipes by brazing or soldering. In this case, the type of brazing and soldering and the method of application are to be suitable for their service conditions.

3 Joints between pipes and pipe fittings, except flanges, are to be in compliance with the requirements in **10.4.2** and **-1** above.

Fig. 7.10.2 Type of Flange Connections



Notes:

1. Standard dimensions of welds are as follows:

   $e = 1.4t$

   $m = t$

   $S_1 = t$

   $S_2 = 0.5t$

where t is the required thickness of the pipe

2. For type D, the pipe and flange are to be screwed with a tapered thread and the pipe is to be secured to the flange by means of expansion. However, the outside diameter of the screw portion of the pipe over the thread is not to be appreciably less than the outside diameter of an unthreaded pipe.

Table 7.10.10 Types of Joints between Pipe and Pipe Flange and Their Application Classification

Class of Pipes	Design Temperature $°C$	Type of Joints	
		Steam, air and water	Fuel oil, lubricating oil, hydraulic oil and thermal oil
Group I	over 400	*A*, *B* (Note 1.)	*A*, *B*
	400 or below	*A*, *B* (Note 2.)	
Group II	over 250	*A*, *B*, *C*	*A*, *B*, *C*
	250 or below	*A*, *B*, *C*, *D*, *E*	*A*, *B*, *C*, *E* (Note 3.)
Group III	-	*A*, *B*, *C*, *D*, *E*, *F* (Note 4.)	*A*, *B*, *C*, *E* (Note 3.)

Notes:

1. Type (*B*) joints may be used for steam pipes of a nominal diameter of 50*A* or below.
2. Type (*B*) joints may be used for steam pipes of a nominal diameter of 150*A* or below.
3. Type (*E*) joints may be used for pipes with a design pressure of 1.0*MPa* or less.
4. Type (*F*) joints may be used for water pipes or pipes with an open end.

10.4.4 Forming of Pipes and Heat Treatment after Forming

1 Hot forming of pipes of Group I and Group II is to conform to the following requirements:

(1) Hot forming is to be generally carried out in a temperature range of 1000$°C$ - 850$°C$. However, the temperature may be decreased to 750$°C$ during the forming process.

(2) For steel pipes of Grade 4 in **Table 7.9.6**, stress relieving heat treatment is to be carried out according to the requirements regarding the holding temperature and holding time for the pipes specified in **9.3.1**.

2 When pipes of Group I and Group II are subjected to cold-forming, a suitable heat treatment is to be carried out according to the pipe material, service environment, etc. with consideration given to any harmful plastic deformation due to cold-forming and development of residual stresses that may occur.

3 Regarding the forming and after forming heat treatment for steel pipes other than those specified in **-1** and **-2** above as well as pipes of materials other than steel, they are to be approved by the Society.

10.5 Construction of Auxiliary Machinery and Storage Tanks

10.5.1 General

1 Auxiliary machinery and storage tanks are to have sufficient strength and to be constructed so that maintenance and inspection can be easily carried out.

2 The thickness of the steel plating used for fuel oil storage tanks is not to be less than 6*mm*, but in the case of small tanks, the thickness may be reduced to 3*mm*.

3 Storage tanks for fuel oil and for heated lubricating oil, hydraulic oil, etc. which are installed in machinery spaces are not to have openings in the machinery space.

10.6 Tests

10.6.1 Shop Tests

1 Tests of welds in piping systems and auxiliaries are to comply with the requirements in **Chapter 9** of this Part.

2 Pipes in Group I and Group II as well as steam pipes, feed water pipes, compressed air pipes and fuel oil pipes with the design pressure exceeding 0.35*MPa* are to be subjected to hydrostatic tests together with the welded fittings after completion of all the fabrication process at a pressure equal to 1.5 *times* the design pressure. This test may be carried out after installation on board.

3 Steel pipes with a design temperature exceeding 300$°C$ are to be subjected to a hydrostatic test at the pressure determined by the formula below. However, in cases where the pressure determined by this formula is greater than 2 *times* the design pressure value, a value of 2 *times* the design pressure value may be used. In addition, when there is a fear of any excessive stress in way of bends, T-pieces, etc., the value of test pressure may be reduced to 1.5 *times* the design pressure. This test may be carried out after installation on board.

$$P_t = 1.5 \frac{K_{100}}{K_t} P$$

Where:

P_t : Test pressure (*MPa*)

K_{100} : Allowable stress of pipe material at 100°*C* (*N/mm*^{2})

K_T : Allowable stress of pipe material at the design temperature (*N/mm*^{2})

P : Design pressure (*MPa*)

4 In cases where primary general membrane stress in the pipe wall is expected to exceed 90% of the specified yield stress at the test pressure specified in **-2** and **-3**, the test pressure is to be lowered to decrease the stress to 90% of the specified yield stress.

5 Valves and pipe fittings used for pipes in Group I and Group II are to be subjected to hydrostatic tests at a pressure equal to 1.5 *times* their design pressure.

6 Valves fitted to the ship's side below the designed maximum load line are to be subjected to hydrostatic tests at a pressure of 1.5 *times* their design pressure or 0.5*MPa*, whichever is greater.

7 The pressure parts of auxiliaries (excluding auxiliary machinery for specific use etc.) are to be subjected to hydrostatic tests at a pressure equal to 1.5 *times* their design pressure or 0.2*MPa*, whichever is greater.

8 Free standing fuel oil storage tanks are to be subjected to hydrostatic tests at a pressure corresponding to a water head of 2.5*m* above the top plate.

9 Auxiliaries (excluding auxiliary machinery for specific use etc.) are to be subjected to running tests as deemed appropriate by the Society.

10.6.2 Tests after Installation on Board.

In cases where joints between pipes or between pipes and valves are welded aboard ship, such piping systems are to be subjected to hydrostatic tests as deemed appropriate by the Society.

Chapter 11 PIPING SYSTEMS

11.1 General

11.1.1 Scope

The requirements in this Chapter apply to piping systems.

11.1.2 Drawings and Data

Drawings and data to be submitted are generally as follows:

(1) Drawings (with materials, sizes, kinds, design pressures, design temperatures, etc. of pipes, valves, etc.)
  (a) Piping diagrams for the entire ship
  (b) Piping diagrams for the engine room
  (c) Other drawings considered necessary by the Society

(2) Data
  (a) Machinery particulars
  (b) Other data considered necessary by the Society

11.2 Piping

11.2.1 General

1 Installation of pipes

(1) Ample provision is to be made in consideration of the effects of expansion, contraction, deflection of the hull and vibration. Pipes are to be supported at suitable spans to avoid any excessive load.

(2) The number of detachable pipe connections is to be minimized as far as practicable.

2 Radius of curvature of pipes

In cases where pipes are bent, the radius of curvature at the centre line of a pipe is generally not to be less than twice the external diameter of the pipe.

3 Functions of pipes

Pipes are to be so arranged so that any lingering drainage and air pockets as well as any pressure loss in the pipes do not have any adverse effects on the performance of any machinery.

4 Piping in the vicinity of electrical equipment

Pipes are not to be laid in way of electrical equipment such as generators, switchboards, control gears, etc. as much as possible. In case where such a situation is unavoidable, care is to be taken to make sure that no flanges or joints are arranged over or near any electrical equipment, unless provisions are made to prevent any leakage from pouring onto the equipment.

5 Protection of piping systems and fittings

(1) All pipes, valves, cocks, pipe fittings, valve operating rods, handles, etc. located at positions on weather decks where they are liable to be damaged are to be adequately protected. Where a casing is provided for protection, it is to be so constructed that it can be easily removed for inspection.

(2) For pipes arranged in positions inaccessible for maintenance and inspection, due consideration such as corrosion protection is to be given to prevent corrosion.

6 Relief valves

(1) All piping systems which may be subjected to an internal pressure that exceeds design pressure are to be safeguarded with relief valves or, as an alternative, overpressure protective devices.

(2) Discharge ends of relief valves or overpressure protective devices are to be led into safe spaces.

7 Pressure and temperature measuring devices

(1) Pressure and temperature measuring devices are to be provided on piping systems where considered necessary.

(2) Cocks or valves are to be provided at the root of pressure measuring devices in order to isolate them from the pipes under a pressurized condition.

(3) In cases 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 any oil from spraying out if the thermometer should fracture or be removed.

8 Distinct marking of piping systems

(1) Pipes located in spaces where deemed necessary for safety are to be marked with distinctive colours to avoid any mishandling.

(2) Identification plates, which show the purpose of a valve, are to be affixed to valves where deemed necessary for safety, and all valves which are used for fire extinguishing are to be painted red.

(3) Identification plates are to be affixed to the open ends of air pipes, sounding pipes and overflow pipes.

9 Cleaning of piping systems

Piping systems are to be cleaned after fabrication or installation on ship where considered necessary.

11.2.2 Connection and Common Use of Pipes

1 Connection of oil pipes with other pipes

(1) Fuel oil pipes are to be entirely separate from other pipes, unless means are provided to prevent any accidental contamination with other liquids while in operation.

(2) Lubricating oil pipes are to be entirely separate from all other pipe lines.

(3) Fresh water pipes, used for boiler feed water or drinking water, are to be entirely separate from other pipes to avoid any accidental contamination with oil or oily water.

2 Common use of river water pipes and fresh water pipes

River water pipes and fresh water pipes are to be separated, unless adequate measures are taken to avoid any accidental contamination between the two.

11.2.3 Penetration of Pipes

In cases where pipes pass through watertight bulkheads, decks, top plates, bottom plates as well as bulkheads of deep tanks and inner bottom plating, measures are to be taken to ensure the watertightness of the structures.

11.2.4 Slip-on Joints

Slip-on joints are not to be used on pipe lines in deep tanks and other spaces which are not easily accessible, unless approved by the Society.

11.2.5 Bulkhead Valves

1 Valves or cocks, such as drain valves, which do not constitute any part of a piping system is not to be fitted on collision bulkheads.

2 Pipes passing through collision bulkheads are to be fitted with suitable valves that are operable from above the bulkhead deck and valve chests are to be secured to a bulkhead located inside the forepeak. However, these valves may be fitted on the aft side of the collision bulkhead in question provided that the valves are readily accessible under all service conditions. Remote control devices for these valves may be omitted.

3 Valves and cocks, such as drain valves, which do not constitute any part of a piping system, may be fitted on watertight bulkheads other than collision bulkheads, provided that they are readily accessible at any time for inspection. Such valves and cocks are to be operable from above the bulkhead deck and are to be provided with an indicator to show whether they are open or closed, except in cases where the valves or cocks are secured to a fore or aft bulkhead located inside the engine room.

4 Means for controlling valves or cocks from above freeboard decks or bulkhead decks are to be constructed so that the weights thereof are not supported by the valves or the cocks.

11.2.6 Prevention of Freezing of Pipes

Suitable measures are to be taken to prevent the freezing of any bilge pipes, air pipes, sounding pipes, drain pipes, etc. that pass through or are arranged near any refrigerated chambers, in cases where the inner surfaces of the pipes are at risk of freezing.

11.3 River Water Suction Valves and Overboard Discharge Valves

11.3.1 River Water Suction Pipes and Overboard Discharge Pipe Connections

River water inlet and overboard discharge pipes are to be connected to valves or cocks which are fitted in accordance with the requirements given in **11.3.2-2** and **-3**.

11.3.2 Location and Construction of River Water Suction Valves, Overboard Discharge Valves, etc.

1 The locations of overboard discharges are not to be such that water can be discharged into lifeboats and liferafts at fixed launching positions, including those under launching devices, when they are launched, unless special provisions have been taken to prevent such discharge.

2 River water suction valves and overboard discharge valves or cocks fitted to the ship's side as well as any sea chests forming a part of the ship's structure or any distance pieces attached to the shell plating are to be located at easily accessible positions.

3 Valves or cocks prescribed in **-2** are to be fitted in accordance with the following **(1)** or **(2)**:

(1) Valves or cocks are to be fitted to doublings which are welded to the shell plating or sea chest by using stud bolts not passing through the shell plating and sea chest.

(2) Valves or cocks are to be fitted by bolts to distance pieces attached to the shell plating. In this case, the distance piece is to be of rigid construction and as short as practicable.

4 Valve spindles of river water suction valves are to be extended above the lower platform where they are easily operable. Power-operated river water suction valves are to be also arranged for manual operation.

5 Overboard discharge valves and cocks are to be fitted with spigots passing through the shell plating and protection rings specified in **-6(1)**, but spigots on valves or cocks may be omitted if these fittings are attached to pads or distance pieces which themselves form spigots in way of the shell plating and protecting rings. Overboard discharge valves and cocks are to be provided with indicators to show whether they are open or closed.

6 Blow-off valves or cocks of boilers and evaporators are to comply with the following requirements in **(1)** and **(2)**:

(1) Blow-off valves or cocks of boilers and evaporators are to be fitted in accessible positions and to be provided with protection rings on the outside of the shell plating to prevent corrosion.

(2) Cock handles are not to be capable of being removed unless the cocks are shut, and, if valves are fitted, wheel handles are to be suitably fastened to the spindle.

11.3.3 Construction of Sea Chests

Sea chests are to be of substantial construction and not to block off suction due to airlocking.

11.3.4 Gratings of River Water Suctions

1 Gratings are to be fitted at the river water inlets. The area of grating openings is not to be less than twice the total inlet river water suction valve opening area.

2 Provisions are to be taken for cleaning the gratings specified in **-1** by use of low pressure steam, compressed air, etc.

11.4 Scuppers, Sanitary Discharges, etc.

11.4.1 General

1 Scupper pipes, sufficient in number and size, to provide effective drainage are to be provided for all decks.

2 Scupper pipes draining weather decks are to be led overboard.

3 Scupper pipes originating from within enclosed superstructures or enclosed deckhouses on freeboard decks are to be led directly into inboard bilge wells. They may, however, be led overboard in cases where they are provided with efficient and accessible means for preventing water from passing inboard.

11.4.2 Common Overboard Discharge

The number of scuppers, sanitary discharges and other similar openings in the shell plating is to be kept to a minimum by either making each discharge serve as many sanitary and other pipes as possible, or using other satisfactory means. However, different systems of overboard discharges are, in general, not to be connected to each other, unless specially approved by the Society.

11.4.3 Sanitary Discharge

Sanitary discharges are to comply with the requirements in **11.4.1** and **11.4.2**.

11.5 Bilge and Ballast Piping

11.5.1 General

1 An efficient bilge pumping system is to be provided, capable of pumping out and draining any watertight compartment under practical conditions, except for tanks specially used to hold liquids and those spaces provided with efficient means of pumping.

2 An efficient ballast piping system, capable of pumping ballast water into and out off any tanks for holding ballast water under practical conditions, is to be provided.

3 Suitable measures are to be taken so that bilge pumping systems prevent the possibility of any ingress of river water into any watertight compartments and to prevent any bilge from inadvertently passing from one compartment to another. To achieve this requirement, all bilge distribution boxes and manually operated valves in connection with bilge pumping systems are to be in positions which are accessible under ordinary conditions. All valves in bilge distribution boxes are to be of a non-return type.

4 Bilge suction pipes are to be entirely separate from any other pipe that is not a bilge suction pipe.

5 Bilge pipes passing through deep tanks used exclusively for ballasting and bilge pipes and ballast pipes passing through deep tanks other than ballast tanks are to be led through an oiltight or watertight pipe tunnels; or, are to be of sufficient thicknesses in accordance with the requirements in **Table 7.10.6(1)** and **Table 7.10.6(2),** and all of their joints are to be welded.

6 Bilge pipes passing through double bottom tanks are to be led through oiltight or watertight pipe tunnels; or, they are to be of sufficient thickness in accordance with the requirements in **Table 7.10.6(1)** and **Table 7.10.6(2)**.

7 Bilge pipes passing through double bottoms, side tanks, bilge hopper tanks or void spaces, in cases where there is a possibility of these pipes being damaged due to grounding or collision, are to be provided with non-return valves near their bilge suctions or stop valves capable of being closed from readily accessible positions.

8 Ballast piping systems are to be provided with suitable provisions, such as non-return valves or stop valves, which can be kept closed at all times, excluding times of ballasting and de-ballasting; and, which are provided with indicators to show whether such valves are opened or closed, in order to prevent the possibility of any inadvertent ingress of river water into the ballast tanks or of any ballast water passing from one ballast tank to another.

11.5.2 Terminology

1 A Main Bilge Line is the part of a bilge suction line which forms the main of bilge suction line connected to bilge pumps and to which all branch bilge suction pipes from the bilge suctions are connected.

2 A Branch Bilge Suction Pipe is a pipe connected to the main bilge line from the bilge suction of each compartment.

11.5.3 Size of Bilge Suction Pipes

1 The internal diameter of main bilge lines and branch bilge suction pipes of watertight compartments is to be calculated using the following formulae **(1)** and **(2)** or, standard pipes nearest in internal diameters to the calculated diameter are to be used. In cases where the internal diameter of the standard pipes closest to the calculated value is short of that value by 13*mm* or more, a standard pipe of one grade higher is to be used.

(1) For main bilge lines and direct bilge suction pipes:

$$d = 1.68\sqrt{L(B+D)} + 25 \ \ (mm)$$

(2) For branch bilge suction pipes:

$$d' = 2.15\sqrt{l(B+D)} + 25 \ \ (mm)$$

Where:

d : Internal diameter of the main bilge line or direct bilge suction pipes (*mm*).

d' : Internal diameter of branch bilge suction pipes (*mm*).

B and D : Ship length, breadth and depth respectively (*m*)

L : Length (*m*) of ship specified in **2.1.4, Part 1 of the Rules**.

l : Length of the compartment to be served by the branch bilge suction pipes (m).

2 Internal diameters of main bilge lines are not to be less than the internal diameters of any branch bilge suction pipes obtained from the formula in **-1(2)**.

3 In cases where bilge pumps in engine rooms are exclusively used for bilge drainage in the engine room, the internal diameters of the main bilge line may be reduced to that obtained from the following formula:

$$d = \sqrt{2}(2.15\sqrt{l(B+D)} + 25) \ (mm)$$

Where:

l : Length of the engine room (m).

d, B and D : As defined in **-1**.

4 The internal diameters of branch bilge suction pipes are not to be less than 40mm. However, the internal diameters of those used for the drainage of a small compartment may be reduced to 35mm where considered acceptable by the Society.

11.5.4 Bilge Pumps

1 Number of bilge pumps

(1) All ships are to be provided with at least two independently powered bilge pumps that are connected to the main bilge suction pipes. However, one of the required pumps may be driven by the main propulsion machinery. For ships less than 20m in length, one of required pumps may be a hand pump.

(2) Ballast, sanitary and general service pumps driven by independent power may be accepted as independently powered bilge pumps specified in **(1)** above, provided that they are connected properly to the main bilge line.

(3) For ships provided with at least two independently powered bilge pumps in accordance with **(1)** above, one of the pumps may be substituted for by an eductor that is driven by a type of river water pump other than a bilge pump in cases where deemed appropriate by the Society. In such cases, the capacity of the eductor is to be in accordance with the requirement in **-2**.

2 Capacity of bilge pumps

Each pump specified in **-1** is to be capable of discharging bilge, through the main bilge line specified in **11.5.3**, of an amount not less than that obtained from the following formula:

$$Q = 5.66d^2 \times 10^{-3}$$

Where:

Q : Required quantity (m^3/h).

d : Internal diameter of the main bilge line specified in **11.5.3** (mm).

In cases where one of these pumps is of a capacity slightly less than what is required, the deficiency may be made good by any excess capacity of the other pump.

3 Types of bilge pumps

All of the independently powered bilge pumps prescribed in **-1** are to be of a self-priming type or an equivalent thereto; and, they are to be so arranged that they always available for immediate use.

4 Connection of bilge pumps to suction pipes

All of the power driven pumps prescribed in **-1** are to be arranged for discharging bilge from all compartments.

11.5.5 Bilge Drainage from the Top of Deep Tanks, Fore and After Peak Tanks and Chain Lockers

1 Bilge of the fore and after peak tanks, decks forming the top of these tanks and chain lockers 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 positions above the designed maximum load line.

2 Efficient means are to be provided for draining bilge from the top of deep tanks and other watertight flats.

3 Drainage from spaces above deep tanks may be led to bilge wells in the shaft tunnel or an accessible compartment. In this case, these pipes are not to be more than 65A in nominal diameter and are to be provided with quick-acting self-closing valves located in an accessible position.

4 In cases where a suction line passes through a collision bulkhead, it is to comply with the requirements in **11.2.5-2**.

11.5.6 Strainers

Bilge suction piping in engine rooms and shaft tunnels is to be provided with strainers that are easily accessible from above, and that have covers which may be easily opened and closed.

11.6 Air Pipes

11.6.1 General

1 All tanks and cofferdams are to be provided with air pipes having sufficient cross sectional areas to permit easy venting from any part of the tank and cofferdam.

2 Tanks having top plates not less than 7 *metres* either in length or in width are to be provided with two or more pipes arranged a suitable distance apart. However, tanks having inclined top plates may be provided with one air pipe located at the highest part of the top plate.

3 In cases where tanks or cofferdams are of a complicated profile, special consideration is to be given to the number and positions of all air pipes.

4 Air pipes are to be arranged to be self-draining.

11.6.2 Open Ends of Air Pipes

1 The position of the open ends of air pipes are to be in accordance with the following requirements **(1)** to **(4)** depending on the type and purpose of tanks.

(1) Air pipes to the following tanks and cofferdams are to be led above the bulkhead deck.
   - (a) Double bottom tanks
   - (b) Deep tanks
   - (c) Tanks which allow for ingress of river water
   - (d) Cofferdams

(2) Air pipes to the following tanks and cofferdams are to be led to the weather part.
   - (a) Fuel oil tanks and thermal oil tanks
   - (b) Heated lubricating oil tanks and hydraulic oil tanks
   - (c) Tanks which hold liquids and are filled by pumps, (only for tanks which are situated outside machinery spaces and not provided with overflow pipes)
   - (d) Cofferdams adjacent to fuel oil tanks.

(3) Air pipes to tanks, which hold liquids and are filled by pumps, are to be led to a safe position where the equipment cannot suffer any damage from any overflowing which may occur when the tank is being filled with a liquid.

(4) Air pipes to tanks carrying combustible or flammable liquids are to be led to a safe position where there is no possibility of fire caused by any oil or gas leaking from the openings when the tank is being filled.

2 The open ends of air pipes to fuel oil tanks are to be provided with a flame arresting wire gauze of corrosion resistant materials that is easy to clean and detach as well as have a clear area through the mesh of not less than the required sectional area of the air pipe.

11.6.3 Size of Air Pipes

The total sectional area of air pipes to tanks, which hold liquids and are filled by pumps, is not to be less than 1.25 *times* the total sectional area of the filling pipes. In cases where the tank is provided with an overflow pipe specified in **11.7**, the internal diameter of the air pipes may be reduced to 50 *mm*.

11.6.4 Height of Air Pipes

In cases where air pipes are led above the freeboard deck or the superstructure deck, all exposed parts of the pipes are to be of substantial construction and the height from the upper surface of the deck to the point where the water enters below is to be not less than 450 *mm*. If, however, such a height interferes with ship operations, the height may be reduced to values designated by the Society, provided that the Society is satisfied that the operation of the closing arrangements, etc. is not adversely affected by the lower height.

11.7 Overflow Pipes

11.7.1 General

1 In cases where tanks which hold liquids and are filled by pumps, fall under either one of the following categories, overflow pipes are to be provided:

(1) In case where the sectional area of the air pipes does not comply with the requirements in **11.6.3**;

(2) In cases where there is any opening below the open ends of air pipes fitted to the tanks; and

(3) Fuel oil settling tanks and fuel oil service tanks.

2 Overflow pipes other than those to tanks for fuel oil, lubricating oil and other flammable oils are to be led to the open air, or to positions where any overflow can be properly disposed of.

3 Overflow pipes are to be arranged to be self-draining.

4 In addition to **11.7**, overflow pipes for tanks for fuel oil, lubricating oil and other flammable oils are to comply with the requirements in **3.2.2(4)**, **Part 9**.

11.7.2 Sizes of Overflow Pipes

1 The aggregated sectional area of overflow pipes which come under **11.7.1-1** is to be not less than 1.25 *times* the aggregated sectional area of the filling pipes.

2 The internal diameter for overflow pipes is not to be less than 50*mm*.

11.7.3 Overflow Pipes to Fuel Oil, Lubricating Oil and Other Flammable Oil tanks

1 Overflow pipes are to be fed into an overflow tank of adequate capacity or into a storage tank having sufficient space reserved for overflow purposes.

2 Overflow pipes are to be provided with sight glasses at readily visible positions on the vertical pipes, except in cases where an alarm device to give warning, when the oil level rises to a predetermined point in the tanks, is installed.

11.7.4 Preventive Means of Counter-flow of Overflow

1 In cases where overflow pipes to deep tanks which are used alternately to carry fuel oil, ballast water, etc. are connected to an overflow main common to other tanks, arrangements are to be made to prevent any liquid of different quality from leaking into those other tanks from the deep tank carrying the liquid.

2 Adequate means are to be provided for overflow pipes so that in the event of any one of the tanks being bilged, the other tanks cannot be flooded from the river through the overflow pipes.

3 Overflow pipes discharging through the ship's sides are to extend above the designed maximum load line, and are to be provided with non-return valves fitted on the ship's sides. In case where overflow pipes do not extend above the freeboard deck, additional effective means are to be provided to prevent the river water from passing inboard.

11.8 Sounding Pipes

11.8.1 General

1 All tanks, cofferdams and areas which are difficult to access are to be provided with a sounding pipe or a liquid level indicator.

2 Name plates are to be affixed to the upper ends of all sounding pipes.

3 In addition to **11.8**, sounding pipes for tanks for fuel oil, lubricating oil and other flammable oils are to comply with the requirements in **3.2.2(3)(e)**, **Part 9**.

11.8.2 Upper Ends of Sounding Pipes

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 an effective closing means at their upper ends. However, sounding pipes may be led to readily accessible positions from the platform of a machinery space provided that the closing means specified in **3.2.2(3)(e)** and **3.2.3(2)**, **Part 9** are provided according to the kinds of tanks. Sounding pipes for tanks other than those for flammable oil and cofferdams may be led to readily accessible positions from the platform of a machinery space provided that sluice valves, cocks or screw caps attached to the pipes by chain are provided.

11.8.3 Construction of Sounding Pipes

1 Sounding pipes are to be as straight as practicable and if they are curved, the curvature is to be sufficiently large.

2 Striking plates of adequate size and sufficient thickness are to be fitted to the bottom plating under open ended sounding pipes to prevent any damage to the plating by the striking of the sounding rods. In cases where sounding pipes that have closed ends are employed, all closing plugs are to be of substantial construction.

3 The internal diameter of sounding pipes passing through a refrigerated chamber that has been cooled down to 0*°C* or below is not to be less than 65*mm* and is not to be less than 32*mm* for all other sounding pipes.

11.8.4 Construction of Liquid Level Indicators

A liquid level indicator which is specified in **11.8.1** above is to be of a type that has been approved by the Society. However, when a liquid level indicator conforms to other standards approved by the Society or when it is provided with a certificate recognized by the Society, these requirements do not apply. The liquid level indicator for tanks for fuel oil, lubricating oil and other flammable oils are to comply with the requirements in **3.2, Part 9**.

11.9 Fuel Oil Systems

11.9.1 General

1 Fuel oil systems in the machinery spaces where main propulsion machinery is installed and where a boiler is installed are to be such that easy maintenance and inspection can be performed. All valves or cocks are to be capable of being operated from above the platform.

2 Valves and pipe fittings with a design temperature above 60*°C* and a design pressure above 1*MPa* are to be suitable for use under a pressure of not less than 1.6*MPa*. Valves and pipe fittings used for fuel oil transfer piping lines, fuel oil suction piping lines and other low pressure fuel oil piping lines are to be suitable for use under a pressure of not less than 0.5*MPa* .

3 Two fuel oil service tanks for each type of fuel used on board that is necessary for propulsion and vital systems or equivalent arrangements are to be provided.

4 In addition to **11.9**, fuel oil systems are to comply with the requirements in **3.2**, **Part 9**.

11.9.2 Fuel Oil Filling Pipes

1 Fuel oil filling pipes from outboard are to be used exclusively for fuel. The open ends of these pipes are to be led above decks as far as possible and to be provided with rigid covers.

2 In cases where fuel oil filling pipes are not fitted on or near the top of the fuel oil tanks, non-return valves are to be fitted close to tanks; or, valves or cocks able to be closed by remote control as specified in **3.2.2(3)(d)**, **Part 9** are to be provided.

3 Notwithstanding the requirements in **-1**, in cases where fuel oil filling pipes are connected to suction pipes, stop valves are to be provided on the filling pipes. In addition, stop valves are to be provided in cases where the tanks are situated on a higher position than the double bottom and in cases where there is the fear that fuel oil may pass to other fuel oil tanks through the filling pipes thereto or of any overflow from the openings of sounding pipes, etc.

11.9.3 Fuel Oil Transfer Pumps

For ships in which there is a need to transfer fuel oil, at least one independently powered fuel oil transfer pump is to be provided.

11.9.4 Drip Trays and Drainage Systems

1 Metal drip trays of a sufficient depth are to be provided under all equipment that uses or handles fuel oil such as diesel engines (except main propulsion machinery), burners, fuel oil pumps, fuel oil heaters, fuel oil coolers and fuel oil filters as well as fuel oil tanks. In cases where it is not practicable to provide metal drip trays, coamings are to be provided to hold any oil spillage.

2 Drain valves or cocks fitted to fuel oil tanks are to be of a self-closing type.

3 Drainage arrangements are to comply with the following requirements:

(1) Oil in drip trays or in coamings and drainage from drain valves or cocks are to be led to fuel oil drain tanks. Such tanks are to be provided with either an arrangement means for processing using an appropriate method or disposing of any fuel oil drainage.

(2) The fuel oil drain tanks prescribed in **(1)** are not to be part of an overflow system.

11.9.5 Fuel Oil Heaters

1 In cases where heaters are provided for fuel oil systems, they are to be equipped with temperature controllers as well as high temperature alarm devices or low flow alarm devices, unless where the oils would not be heated to a temperature that is 10°*C* or less below the flash point of the fuel oil.

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:

(1) Heaters are to be provided with automatic temperature controlling devices.

(2) Safety switches with independent temperature sensors are to be provided. These safety switches are to cut off the electrical power supply in order to prevent the surface temperature of heating elements from rising to 220°*C* or above; and, they are to be provided with manual reset devices.

(3) Electric heaters are to be adequately protected against any mechanical damage during times of tank cleaning.

11.9.6 Fuel Oil Systems for Diesel Engines

1 The number and capacity of fuel oil supply pumps for main propulsion machinery are to comply with either the following **(1)** or **(2)**:

(1) At least two fuel oil supply pumps of the same capacity are to be provided, the total capacity of which is to be sufficient enough to ensure the maximum continuous output of the main engine. In addition, in cases where one pump fails, the total capacity of the remaining pumps is to be sufficient enough to ensure the navigable speed of the ship.

(2) In cases where there are two or more main engines, each main engine may be provided with a dedicated fuel oil supply pump if the pump has a capacity sufficient enough to ensure both maximum continuous output of the engine and the navigable speed of the ship even in cases where one of the main engines is out of service.

2 Two fuel oil pumps of the same capacity are to be provided for both diesel engines used to drive electrical generators and auxiliary machinery for which redundancy is required. The total capacity of the two pumps is to be enough to ensure a sufficient supply of oil at maximum continuous output of the engine, and the capacity of each pump is to be sufficient enough to ensure the navigable speed of the ship in cases where the other pump fails. The above requirement, however, does not apply to cases where each engine is provided with a dedicated fuel oil supply pump that has enough capacity to ensure a sufficient supply of oil at maximum continuous output.

3 Fuel oil filters are to be provided for the fuel oil supply piping systems of diesel engines. The filters for diesel engines used as main propulsion machinery are to be capable of being cleaned without stopping the supply of filtered oil. The fuel oil filters are to be provided with valves or cocks for depressurization before being opened.

4 In cases where low grade oil is used for fuel oil, suitable fuel oil heating devices and fuel oil purifying devices are to be provided.

11.9.7 Burning Systems for Boilers

1 An arrangement of two fuel oil burner pumps of the same capacity and two fuel oil heaters of the same capacity is to be provided for each essential boiler and each fuel oil heating device necessary for the operation of main propulsion machinery. The total capacity of the arrangement is to be sufficient enough to ensure the maximum evaporation volume of the boiler, and the capacity of each pump and each heater is to be sufficient enough to ensure the navigable speed of the ship in cases where the other pump or heater fails. However, an arrangement of only one pump and one heater is acceptable in cases where an alternative means is provided to ensure normal navigation when either the pump or heater fails.

2 In cases where fuel oil is supplied to the burners by gravity, fuel oil filters capable of being cleaned without stopping the supply of filtered oil are to be provided.

3 In cases where either steam or air is used to remove residual fuel oil from boiler burners, means are to be provided to prevent the mixing of any oil with the steam or air.

11.10 Lubricating Oil Systems and Hydraulic Oil Systems

11.10.1 General

1 The location, drip trays, drainage arrangements and heaters of lubricating oil systems are to comply with the requirements in **11.9.1-1**, **11.9.4-1** and **-3**, and **11.9.5** respectively (in these cases the term “fuel oil” is to be read as “lubricating oil”).

2 The location, drip trays and drainage arrangements of hydraulic oil systems are to comply with the requirements in **11.9.1-1**, **11.9.4-1** and **-3** (in these cases the term “fuel oil” is to be read as “hydraulic oil”).
3 In addition to **11.10**, lubricating oil systems and hydraulic oil systems are to comply with the requirements in **3.2.3**, **Part 9** and **3.2.4**, **Part 9** respectively.

11.10.2 Lubricating Oil Pumps

1 The number and capacity of lubricating oil pumps for main propulsion machinery, propulsion shafting systems, and their associated power transmission systems are to comply with the following **(1)** or **(2)** :

(1) At least two lubricating oil pumps of the same capacity are to be provided for each main engine, propulsion shafting system and power transmission system. The total capacity of the pumps for each of the above is to be sufficient enough to ensure the maximum continuous output of the main propulsion machinery. In addition, in cases where one pump fails, the total capacity of the remaining pumps of each of the above is to be sufficient enough to ensure the navigable speed of the ship.
(2) In cases where there are two or more main propulsion machinery, propulsion shafting systems or their associated power transmission systems, each may be provided with a dedicated lubricating oil pump if the pump has a capacity sufficient enough to ensure both the maximum continuous output of the engine or system, and the navigable speed of the ship even in cases where one of the engines or shafting systems is out of service.

2 Two lubricating fuel oil pumps of the same capacity are to be provided for both diesel engines used to drive electrical generators and auxiliary machinery for which redundancy is required. The total capacity of the two pumps is to be enough to ensure a sufficient supply of oil at maximum continuous output of the engine, and the capacity of each pump is to be sufficient enough to ensure the navigable speed of the ship in cases where the other pump fails. The above requirement, however, does not apply to cases where each engine is provided with a dedicated lubricating oil pump that has the capacity to ensure a sufficient supply of oil at maximum continuous output.

11.10.3 Lubricating Oil Filters

1 In cases where a forced lubrication system (including gravity tanks) is adopted for the lubrication of machinery installations, lubricating oil filters are to be provided.
2 Filters used for the lubricating oil systems of the main propulsion machinery, power transmissions of propulsion shafting and controllable pitch propeller systems are to be capable of being cleaned without stopping the supply of filtered oil.

11.10.4 Lubricating Oil Purifying Devices

Lubricating oil systems are to be provided with lubricating oil purifying systems such as lubricating oil purifiers or filters in lieu of purifiers.

11.11 Thermal Oil Systems

11.11.1 General

The location of thermal oil systems and the valves fitted to the pumps of such systems are to comply with the requirements in **11.9.1-1**. Any filling pipes from outside the ship are to comply with the requirements in **11.9.2-2**. Drip trays and drainage systems are to comply with the requirements in **11.9.4-1** and **-3**. In these cases the term “fuel oil” is to be read as “thermal oil”. In addition to **11.11**, these systems are to comply with the requirements in **3.2.4**, **Part 9**.

11.11.2 Thermal Oil Systems

Thermal oil systems are to comply with the following requirements:

(1) Expansion tanks are to be provided with liquid level indicators.
(2) Circulating pumps are to be provided with a pressure measuring device at a suitable position on both the delivery and suction sides.
(3) The inlet and outlet valves on thermal oil heaters are to be controllable from outside the compartment where they are installed, unless an arrangement for the quick drainage by gravity of any thermal oil contained in the system into a collecting tank is made.

11.11.3 Pumps for Thermal Oil Heaters

Thermal oil heaters of important use are to be provided with two thermal oil circulating pumps. However, only one pump may be acceptable, in cases where alternative means are available to ensure normal navigation in case of pump failure.

11.12 Cooling Systems

11.12.1 Cooling Pumps

1 The number and capacity of cooling pumps for main propulsion machinery are to comply with the following **(1)** or **(2)**:

(1) At least two cooling pumps of the same capacity are to be provided for main propulsion machinery, the total capacity of which is to be sufficient enough to ensure the maximum continuous output of the main propulsion machinery. In addition, in cases where one of the pumps fails, the total capacity of the remaining pumps is to be sufficient enough to ensure the navigable speed of the ship.

(2) In cases where there are two or more main propulsion machinery are provided, each main propulsion machinery may be provided with a dedicated cooling pump if the pump has a capacity sufficient enough to ensure both the maximum continuous output of the engine and the navigable speed of the ship even in cases where one of the main propulsion machinery is out of service.

2 Two cooling pumps of the same capacity are to be provided for diesel engines used to drive electrical generators and auxiliary machinery for which redundancy is required. The total capacity of the two pumps is to be enough to ensure a sufficient supply of water (oil) at maximum continuous output of the engine. In addition, the capacity of each pump is to be sufficient enough to ensure the navigable speed of the ship in cases where the other pump fails. The above requirement, however, does not apply to cases where each engine is provided with a dedicated cooling that has enough capacity to ensure a sufficient supply of water (oil) at maximum continuous output.

11.12.2 Suction of River water

Arrangements are to be provided to introduce cooling river water from suction valves fitted on two or more sea chests or suction inlets.

11.12.3 Cooling Systems for Diesel Engines

In cases where river water is used for the direct cooling of the propulsion machinery, diesel engines driving electrical generators, or any auxiliary machinery for which duplication is required, strainers, which are arranged so as they are capable of being cleaned without stopping the supply of filtered cooling water to the respective engines, are to be provided between the river water suction valve and the cooling river water pump.

11.13 Pneumatic Piping Systems

11.13.1 Arrangement of Air Compressors and Pressure Relief Systems

1 Air compressors are to be so arranged that any mixing between oil and incoming air is minimized as much as possible.

2 Each air compressor is to be provided with a relief valve to prevent the pressure from rising more than 10% above the maximum working pressure of its cylinders.

3 In cases where water jackets of air coolers might be subject to dangerous level of excessive pressure due to any leakage of compressed air into them, suitable pressure relief arrangements are to be provided for these water jackets.

11.13.2 Relief Devices and Other Fittings for Air Tanks

Relief devices and other fittings for air tanks are to comply with the requirements in **8.8**.

11.13.3 Number and Total Capacity of Air Compressors

1 In cases where the main propulsion machinery is designed for starting by compressed air, two or more starting air compressors are to be provided and arranged so as to be able to charge each air reservoir. However, in cases where cylinders are provided with air charging valves, these charging valves will be considered to be equivalent to any air compressors driven by the main propulsion machinery.

2 One of the air compressors prescribed in **-1** is to be driven by a prime mover that is not the main propulsion machinery.
3 The total capacity of air compressors is to be sufficient to supply air into the air reservoirs from atmospheric pressure to the pressure required for the consecutive starts prescribed in **2.5.3-2** within one *hour*.

11.13.4 Compressed Air Piping

1 Drainage systems are to be provided for compressed air piping to remove any drainage remaining inside the pipes.
2 All discharge pipes for starting air reservoirs are to be laid directly from starting air compressor.

11.14 Feed Water Systems for Boilers

11.14.1 Feed Water Systems

1 Two feed water systems are to be provided for each essential boiler and each fuel oil heating device necessary for the operation of main propulsion machinery. Each feed water system is to consist of a stop valve and a non-return valve fitted where boiler feed water pipes connect to the boiler as well as a feed water pump of the same capacity for each system. The total capacity of a system is to be both sufficient enough to ensure the maximum evaporation volume of the boiler, and sufficient enough to ensure the navigable speed of the ship in cases where the other system fails. However, the provision of only one feed water system of a capacity sufficient enough to ensure the maximum evaporation volume of the boiler is acceptable if either an alternative means is provided to ensure unhindered navigation even in cases where the feed water system fails or a complete replacement feed water system (including a feed water pump, stop valve and non-return valve) which can be installed, if needed, within a short period of time is kept on board.
2 Feed water pipes are to be so arranged to prevent any mixing of boiler feed water with oil or chlorides.

11.15 Exhaust Gas Piping Arrangements

11.15.1 Exhaust Gas Pipes from Diesel Engines

1 In principle, exhaust gas pipes of two or more diesel engines are not to be connected together. In cases where these pipes are connected to a common silencer, effective means are to be provided to prevent the exhaust gas from returning into any cylinders of non-operating engines.
2 Exhaust gas piping lines that are led overboard near the water line are to be so arranged as to prevent water from being siphoned back into the cylinders.
3 Boiler uptakes and exhaust piping lines from diesel engines are not to be connected together, except in cases where the boilers are arranged to utilize waste heat from the diesel engines.

11.15.2 Exhaust Gas Pipes from Incinerators

In cases where incinerator exhaust gas pipes are of a shape (e.g., u-shaped, etc.) which is susceptible to the accumulation of unburnt matter, a cleaning hole is to be provided for maintenance at the parts where said unburnt matter is expected to easily accumulate.

11.16 Tests

11.16.1 Shop Tests

Auxiliaries and piping are to be tested in accordance with the requirements in **10.6** after manufacture.

11.16.2 Tests on Board

1 Auxiliaries (excluding auxiliary machinery for specific use etc.) are to be subjected to running tests after installed on board. However, in the case of machinery having passed the running tests specified in **10.6.1-9**, the test methods on board may be suitably modified at the discretion of the Society.
2 Fuel oil piping systems, thermal oil piping systems and heating coils in tanks are, after installed on board, to be subjected to a leak test at a pressure of 1.5 *times* the design pressure or 0.4*MPa*, whichever is greater.

Chapter 12 STEERING GEARS

12.1 General

12.1.1 Scope

1 The requirements in this Chapter apply to power-driven steering gears.

2 For those items mentioned in this Chapter, the requirements given in this Chapter are applied in lieu of the requirements in **Chapters 10** and **11**.

3 Electrical equipment and cables used for steering gears are to conform to the requirements of **Part 8** in addition to those specified in this Part.

4 Manual steering gears will be considered by the Society in each case.

12.1.2 Terminology

The terms used in this Chapter are defined as follows:

(1) A main steering gear is defined as the machinery, rudder actuators, steering gear power units, if any, and ancillary equipment and the means of applying torque to the rudder stock (tiller, etc.) necessary for effecting movement of the rudder for the purpose of steering the ship under normal service conditions.

(2) An auxiliary steering gear is defined as 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 tiller, etc.

(3) A 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 electrohydraulic 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) A power actuating system is defined as 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 systems may share common mechanical components, *i.e.*, tiller, etc.

(5) A rudder actuator is defined as the component which converts directly hydraulic pressure into mechanical action to move the rudder.

(6) A control system is defined as 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.

12.1.3 Drawings and Data

Drawings and data to be submitted are generally to be as follows:

(1) Drawings:
   - (a) General arrangements of steering gear
   - (b) Details of tiller, 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 diagrams of an alternative source of power
   - (h) Diagram of the rudder angle indicator
   - (i) Other drawings considered necessary by the Society

(2) Data:
   - (a) Particulars
   - (b) Operating instructions (including drawings showing the change-over procedure for power units and control systems, drawings showing the sequence of automatic supply of power from an alternative source of power,

data showing the kind, particulars and assembly of power sources in the case that the alternative source of power is an independent source of power and information about hydraulic fluid quality)

(c) Manuals for countermeasures to be taken at the time of a single failure of the power actuating system;

(d) Calculation sheet of the strength of essential parts.

(e) Other data considered necessary by the Society.

12.1.4 Display of Operating Instructions, etc.

1 Simple operating instructions with block diagrams 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 for all ships equipped with power-operated steering gears.

2 In cases where system failure alarms are provided in accordance with to **12.3.1-4**, appropriate instructions for emergency procedures related to such alarms are to be permanently displayed on the navigation bridge.

12.2 Performance and Arrangement of Steering Gears

12.2.1 Number of Steering Gears

1 Unless expressly specified 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 In cases where the main steering gear comprises two or more identical power units, an auxiliary steering gear need not be fitted, provided that:

(1) The main steering gear is capable of operating the rudder as required by **12.2.2(1)** while operating with all power units;

(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 those of the hydraulic type, will be considered by the Society in each case.

12.2.2 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 **2.1.9, Part 1** 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 when the main steering gear has to meet the requirements in **(1)** or when the diameter of the upper stock is required in **Chapter 2, Part 4** to be over 120 *mm* (calculated with a material factor K_S =1 where K_S is less than 1, and excluding the increase required for ships which have 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 proved by trials at maximum astern speed and maximum rudder angle.

12.2.3 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 **2.1.9, Part 1** or 7 *knots*, whichever is 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 stock is required in **Chapter 2, Part 4** to be over 230 *mm*.

12.2.4 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 after taking into consideration the type and design of the power actuating system.

3 Arrangements for bleeding air from 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 the 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 practical indication of any hydraulic fluid leakage. This alarm is to be audible and visual and to be given on the navigating bridge and at a position from where the main engine is normally controlled.

6 In cases where the steering gear is so arranged that more than one system (either power or control) can be simultaneously operated, the risk of hydraulic locking caused by a single failure is to be considered.

12.2.5 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 from a position on the navigating 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.

12.2.6 Alternative Source of Power

In cases where the diameter of upper stock is required in **Chapter 2, Part 4** to be over 230 *mm*, an alternative source of power is to be provided in accordance with the following:

(1) The alternative source of power is to be either:

  (a) An emergency source of electric power specified in **3.3, Part H of the Rules for the Survey and Construction of Steel Ships**; or

  (b) An independent source of power located in the steering gear compartment and used only for this purpose.

(2) Any 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 this case the alternative source of power is to be capable of giving sufficient power to the power unit so that the steering capability required by **12.2.3(1)** can be regained. In every ship of 10,000 *gross tonnage* or more, alternative sources of power are to have the capacity for at least 30 *minutes* of continuous operation of the steering gear and for at least 10 *minutes* in any other ship.

(3) Automatic starting arrangements for generators or prime movers of pumps used as the independent source of power specified in **(1)(b)** are to comply with the requirements for starting devices and performance in **3.4.1, Part H of the Rules for the Survey and Construction of Steel Ships**.

12.2.7 Electrical Installations for Electric and Electrohydraulic Steering Gear

1 Cables used in power circuits required to be installed in duplicate by this Chapter are to be separated as far apart as practicable throughout their entire length.

2 Means for indicating that power units are running is to be installed on the navigating bridge and at the position from which the main engine is normally controlled.

3 Each electric or electrohydraulic steering gear comprising one or more power units is to be served by at least two exclusive circuits fed directly from the main switchboard.

4 Any auxiliary electric or electrohydraulic steering gear associated with the main electric or electrohydraulic steering gear may be connected to one of the circuits supplying this main steering gear. These circuits are to have adequate rating for supplying all motors which can be simultaneously connected to them and may be required to be operated simultaneously.

5 Protection against any excess current, including the starting current, if provided, is to be for not less than twice the full load current of the motor or circuit so protected, and to be arranged to permit the passage of the appropriate starting currents.

6 When any auxiliary steering gear, in ships of less than 1,600 *gross tonnage*, which is required by **12.2.3(2)** 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. However, in cases where such an electric motor, primarily intended for other services, is arranged to power such auxiliary steering gear, the requirements in **-5** may be waived if the Society is satisfied that these protection arrangements are in accordance with the requirements in **12.2.5** and **12.3.1-1(3)** for auxiliary steering gear.

7 For ships with a gross tonnage less than 1,600 *gross tonnage* that are equipped with manual auxiliary steering gears, the power supply circuit from the main switchboard to the main steering gear may be one circuit.

12.2.8 Position of Steering Gears

1 The steering gear compartments are to be readily accessible and as far as practicable, separated from machinery spaces.

2 The steering gear compartments are 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 nonslip surfaces to ensure suitable working conditions in the event of hydraulic fluid leakage.

12.2.9 Means of Communication

A means of communication is to be provided between the navigating bridge and the steering gear compartment.

12.2.10 Rudder Angle Indictor

The angular position of rudder is to be:

(1) indicated on the navigating bridge. The rudder angle indicator is to be independent of the control system;

(2) recognizable in the steering gear compartment.

12.3 Controls

12.3.1 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) In cases where the main steering gear is arranged in accordance with the requirements in **12.2.1-2**, by two independent control systems, both operable from the navigating bridge. This does not require duplication of the steering wheel or steering lever. In cases where the control system consists of a hydraulic telemotor, a second independent system need not be fitted.

(3) For any 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 systems 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 For the steering gears which are so arranged that more than one system (either power or control) can be simultaneously operated, where hydraulic locking, caused by a single failure, may lead to loss of steering, audible and visual alarms, which identifies the failed system, are to be provided on the navigation bridge.

12.3.2 Change-Overs from Automatic to Manual Steering

The steering gears of ships provided with automatic pilots are to be capable of immediate change-overs from automatic to manual steering.

12.4 Materials, Constructions and Strength of Steering Gears

12.4.1 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, piping subjected to a hydraulic pressure and components transmitting mechanical forces to the rudder stock are not to have a minimum elongation of less than 12%, or a specified tensile strength in excess of 650 *N/mm*^{2}. This does not apply to those materials for valves and bolts where approved by the Society.

3 Materials used for tillers are to be forged steels or cast steels tested in accordance with the requirements in **Part K of the Rules for the Survey and Construction of Steel Ships**.

4 Materials used for bosses and vanes of rotary vane type rudder actuators are to be forged steels, cast steels or nodular graphite cast irons tested in accordance with the requirements in **Part K of the Rules for the Survey and Construction of Steel Ships**.

5 Materials used for bolts for assembling split type tillers and bolts for securing 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 **Part K of the Rules for the Survey and Construction of Steel Ships**.

6 Materials used for major parts other than those mentioned in **-3** to **-5** are to comply with the requirements in those recognized standards deemed appropriate by the Society.

7 Materials other than those mentioned in **-2** to **-6** may be used where approved by the Society.

12.4.2 Welding

1 All welded joints of parts used in power actuating systems are to be such that there is no incomplete penetration or any other injurious defects.

2 Welded joints in parts subjected to the internal pressure of power actuating systems are to have sufficient strength.

12.4.3 General Construction of Steering Gear

1 Steering gears are to be of sufficient strength and reliability.

2 Configurations of the major parts of steering gears are to be determined to avoid any 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 **12.2.2(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, in cases 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 In cases where considered necessary, fatigue analysis is to be carried out on piping and components, taking into account any pulsating pressure due to dynamic loads. Both the cases of high cycle and cumulative fatigue are to be considered.

12.4.4 Strength of Rudder Actuators

1 The strength of all of the components of rudder actuators subjected to an internal pressure, except for the amount of allowable stress specified in this Chapter, is to comply with relevant requirements in **Chapter 8**.

2 In the strength calculations specified in **-1**, the allowable stress for any equivalent primary general membrane stress is to be not greater than either of the following values **(1)** or **(2)**, whichever is smaller:

(1) $\dfrac{\delta_B}{A}$

(2) $\dfrac{\delta_Y}{B}$

Where:

δ_B : Specified tensile strength of the material (*N/mm*^{2})

δ_Y : Specified yield strength or 0.2% proof stress of the material (*N/mm*^{2})

A and B : As given in **Table 7.12.1**.

Table 7.12.1 A and B

	Rolled or Forged Steel	Cast Steel	Nodular Cast Iron
A	3.5	4	5
B	1.7	2	3

12.4.5 Oil Seals in Rudder Actuators

1 Oil seals between any non-moving parts which form part of the external pressure boundary, are to be of the metal upon metal type or of an equivalent type.

2 Oil seals between any moving parts which form 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 in cases where approved by the Society.

12.4.6 Flexible Hose Assembly

Flexible hose assemblies specified in **10.3.4** are to be used in piping systems in cases where flexibility is required.

12.4.7 Tillers, etc.

1 The scantlings of tillers, etc., made of forged steels or cast steels, which transfer power from the rudder actuator to the rudder stock, are to be so determined so that the bending stress does not exceeding 118/K(N/mm^2) and the shearing stress does not exceeding 68/K(N/mm^2) when the rudder torque T_R is applied.

Where:

T_R : Rudder torque specified in **2.1.5, Part 4** (N-m).

K : Material coefficient of the tiller, specified in **2.1.2, Part 4**

2 Notwithstanding the requirement specified in **-1**, the scantlings of rapson-slide type or trunk piston type tillers may be determined according to the following **(1)** to **(4)**:

(1) The vertical section of each side of tiller boss at the centre line of rudder stock is to comply with the following formulae:

$$(D^2 - d^2)H \geq 170 T_R K$$

$$H / d \geq 0.75$$

Where:

D : Outer diameter of boss (mm).

d : Inner diameter of boss (mm).

H : Depth of boss (mm).

T_R : Rudder torque specified in **2.1.5, Part 4** (N-m).

K : Material coefficient of the tiller, specified in **2.1.2, Part 4**

(2) The section modulus of an arm about its vertical axis is to be not less than that obtained from the following formula:

$$Z_{TA} = 11\left(1 - \frac{r}{R_1}\right) T_R K$$

Where:

Z_{TA} : Required section modulus of the arm about its vertical axis (mm^3).

r : Distance from the centre of rudder stock to the section (mm).

R_1 : Length of the tiller arm measured from the centre of the rudder stock to the point of application of the driving force (mm). In cases where this length varies in accordance with rudder angle, R_1 is the maximum length within 35 *degrees* of rudder angle.

T_R : Rudder torque specified in **2.1.5, Part 4** (N-m).

K : Material coefficient of the tiller, specified in **2.1.2, Part 4**

(3) The sectional area of an arm at its outer end is to be not smaller than that obtained from the following formula:

$$A_R = 18.5 \frac{T_R}{R_2} K$$

Where:

A_R : Required sectional area of the arm at its outer end (mm^2).

R_2 : Length of the tiller arm measured from the centre of the rudder stock to the point of application of the driving force (mm). In cases where this length varies in accordance with rudder angle, R_2 is the length at 0 *degrees* of rudder angle.

T_R : Rudder torque specified in **2.1.5, Part 4** (N-m).

K : Material coefficient of the tiller, specified in **2.1.2, Part 4**

(4) In cases where a tiller having two arms which have power units that are connected to each arm and these two power units are driven simultaneously, the scantlings of the arms may be reduced from those required in **(2)** and **(3)** to a value recognized by the Society.

3 Notwithstanding the requirement specified in **-1**, the scantlings of rotary vane type rudder actuators of forged steels or cast steels may be determined according to the following requirements, in addition to those requirements specified in **12.4.4**.

(1) Scantlings of the boss are to comply with the requirement specified in **-2(1)**.

(2) The section modulus about the vertical axis and the sectional area of vane is to be not less than that obtained from the following formulae:

$$Z_v = 11\left(\frac{B}{D+B}\right)\frac{T_R}{n}K$$

$$A_R = 37\left(\frac{1}{D+B}\right)\frac{T_R}{n}K$$

Where:

Z_v : Required section modulus of vane about the vertical axis (mm^3).

A_R : Required sectional area of vane (mm^2).

D : Outer diameter of boss (mm).

B : Height of vane measured from outer surface of boss (mm).

n : Number of vanes.

T_R : Rudder torque specified in **2.1.5, Part 4** (N-m).

K : Material coefficient of the vane, specified in **2.1.2, Part 4**

4 In cases where tillers which are separated into two pieces are bolted, there are to be at least two bolts on each side of the head. The diameter of bolts at bottom of thread is not to be less than that obtained from the following formula. In such case, the thickness of any coupling flange is to not less than three-fourth of the diameter of the bolts.

$$d_b = 1.45\sqrt{\frac{T_R}{nb}K}$$

Where:

d_b : Required diameter of bolts at bottom of thread (mm).

T_R : Rudder torque specified in **2.1.5, Part 4** (N-m).

K : Material coefficient of the bolt, specified in **2.1.2 Part 4**

n : Number of bolts on each side of the head.

b : Distance from the centre of rudder stock to the centre of bolt (cm).

5 Tillers are to be coupled, using a key, to rudder stocks by shrinkage fitting, force fitting or the bolted method. However, tillers may be coupled without a key, in cases where the fitting methods are in compliance to the satisfaction of the Society.

6 Scantlings of rotary vane type rudder actuators of nodular graphite cast iron are to be specified to not to be applied with bending stress exceeding $94/K$ *(N/mm^2)*, or shearing stresses exceeding $54/K$ *(N/mm^2)* under the rudder torque T_R applied. Alternatively, the scantlings may be determined according to the requirements specified in **-3**, using 1.2 *times* the rudder torque T_R specified in **2.1.5, Part 4** as rudder torque for calculating.

12.4.8 Stoppers

1 Tillers 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. However, these arrangements may be operated through mechanical links such as floating levers.

3 Suitable brake arrangements or ropes are to be provided to tillers to keep the rudder steady in the event of an emergency. In the case of hydraulic steering gear, where the rudder can be stopped safely by closing the oil pressure valves, this brake arrangement will not be required.

12.4.9 Buffers

Steering gears other than those of a hydraulic type are to be provided with spring buffers or other suitable buffer arrangements to relieve the gears from any shock given off by the rudder.

12.5 Testing

12.5.1 Shop Tests

1 Pressure vessels and piping systems are to be subjected to tests in accordance with the requirements in **8.9**, **10.6** and **11.16** in addition to the tests specified in **12.5**.

2 All pressure parts are to be subjected to pressure tests with a pressure equal to 1.5 *times* the design pressure.

3 The pumps of power units are to be subjected to running tests. Such tests, however, may be waived for power units with a proven track record of reliability in marine service.

12.5.2 Tests after Installation On Board

1 Hydraulic piping systems are, after installed on board, to be subjected to a leak test at a pressure that is at least equal to their maximum working pressure.

2 The steering gear is, after installed on board, to be subjected to a running test.

3 In cases where the steering gear is designed to avoid any hydraulic locking, this feature is to be demonstrated. In cases where this feature needs to be demonstrated at river, this test to be carried out during river trial.

Chapter 13 WINDLASSES AND MOORING WINCHES

13.1 General

13.1.1 Scope

1 The requirements in this Chapter apply to windlasses and mooring winches driven by electric power, hydraulic power or steam.

2 The windlasses and mooring winches other than those specified in **-1** are to be subject to approval by the Society.

13.1.2 Structure etc.

1 Windlasses and mooring winches are to comply with the Japanese Industrial Standards or other recognized standards deemed appropriate by the Society.

2 Windlasses, mooring winches and their beds and other accessory facilities are to be installed effectively and securely onto the deck.

13.1.3 Ability of Windlasses

The windlass is to have sufficient ability to lift an anchor and chains paid out in the river.

13.2 Test

13.2.1 Tests after installation on board

Required tests in **2.3.1 of Part 2** for windlasses are to be carried out during river trials.

Chapter 14 AUTOMATIC AND REMOTE CONTROL

14.1 General

14.1.1 Scope

1 The requirements in this Chapter apply to automatic or remote control systems which are used to control the following machinery and equipment:

(1) Main propulsion machinery (in this Chapter, propulsion generating sets in electric propulsion ships are excluded)

(2) Controllable pitch propeller

(3) Steam generating sets

(4) Electric generating sets (in this Chapter, propulsion generating sets in electric propulsion ships are included)

(5) Auxiliary machinery associated with the machinery and equipment listed in **(1)** to **(4)**

(6) Fuel oil systems

(7) Bilge systems

(8) Deck machinery

2 In case where considered necessary by the Society, the requirements in this Chapter are correspondingly applied to those automatic or remote control systems which are used for controlling machinery and equipment not listed in **-1(1)** to **(8)**.

14.1.2 Terminology

Terms used in this Chapter are defined as follows:

(1) A monitoring station (excluding control stations) is defined as a position where measuring instruments, indicators, alarms, etc. for machinery and equipment are centralized and all information necessary to grasp the operating condition of them can be obtained. However, in cases where a monitoring station is provided with the ship in addition to the control station mentioned in **(2)** below, the requirements of the Rules relating to monitoring stations do not apply to the monitoring station concerned.

(2) A control station is defined as a position which can function as a monitoring station and from which machinery and equipment can be controlled.

(3) A main control station is defined as a control station, provided with equipment necessary and sufficient to control the main propulsion machinery (this equipment will be referred to as "main control equipment" in **(3)** and **(4)**) and from which the main propulsion machinery is normally controlled, of those ships which provide main control equipment at a position outside of the navigation bridge.

(4) The main control station on the bridge is defined as a navigation bridge of the ship which provides main control equipment at the navigation bridge and the location the main propulsion machinery is normally controlled.

(5) A sub-control station is defined as a control station at which the main propulsion machinery is capable of being controlled, except for those local control stations for main propulsion machinery that are provided in the machinery spaces of the ship that has a main control station on its bridge.

(6) Bridge control devices are defined as remote control devices for main propulsion machinery or controllable pitch propellers provided on a navigation bridge or at the main control station on the bridge.

(7) Sequential control is defined as a pattern of control that can be carried out automatically in a predetermined sequence.

(8) Program control is defined as a pattern of control in which desired values can be changed in a predetermined schedule.

(9) Local control is defined as direct manual control of machinery and equipment performed at or near their locations, receiving necessary information from the measuring instruments, indicators and so on.

(10) A safety system is defined as a system which operates automatically, in order to prevent damage to machinery and equipment in cases where serious impediments to functioning should occur during their operation so that one of the following actions in **(a)** to **(c)** will take place:

(a) Starting of stand-by machinery or equipment
(b) Reduction of output of machinery or equipment
(c) Shutting off fuel or power supplies, thereby stopping the machinery or equipment

14.1.3 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
    i) List of controlled objects and controlled variables
    ii) Kinds of control energy sources (self-actuated, pneumatic, electric, etc.)
    iii) List of conditions for emergency stopping, speed reduction (automatic or demand for reduction), etc.

(2) The following drawings and data for the automatic control devices and remote control devices for main propulsion machinery or controllable pitch propellers.
  (a) Operating instructions of main propulsion machinery such as starting and stopping, change-over of direction of revolution, increase and decreased of output, etc.
  (b) Arrangements of safety devices (including those attached to 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, alarm panels and control stands at respective control stations

(6) Drawings and data for those computers and computerized systems specified in **14.2.7**.

14.2 System Design

14.2.1 System Design

1 Control systems, alarm systems and safety systems are to be so designed that one fault does not result in any other faults as far as practicable and the extent of any damage is kept to a minimum.

2 Control systems, alarm systems and safety systems are to be designed on the fail-to-safe principle. The characteristic of fail-safe is to be evaluated on the basis not only of the respective systems themselves and all associated machinery and equipment, but also on the total safety of the ship.

3 Automatic or remote control systems are to be sufficiently reliable under service conditions.

4 Signal cables are to be installed in such a manner that any harmful induced interference can be avoided.

14.2.2 Supply of Power

1 Supply of electrical power

The supply of electrical power is to be in accordance with the following:

(1) Electrical supply circuits to control systems, alarm systems and safety systems are not to branch off from power circuits and lighting circuits, except in cases where the electrical power to control systems, alarm systems and safety systems is supplied from power circuits to the machinery and equipment they serve.

(2) Electrical 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:

(1) Sources of oil pressure are to be capable of stably supplying all necessary pressure and quantities of purified oil.

(2) Overpressure preventive devices are to be provided for the delivery side of oil pressure pumps.

(3) Two or more sets of oil pressure pumps for control of the main propulsion machinery and the main shafting are

to be provided and they are to be so arranged that in cases where one of the pumps in operation fails, stand-by pump(s) either start automatically or be readily started by remote control. In this case, oil pressure pumps are not to be used for the control of machinery and equipment other than the main propulsion machinery and the main shafting.

3 Supply of pneumatic pressure

The supply of control air is to be in accordance with the following:

(1) Control systems are to be provided with an air reservoir having a capacity capable of supplying air to control devices for at least 5 *minutes* in the event of the failure of the control air compressor.

(2) In cases where starting air reservoirs of diesel engines used as main propulsion machinery are used as control air reservoirs, pressure reducing valves are to be duplicated or a spare pressure reducing valve is to be provided on board.

(3) 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.

(4) Control air is to pass through a filter and, if necessary, a drier so that any solids, oil and water may be removed as much as possible.

(5) Control air pipes are to be independent of general service air pipes and starting air pipes.

14.2.3 Environmental Conditions

Automatic or remote control systems are to be capable of withstanding the environmental conditions of the places where they are installed.

14.2.4 Control Systems

1 Independence of control systems

Control systems for main propulsion machinery or controllable pitch propellers, boilers, electric generating sets and auxiliary machinery essential for main propulsion of the ship are to be independent each other. However, when the propulsion generator plant and the main generating plant are connected to the same bus line, they may have common control systems.

2 Interconnection devices

In the case of multiple main propulsion machinery or controllable pitch propellers, electric generating sets, or auxiliary machinery (excluding auxiliary machinery for specific use, etc.) in which these multiple units are designed to be operated simultaneously under the same conditions, 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 that conform to the dynamic properties of the machinery and equipment they serve and consideration is to be given so that no malfunctions and hunting occurs due to any external disturbances.

4 Interlocks

Control devices are to be provided with suitable interlocking arrangements in order to prevent any damage to machinery and equipment due to anticipated malfunctions and mal-operation of such machinery and equipment.

5 Change-over to manual operation

Change-over to manual operation is to comply with the following requirements in **(1)** to **(3)**:

(1) Main propulsion machinery or controllable pitch propellers, boilers, electric generating sets and auxiliary machinery essential 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 becomes inoperative.

(2) Automatic control devices are generally to be provided with provisions for the manual stopping of the automatic functions of these devices.

(3) The provisions specified in **(2)** are to be capable of stopping the automatic functions of automatic control devices, even in cases where any part of the automatic control device becomes inoperative.

6 Cancellation of remote control functions

For remote control devices, remote control function is to be capable of being manually cancelled.

7 Indication of control locations

In cases where machinery and equipment are capable of being operated from more than one station, the following requirements in **(1)** and **(2)** are to be complied with. However, this requirement need not be complied with in cases where the safety of the machinery and equipment and the safety at the time of maintenance work can be guaranteed by other means considered appropriate by the Society.

(1) At each control station there is to be an indicator showing which station is in control of the machinery and equipment.

(2) Control of the machinery and equipment is to be possible only from one station at a time.

14.2.5 Alarm Systems

1 The function of alarm systems is to comply with the following requirements:

(1) In cases where an abnormal condition is detected, devices to issue a visual and audible alarm (hereinafter referred to as “alarm devices” in this Part) are to operate.

(2) In cases where arrangements are made to silence audible alarms they are not to turn off visual alarms.

(3) Two or more faults are to be indicated at the same time.

(4) Audible alarms for machinery and equipment are to be clearly distinguishable from other audible alarms such as general alarms, fire alarms, CO_2 flooding alarms, etc.

2 The function of the alarm systems provided in monitoring station for main propulsion machinery or controllable pitch propellers is to comply with the following requirements, in addition to those requirements in **-1** above:

(1) Visual alarms are to remain on until all faults have been corrected.

(2) The acceptance of any one alarm is not to inhibit the activation of any other alarm.

(3) If an alarm has been activated and a second fault occurs prior to the first one being corrected, alarm devices go into operation again.

(4) In cases where an alarm has been manually stopped, clear indication of details of this stoppage is to be given.

3 Visual alarms are to be so arranged that each abnormal condition of machinery and equipment is readily distinguishable and that acknowledgement is clearly noticeable.

14.2.6 Safety Systems

1 Constitution of systems

Constitution of safety systems is to comply with the following requirements:

(1) Safety systems are to be, as far as practicable, provided independently of control systems and alarm systems.

(2) Safety systems for main propulsion machinery, boilers, electric generating sets and auxiliary machinery essential for main propulsion of the ship are to be independent each other.

2 Function of safety systems

The function of the safety systems is to comply with the following requirements:

(1) Alarm systems which have functions prescribed in **14.2.5** are to operate when safety systems are put into action.

(2) In cases where safety systems are put into action and the operation of machinery or equipment has been stopped, the safety system is not to automatically restart before manual reset is made.

3 Override arrangements

In cases where arrangements are provided for overriding a safety system, the following requirements **(1)** and **(2)** are to be complied with:

(1) Visual indication is to be given at the relevant control stations of machinery and equipment when an override is operated.

(2) Override arrangements are to be such that any inadvertent operation is prevented.

14.2.7 Computers and Computerized Systems

1 Computerized control systems, alarm systems and safety systems are divided into three categories as shown in **Table 7.14.1** based upon the impact a single failure has on human and vessel safety as well as the environment. These systems are to comply with the requirements in this Chapter and the following **-2** through **-5**. However, where this requirement is impracticable, the systems are to comply with requirements deemed appropriate by the Society.

Table 7.14.1 Computerized System Categories

Category	Effects in case of failure	System functionality
I	Those systems which will not lead to dangerous situations for human safety, safety of the vessel and threat to the environment.	- Systems related to informational or administrative tasks
II	Those systems which could eventually lead to dangerous situations for human safety, safety of the vessel and threat to the environment.	- Alarm systems - Control systems which are necessary to maintain the ship in normal operational and habitable conditions
III	Those systems which could immediately lead to dangerous situations for human safety, safety of the vessel and threat to the environment.	- Control systems for maintaining the vessel's propulsion and steering - Safety systems

2 Computers used for the control systems, alarm systems and safety systems for machinery and equipment, considered necessary by the Society, are to comply with the following **(1)** through **(4)**:

(1) Reliability and maintainability

The reliability and maintainability of the computerized systems are not to be inferior to those of systems not relying upon computers.

(2) Requirements for Computers

(a) The composition of computers is to be so planned that the extent of any damage due to a failure in any part of a circuit or component is kept to a minimum as far as possible.

(b) Each component is to be protected against any fear of overvoltage (electronic noise) which may intrude from input or output terminals.

(c) Central processing units and important peripheral devices are to have self-monitoring functions.

(d) Important programs and data are to be ensured against loss in cases where an external electrical power supply may be temporarily interrupted.

(e) Computers are to be set up so they can be quickly re-started following planned procedures within a short period of time after electrical power has been restored after a power failure.

(f) Spare parts for all important elements which require special techniques for repair work, are to be kept in ample supply for easy replacement.

(g) Change-over to back-up means is to be able to be performed easily and soundly.

(3) Back-up means

(a) In cases where one computer simultaneously performs fuel control (governor control, electronic injection control, etc.) and remote control of main propulsion machinery in diesel or turbine ships, or output control (rotational speed control, load control, etc.) and remote control of main propulsion machinery in electric propulsion ships, one of the following systems is to be provided in case of a computer failure. However, where this requirement is impracticable, the systems are to comply with requirements deemed appropriate by the Society.

i) Stand-by computer

ii) Governor controlled back-up systems operated at the main control station

(b) 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.

(c) In cases where visual display units (VDU) are adopted as indicators for the alarm systems stipulated in this Chapter, at least two VDUs are to be installed or other arrangements, deemed appropriate by the Society, are to be considered.

(4) Components of computerized systems

The separation of computerized control systems and safety systems are to comply with the requirements in **14.2.4-1** and **14.2.6-1** respectively. However, in cases where these requirements are impracticable, those systems are to comply with requirements deemed appropriate by the Society.

3 The communication links for transferring data between separate terminals of those systems categorized as Categories II and III in **Table 7.14.1** are to comply with the following:

(1) In cases where the failure of a single component of the data communication link results in a loss of data communication, means are to be provided for the automatic restoration of the link.
(2) In cases where a data communication link covers two or more systems from among those control systems, alarms systems and safety systems specified in this Chapter, the link including cables is to be installed in duplicate; unless there are alternate means of performing the same functions without the use of the link.
(3) The data communication link is to be self-checking and visual and audible alarms are to be activated when failures in the link are detected.
(4) System self-checking capabilities are to be arranged to initiate a transition to the least hazardous state for the complete installation in cases where failures of data communication have occurred.
(5) The characteristics of the data communication links are to be able to ensure the prevention of overloading and that at all necessary information is transmitted in an appropriate amount of time.

4 The wireless data communication links for transferring data between separate terminals of those systems categorized as Category II in **Table 7.14.1** are to comply with the following **(1)** to **(3)** in addition to **3** above. However, in cases where systems categorized as Category III in **Table 7.14.1** are used, such systems are to comply with requirements deemed appropriate by the Society.

(1) In cases where functions that are required to operate continuously in order to provide essential services dependant on wireless data communication links are used, an alternative means of control which can be brought in action within an acceptable period of time is to be provided.
(2) Wireless data communications are to be employed recognized international wireless communication system protocols that incorporate the following:
   (a) Fault prevention, detection, diagnosis, and correction in order to ensure message integrity (i.e., the received message is neither corrupted nor altered when compared to the transmitted message).
   (b) Configuration and device authentication which only permit the connection of devices included in the system design.
   (c) Massage encryption which is capable of protecting the contents of confidential and/or criticality data.
   (d) Security management which is capable of protecting the network and preventing unauthorized access.
(3) Wireless systems are to comply with the radio frequency and power level standards deemed appropriate by the Society.

5 In cases where system specifications are modified, the following items are to be complied with:

(1) Systems categorized as Categories II and III in **Table 7.14.1** are to be protected against any program modifications by end users.
(2) For systems categorized as Category III in **Table 7.14.1**, any modifications of parameters by manufacturers are to be approved by the Society.
(3) Any modifications made after shipment are to be documented and traceable.

14.3 Automatic and Remote Control of Main Propulsion Machinery or Controllable Pitch Propellers

14.3.1 General

The devices for remote or automatic control by which the main propulsion machinery or controllable pitch propellers are controlled are to comply with the requirements in this **14.3**.

14.3.2 Remote Control Devices for Main Propulsion Machinery or Controllable Pitch Propellers

1 General

Remote control devices for main propulsion machinery or controllable pitch propellers are to comply with the following requirements in **(1)** to **(6)**:

(1) Remote control devices for main propulsion machinery or controllable pitch propellers 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.
(2) Remote control devices for main propulsion machinery or controllable pitch propellers are to be provided for each propeller. In cases where multiple propellers are designed to operate simultaneously, they may be controlled by one control device.
(3) In cases where the speed of the diesel engines used as main propulsion machinery is controlled by governors, the

governors are to be adjusted so that main propulsion machinery may not exceed 103% of maximum continuous revolutions. These governors are to be capable of maintaining a safe minimum speed.

(4) In cases where a program control is adopted, programs for increasing and decreasing output is to be so designed that any undue mechanical stresses and thermal stresses does not occur in any parts of the machinery.

(5) In remote control stations or monitoring stations and at the manoeuvring platform for main propulsion machinery or controllable pitch propellers, 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.

(6) In remote control stations for main propulsion machinery or controllable pitch propellers, alarm devices necessary for the control of main propulsion machinery or controllable pitch propellers are to be provided.

2 Transfer of control

Remote control devices for main propulsion machinery or controllable pitch propellers are to comply with the following requirements with respect to transfer of control:

(1) Each control station for main propulsion machinery or controllable pitch propellers is to be provided with means to indicate which of them is in control.

(2) Remote control of main propulsion machinery or controllable pitch propellers is to be only possible from one location at a time.

(3) Transfer of control is to be only possible with orders from the serving station and acknowledgement by the receiving station except for the following cases:

(a) Transfer of control between a local control station for main propulsion machinery or controllable pitch propellers and the main control station or sub-control station; and

(b) Transfer of control during a stoppage condition of the main propulsion machinery.

(4) In cases where the main propulsion machinery or controllable pitch propellers is controlled from the navigation bridge or the main control station on bridge, the transfer of control is to be possible from a local control station for main propulsion machinery or controllable pitch propellers to the main control station or the sub-control station even if no order of the transfer of control from the navigation bridge or the main control station on bridge has been given.

(5) Means are to be provided to prevent the propelling thrust from being significantly altered when control is transferred from one location to another, except for when the transfer of control is as described in **(3)(a)** or **(4)**.

3 Failure of remote control systems of main propulsion machinery or controllable pitch propellers

The following requirements in **(1)** to **(5)** are to be complied with in case of a failure of any of the remote control devices for main propulsion machinery or controllable pitch propellers:

(1) In remote control stations for main propulsion machinery or controllable pitch propellers, alarm devices which operate in the event of a failure of any of the remote control devices for main propulsion machinery or controllable pitch propellers are to be provided.

(2) In the event of a failure of any remote control devices for main propulsion machinery or controllable pitch propellers, the main propulsion machinery or the controllable pitch propellers are to be able to be locally controlled. It is also to be possible to control any of the auxiliary machinery, essential for the propulsion and safety of the ship, at or near the machinery concerned.

(3) In the event of a failure of any of the remote control devices for main propulsion machinery or controllable pitch propellers, the preset speed and direction of the propeller thrust are to be maintained until the control is in operation at the main control station, the sub-control station or the local control station for the main propulsion machinery or controllable pitch propellers, unless this is considered impracticable by the Society.

(4) In the event of a failure of any of the remote control devices for main propulsion machinery or controllable pitch propellers, transfer of control to the main control station, the sub-control station or the local control station for the main propulsion machinery or controllable pitch propellers is to be possible by a simple operation.

(5) Remote control stations for main propulsion machinery or controllable pitch propellers are to be provided with independent emergency stopping devices for the main propulsion machinery, which are effective in the event of a failure of any of the remote control devices for the main propulsion machinery or the controllable pitch propellers.

4 Remote starting of main propulsion machinery in diesel ships

Starting by means of remote control devices for main propulsion machinery is to comply with the following:

(1) The number of times of starting main propulsion machinery is to satisfy the number specified in **2.5.3**.
(2) Remote control devices for main propulsion machinery 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 a failure of starting, a visual and audible alarm is to be issued at the relevant control station as well as the main control station on bridge, the main control station or monitoring stations (in cases where a main control station on the bridge and a main control station are not provided) for the main propulsion machinery or the controllable pitch propellers.
(3) In cases where compressed air is used for starting the main propulsion machinery, alarm devices to indicate any low starting air pressure are to be provided at the remote control station and the monitoring station for the main propulsion machinery.
(4) The low starting air pressure mentioned in **(3)** for the operation of alarm devices is to be set at a level to permit further main propulsion machinery starting operations.

14.3.3 Bridge Control Devices

Bridge control devices are to comply with the following **(1)** through **(4)** as well as requirements in **14.3.2**.
(1) Even in cases where main propulsion machinery or controllable pitch propellers is controlled from the navigation bridge or the main control station on the bridge, telegraphed orders from the navigation bridge or the main control station on the bridge are to be indicated in the main or sub-control stations respectively and at any manoeuvring platforms which are capable of controlling main propulsion machinery or controllable pitch propellers.
  (a) Sub-control stations or local control stations for main propulsion machinery or controllable pitch propellers for ships provided with a main control station on bridge; or
  (b) Main control stations for ships not provided with main control station on bridge.
(2) Bridge control devices are to be provided with either one of the following devices in order to prevent any prolonged running of main propulsion machinery in its critical speed range:
  (a) Devices to make main propulsion machinery pass automatically and rapidly through its critical speed range:
  (b) Alarm devices which operate in cases where the main propulsion machinery that is operating exceeds a predetermined period in its critical speed range.
(3) Bridge control devices are to be provided with visual and audible alarms which give the officer in charge of the navigational watch enough time to assess navigational circumstances in an emergency before the safety systems of main propulsion machinery specified in **14.1.2(10)(b)** or **(c)** go into effect.
(4) Bridge control devices are to be provided with an override arrangement specified in **14.2.6-3** for the following safety systems of main propulsion machinery:
  (a) Systems which perform as specified in **14.1.2(10)(b)**
  (b) Systems which perform as specified in **14.1.2(10)(c)** (except in cases where the total failure of main propulsion machinery will occur within a short period of time)

14.3.4 Safety Measures

1 Safety measures for main propulsion machinery or controllable pitch propellers

Safety measures for main propulsion machinery or controllable pitch propellers are to comply with the following requirements in **(1)** to **(3)**:
(1) The following safety measures are to be taken regarding remote control devices for main propulsion machinery or controllable pitch propellers:
  (a) Necessary interlocking devices are to be provided to prevent any serious damage due to operational error.
  (b) In cases where any auxiliary machinery essential for the main propulsion of the ship are driven by electric motors, the main propulsion machinery is to be so designed as to automatically stop in the event of a failure of the main source of electrical power or it is to be capable of being stopped.
  (c) Main propulsion machinery is to be so arranged as to not restart automatically when electrical power is restored after a failure of the main source of electrical power whereas the main propulsion machinery was stopped.
  (d) Remote control devices for main propulsion machinery or controllable pitch propellers are to be so designed that the engine may not be abnormally overloaded in the event of any failure of them.
(2) Stopping devices for main propulsion machinery are to be provided at monitoring stations for main propulsion

machinery or controllable pitch propellers.

(3) With respect to safety measures for main propulsion machinery driven by diesel engines, the requirements specified in **2.4.5-1** are to be applied.

2 Safety systems of main propulsion machinery

Safety systems of main propulsion machinery are to comply with the following requirements in **(1)** and **(2)**:

(1) Devices to shut off the fuel or steam supply (this device hereinafter being referred to as a “safety device”) for main propulsion machinery are not to be automatically activated except in cases which could lead to complete breakdown, serious damage or explosion.

(2) Safety systems for the main propulsion machinery are to be so designed as to not lose their function or fail-safe capability, even in the event of a failure of their main electrical source or their air source.

3 Self-reversing diesel engines

Remote control devices for self-reversing diesel engines are to be at least provided with the following safety measures:

(1) Starting operations are to be only possible when the camshaft is definitely at the position of “Ahead” or “Astern”.

(2) Fuel is not to be injected during reversing operations.

(3) Reversing operations are to be conducted after the “Ahead” revolution is reduced to a predetermined value.

4 Main propulsion machinery of multi-engines coupled to a single shaft ship.

Remote control devices for multi-engines coupled to a single shaft are to be at least provided with the following safety measures:

(1) Each main propulsion machinery is to be provided with overload preventive devices.

(2) Each main propulsion machinery is not to be subjected to abnormally unbalanced loads.

5 Main propulsion machinery with clutches

Remote control devices for engines with clutches are to be at least provided with the following safety measures:

(1) Clutches equipped to main propulsion machinery in multi-engines coupled to single shafts are to be disengaged when the main propulsion machinery is stopped in an emergency. While multi-engines are operating in different directions of rotation, their clutches are not to be engaged simultaneously.

(2) Engaging and disengaging of clutches are to be carried out below a predetermined number of revolutions of the main propulsion machinery.

(3) Overspeed protective devices specified in **2.4.1-2** are to be provided.

(4) In cases where there is fear that the speed of a propulsion motor would exceed 125% of the rated revolutions when the clutch is disengaged, overspeed protective devices, deemed appropriate by the Society, are to be provided.

6 Main propulsion machinery driving controllable pitch propellers

Remote control devices for engines driving controllable pitch propellers are to be at least provided with the following safety measures:

(1) Overload preventive devices are to be provided.

(2) Starting of engines or engaging of clutches is to be performed while the propeller blades are in a neutral position.

(3) Overspeed protective devices as specified in **2.4.1-2**, are to be provided.

(4) In cases where there is fear that the speed of the propulsion motor would exceed 125% of the rated revolutions when the propeller pitch is altered, overspeed protective devices, deemed appropriate by the Society, are to be provided.

14.4 Automatic and Remote Control of Boilers

14.4.1 General

1 Automatic control systems for both combustion and feed water of oil-fired boilers are to comply with the requirements in **14.4.2** to **14.4.5** respectively.

2 Automatic control systems for either combustion or feed water of oil-fired boilers are to comply with the relevant requirements in **14.4.2** or **14.4.3** as well as the requirements in **14.4.4** and **14.4.5**.

3 Automatic control of boilers other than oil-fired boilers or those having special features is to be deemed appropriate by the Society.

4 In cases where boilers are remotely controlled, control devices and monitoring devices necessary for the operation of such boilers are to be provided at all relevant control stations.

5 Remote water level indicators are to comply with the requirements in **9.9.8, Part D of the Rules for the Survey and Construction of Steel Ships**.

14.4.2 Automatic Combustion Control Systems

1 General

Automatic combustion control systems are to comply with the following requirements in **(1)** to **(3)**:

(1) Automatic combustion control systems are to be able to obtain planned steam amount, steam pressure and steam temperature as well as be able to secure stable combustion.

(2) Devices to control the fuel supply to adjust according to the load imposed and are to be capable of ensuring stable combustion in the controllable range of fuel supply.

(3) In cases 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 a planned sequence:

(1) Before ignition of the pilot burner or before ignition of the main burner if a pilot burner is not fitted, the combustion chamber and the flue are to be prepurged by air of not less than 4 *times* the volume of the combustion chamber and the flue up to the boiler uptake. For small boilers with only one burner, a prepurge for not less than 30 *seconds* will be accepted.

(2) In the case of direct ignition, a method of ignition in which the main burner is fired by ignition spark, the opening of the fuel valve is not to precede the ignition spark.

(3) In the case of indirect ignition, a method of ignition in which the main burner is fired by a pilot burner, the opening of the fuel valve for the pilot burner (hereinafter referred to as “ignition fuel valve” in this part) is not to precede the ignition spark, and the opening of the fuel valve for the main burner (hereinafter referred to as “main fuel valve” in this part) is not to precede the opening of the ignition fuel valve.

(4) Firing is to definitely be carried out within the planned period. If the firing of the main burner has failed, main fuel valves are to be so designed as to close after being opened within 10 *seconds* in the case of direct ignition and 15 *seconds* in the case of indirect ignition.

(5) Firing on the main burners is to be carried out at their low firing position.

(6) After closure of the main fuel valve, post-purge is to be carried out for not less than 20 *seconds* to ensure an adequate supply of air to completely burn off all remaining fuel oil between the fuel oil valve and the burner nozzle. Auxiliary boilers need not to be comply with this requirement in cases where deemed appropriate by the Society.

3 Combustion control devices for controlling the number of firing burners

The combustion control devices for controlling the number of firing burners are to comply with the following requirements:

(1) Each burner is to be fired and extinguished according to a planned sequence. However, the base burner may be fired by manual operation and other burners may be fired by a flame from burner(s) already lit.

(2) Any remaining fuel in extinguished burners is to be automatically burnt up in order not to interfere with any restarting of the burner. However, while the pilot burner is not ignited, any remaining fuel in the base burner is not to be removed by steam or air when it is in place.

(3) The burners for main boilers are to be capable of being fired and extinguished from main control stations or the main control station on the bridge, except for the firing of base burner.

4 Other combustion control devices

Other combustion control devices are to be deemed appropriate by the Society. They are also to comply with the relevant requirements in **-2** and **-3**.

14.4.3 Automatic Feed Water Control Devices

Automatic feed water control devices are to be capable of automatically controlling the feed water in order to maintain a water level in the boilers within a predetermined range.

14.4.4 Safety Measures

1 Safety devices

Safety devices are to comply with the requirements in **9.9.10-1, Part D of the Rules for the Survey and Construction of Steel Ships**.

2 Heating of fuel oil

In cases where heated fuel oil is used, an automatic temperature control device is to be provided for the heater; and, the boiler is to be provided with a device to automatically shut off the fuel supply to the burners or an alarm device which operates when the temperature of fuel oil falls below a predetermined value.

14.4.5 Alarms

Alarm devices are to comply with the requirements in **9.9.10-2, Part D of the Rules for the Survey and Construction of Steel Ships**.

14.5 Automatic and Remote Control of Electric Generating Sets

14.5.1 General

1 Electric generating sets arranged to be automatically or remotely started are to be provided with interlocking devices necessary for safe operation.

2 Electric generating sets (other than those used as emergency sources of electrical power) arranged to be automatically started are to be so designed that the number of automatic consecutive attempts which fail to produce a start is limited to two times; and, they are to be provided with an alarm device which operates at times of starting failure.

3 In cases where diesel engines used to drive propulsion generators are remotely started, the number of starts is to conform to the required number specified in **2.5.3**.

4 In cases where the automatic starting of stand-by generating sets with automatic connections to switchboard busbars is provided, automatic closure on to the busbars is to be limited to one attempt in the event of any original power failure being caused by a short circuit.

5 Automatic control and remote control systems for electric generating sets, whose generators are driven by the main propulsion machinery; which supplies electrical power to electrical installations relating to the services specified in **3.1.2(1), Part 8**; and, which is operated while the main propulsion machinery is being controlled by bridge control devices, are to comply with the requirements in **3.2.1, Part 8**, in addition to those in this **14.5**.

6 With respect to safety measures for electric generating set driven by diesel engines, the requirements specified in **2.4.5-1** are to be applied.

14.6 Automatic and Remote Control of Auxiliary Machinery

14.6.1 Automatic Operation of Air Compressors

In cases where air compressors for starting and air compressors for controlling are automatically operated, alarm devices are to be provided to indicate any pressure drop in air reservoirs.

14.6.2 Automatic Starting and Stopping of Bilge Pumping Arrangements

In cases where bilge pumps are capable of being started and stopped automatically, alarm devices are to be provided to indicate any high level of bilge in relevant bilge wells and the running of pumps for a long time.

14.6.3 Thermal Oil Installations

Thermal oil installations arranged to be automatically controlled are to comply with the following:

(1) Control devices

Control devices are to comply with **14.4.2-1** and **-2**, also with **7.3.2-1** and **-2**.

(2) Safety devices

Safety devices are to comply with **7.3.1** and **7.3.2-5**.

(3) 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 **(2)** have operated.

(b) When the temperature of the fuel at the inlet of burner has fallen.

14.6.4 High Temperature Alarm for Oil Heaters

In cases where the temperature for fuel oil and lubricating oil is automatically controlled, high temperature alarm devices are to be provided, except in cases where oils are not heated above their flashpoints.

14.6.5 Opening and Closing Devices for River Water Valves

In cases where river water valves to be fitted on the shell plating below the designed maximum load line are remotely or automatically controlled, other opening and closing devices which can be easily operated even in the event of failure of such automatic or remote control devices are to be provided.

14.6.6 Liquid Level Alarm Systems for Fuel Oil Tanks

In cases where fuel transfer to fuel oil tanks is automatically controlled, the receiving tanks are to be provided with high and low level alarms.

14.6.7 Mooring Arrangements

In cases where mooring arrangements are provided with remote control devices, these mooring arrangements are to be capable of being locally operated.

14.6.8 Fuel Oil Filling Arrangements

In cases where arrangements for filling fuel oil into their respective fuel oil tanks from 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 the filling of fuel, even in the event of failure of any of the remote control devices.

14.6.9 Diesel Engines

With respect to the safety measures for auxiliary machinery driven by diesel engines, the requirements specified in **2.4.5-1** are to be applied.

14.7 Tests

14.7.1 Shop Tests

After being constructed, automatic or remote control systems of machinery and equipment, considered necessary by the Society, are to be subjected to the following tests:

(1) Environmental tests

Devices, units and sensors (hereinafter referred to as “automatic devices” in this Part) and automatic equipment composed of automatic devices are to be subject to the following tests at the manufacturing site. The procedures for these tests are to be deemed appropriate by the Society.

- (a) External examination
- (b) Operation test and performance test
- (c) Electrical power supply failure test (to be applied to electrical/electronic devices, etc.)
- (d) Electrical power supply fluctuation test (to be applied to electrical/electronic devices, etc.)
- (e) Power supply fluctuation test (to be applied to hydraulic/pneumatic devices, etc.)
- (f) Insulation resistance test (to be applied to electrical/electronic devices, etc.)
- (g) High voltage test (to be applied to electrical/electronic devices, etc.)
- (h) Pressure test (to be applied to hydraulic/pneumatic devices, etc.)
- (i) Dry heat test
- (j) Damp heat test
- (k) Vibration test
- (l) Inclination test (to be applied to equipment with moving parts)
- (m) Cold test
- (n) Salt mist test (to be applied to devices installed in unenclosed spaces such as open decks)
- (o) Electrostatic discharge immunity test (to be applied to electronic devices)
- (p) Radiated radio frequency immunity test (to be applied to electronic devices)
- (q) Conducted low frequency immunity test (to be applied to electronic devices)

(r) Conducted high frequency immunity test (to be applied to electronic devices)
(s) Burst/Fast transient immunity test (to be applied to electronic devices)
(t) Surge immunity test (to be applied to electronic devices)
(u) Radiated emission test (to be applied to electronic devices that emit the electromagnetic wave)
(v) Conducted emission test (to be applied to electronic devices that emit the electromagnetic wave)
(w) Flame retardant test (to be applied to flammable enclosures of equipment)
(x) Other tests considered necessary by the Society

(2) Completion tests of automatic equipment

All automatic devices which have passed the environmental tests specified in **(1)** are to be subjected to the following tests after completion of their assembly as automatic equipment. The procedures of these tests are to comply with the requirements deemed appropriate by the Society.

(a) External examination
(b) Operation tests and performance tests
(c) Insulation resistance tests and high voltage tests (to be applied to electric/electronic devices etc.)
(d) Pressure tests (to be applied to hydraulic/pneumatic devices etc.)
(e) Confirmation of the effective implementation of quality control of software and documentation of software modification history.
(f) Other tests deemed necessary by the Society.

14.7.2 Approval of Use

1 In cases where automatic devices and automatic equipment have passed the environmental tests specified in **14.7.1**, they will receive approval of use from the Society; and, upon request from the manufacturer, the Society will make this information public.

2 With respect to all automatic devices and automatic equipment which have already received approval of use from the Society, a part or all of the environmental test specified in **14.7.1(1)** may be omitted.

14.7.3 Tests after Installation on Board

After being installed onboard, the automatic or remote control systems of machinery and equipment are to be confirmed that they operate effectively, under practical conditions as far as possible. However, parts of these tests may be carried out during river trials.

Chapter 15 BARGES

15.1 General

15.1.1 Scope

The requirements of this chapter apply to machinery installed on barges.

15.1.2 Drawings and Data

In general, drawings and data to be submitted for approval are as follows:

(1) The drawings specified in **2.1.2**, **3.1.2**, **7.1.3**, **7.4.2**, **8.1.4** and **11.1.2**, as applicable

(2) For tank barges, the following drawings:

  (a) Piping diagrams of cargo oil pipes and their associated instrumentation.

  (b) Control system diagrams (including safety and alarm systems) of integrated cargo and ballast systems driven by electrohydraulic power.

(3) Other drawings and data deemed necessary by the Society.

15.2 Internal Combustion Engines

15.2.1 General Construction

1 The frames and bedplates are to be of rigid and oil-tight construction and bedplates are to be fixed securely to the engine seatings.

2 Ventilation of crankcase and any arrangement which could produce a flow of external air within the crankcase, is forbidden except case of **(1)** and **(2)**.

(1) Where vent pipes are provided to crankcase: In this case, the diameters of these pipes are to be as small as practicable.

(2) Where a forced extraction of the gases from the crankcase is provided: In this case, the vacuum in the crankcase is not to exceed 25 *mm* of water column.

3 Crankcase and its doors are to have sufficient strength, and the doors are to be securely fastened, so that they will not be readily displaced by an explosion.

4 The fuel oil arrangements for internal combustion engines having a carburetor are to comply with the requirements in **15.4.5** and additionally, the requirements in **2.5.4**.

15.2.2 Safety Devices

1 Where risk from over-speeding of machinery exists, means are to be provided to ensure that the safe speed is not exceeded.

2 Engines having cylinder of large bore size are to be provided with a relief valve or warning device of overpressure in the cylinder, and also to be provided with crankcase explosive relief valve of an approved type.

15.2.3 Installation

1 Where the structures above engines and their surroundings are constructed with combustible materials, adequate measures are to be taken in protection against fire.

2 Engines located on the weather deck are to be provided with ventilated metal hoods or to be installed in well ventilated deckhouses of steel.

15.2.4 Exhaust Gas Pipe Arrangement

1 Exhaust gas pipes and silencers are to be water cooled or are to be effectively insulated.

2 Silencers are to be so arranged that they may be easily cleaned.

3 In principle, exhaust gas pipes of several engines are not to be connected together.

4 Exhaust gas pipe is to extend not less than 2.4 *m* above deck on barge intended to carry liquid cargo having a flash point 60°*C* or below and to be provided with a suitable spark arrestor.

15.3 Boilers and Pressure Vessels

15.3.1 General

Boilers prescribed in **7.1.1** and pressure vessels belonging to Group 1 or Group 2 prescribed in **8.1.3**, are generally to comply with the requirements in **Chapters 7** and **8**. Single system of fuel oil burning and feed water may be acceptable for boiler which is not used for the heating of special cargoes.

15.4 Auxiliaries and Piping Arrangement

15.4.1 Pressure Pipes and Pipe Connections

1 Pipes, flanges, valves and pipe fittings and their joints subject to internal pressure are to have an adequate strength conforming to the service conditions.

2 Sleeve threaded joints are generally not to be used for the joints of direct connection of pipe length and flange-pipe connections which pipings are used for fuel oil, lubricating oil or other inflammable oil systems.

15.4.2 Piping Arrangements

Piping arrangements are to comply with the requirements in **11.2**. However, slip-on joints complying with the requirements specified in **10.3.3** may be acceptable subject to the approval of the Society.

15.4.3 River Water Suction Valves and Overboard Discharge Valves

River water suction valves and overboard discharge valves are to be constructed and installed in accordance with the requirements in **11.3**.

15.4.4 Pneumatic System

1 Air reservoirs are to be provided with a sufficient drainage system.

2 Air compressors are to be provided with a relief valve to prevent the pressure from rising more than 10% above the maximum pressure in the cylinders.

3 In the case of water cooled air compressor, and where water jacket of compressors and coolers might be subjected to dangerous excessive pressure due to leakage into them from air pressure parts safety device for over-pressure is to be provided at their cooling space.

4 Where air reservoirs can be isolated from the relief valves prescribed in **-2** or air reservoirs are charged by hand air compressor only, they are to be provided with a pressure relief device to release the pressure automatically in the event of fire.

5 Starting air piping systems for internal combustion engines are to be provided with non-return valves or other equivalent devices.

15.4.5 Fuel Oil Systems and Lubricating Oil Systems

1 Arrangements for the storage, distribution and utilization of fuel oil and lubricating oil are to be such as to ensure the safety of the barge and persons on board.

2 Machinery spaces in which oil vapour is likely to accumulate, are to be adequately ventilated.

3 Fuel oil systems are to be so arranged that defects and leakage can readily be observed, and the spaces in which the systems are installed are to be adequately illuminated.

4 Materials used for pipes, valves and other fittings of fuel oil systems and lubricating oil systems are to be of the fire resisting metals.

5 Tanks used for the storage of the fuel oil or lubricating oil and oil strainers are not to be installed above hot parts.

6 Free-standing oil tanks are to be of steel and to be of rigid construction.

7 Provision is to be made to prevent overpressure in any part of the fuel oil system and lubricating oil system. Any relief valves are to be discharged to a safe position.

8 Coamings or other arrangements are to be provided at each oil tank, oil pump and oil strainer, and suitable means are to be provided for disposing of fuel oil drains.

9 The suction pipes from all tanks, except double bottom tanks, are to be provided with stop valves or cocks secured to the tank walls.

10 Valves, cocks or other fittings fitted on tanks are to be so located in safe positions as to protect them from the external damage.

11 Main suction valves of all fuel oil tanks except for double bottom tanks are to be capable of being closed from a remote position which will always be accessible. This requirement, however, may not be applied to tanks for which the Society specially approved considering the arrangement or the capacity of the tanks.

12 Fuel oil pipings are to be entirely separated from other pipings. Where, however, it is unavoidable to interconnect to any other pipings, effective means are to be provided to prevent the accidental contamination with other liquids while in operation.

13 Lubricating oil pipings are to be entirely separated from other pipings, unless specially approved by the Society.

14 As for the systems of fuel oil having a flash point below 60°*C*, they are to be as deemed appropriate by the Society.

15.4.6 Air, Overflow and Sounding Pipes

1 Air, overflow and sounding pipes are to comply with the requirements in **11.6**, **11.7** and **11.8** except the following requirements for the inside diameter of the air and overflow pipes and for the arrangements of overflow pipes.

2 Air pipes fitted to free-standing tanks are to have sufficient area for the capacity and service conditions of the tanks.

3 Overflow pipes are to be provided to settling tank and service tank for fuel oil which can be pumped up, or to other tanks having any openings below the open end of air pipes.

4 The overflow pipes are to have sufficient area for pump capacity to prevent overflow from other opening of the tanks while liquid is filled.

5 For unmanned barges, if it is recognized that the safety of the barge is not impaired, the air and sounding pipes may be dispensed with for particular compartment, irrespective of the provision in **-1**.

15.4.7 Bilge Systems

1 An efficient bilge pumping system is to be provided in all barges capable of pumping from and draining each watertight compartment when the barge is on an even keel and either upright or listed 5 *degrees*. If the Society is satisfied that the safety of the barge is not impaired, the bilge system may be dispensed with for particular compartment.

2 Where common bilge main connected with branch bilge suction from each compartment is provided, at least two independent power bilge pumps are to be provided. Each pump is to be connected to the bilge main, and is to be capable of discharging the bilge effectively even where the one pump gets out of order. These pumps may be substituted by bilge ejectors in combination with river water pump.

3 The power bilge pumps specified in **-2** are to have sufficient capacity approved by the Society. Area and length of the bilge suction pipes and the bilge main are to be such that the capability of the bilge pumps is not impaired.

4 Where any source of power is not available on board, such means as manual bilge pumps are to be provided to drain each watertight compartment.

5 Where centrifugal pumps are employed in bilge drainage, they are to be of the self-priming type.

6 The manual pumps prescribed in **-4** are to be located above the upper deck, or at the high convenient level which is easily accessible, and they are to be capable of operating effectively,

7 Special bilge systems are to be subjected to the approval of the Society.

8 Bilge suction pipes are to be entirely separated from pipes used for filling or emptying spaces carrying water ballast or oil.

9 Non-return valve or cock which does not permit the communication between bilge and ballast water tanks, fresh water tanks or fuel oil tanks is to be provided to bilge suction pipes connected to any pump having a river water or fuel oil suction in order to prevent the possibility of water or fuel oil passing into the watertight compartments from the river, fuel oil tanks or water tanks or bilge passing from one compartment to another through the bilge pipes.

10 Valves and cocks which are connected to bilge system are to be located at an easily accessible position.

11 Branch pipes of each bilge suction are to be led to strainers which are to be arranged for easy cleaning without disconnecting any joint of the pipe.

12 For barges which are intended to carry oil having a flash point 60°*C* or below as cargo, bilge in a pump room and compartments which are adjoining to cargo oil tanks is not to be led to compartments which do not adjoin to the cargo tanks. Further, bilge pipes in a cargo oil pump room and compartments which are adjoining to cargo oil tanks are to be entirely separated from the bilge pipes in other compartments not adjoining to the cargo tanks.

13 For unmanned barges, in general, portable pumps or other suitable drainage means are to be provided.

15.4.8 Scuppers

1 Scuppers sufficient in number and size to provide effective drainage are to be provided in the upper deck.

2 Scuppers draining weather decks are to be led over-board.

3 Scuppers from spaces below the upper deck or spaces within enclosed superstructures or enclosed deckhouses on the upper deck are to be led to the bilges. Alternatively, scuppers provided with valves may be led overboard, where the Society is satisfied that the pipes are provided with adequate protection to prevent from flooding into the board.

4 Scuppers 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 designed maximum load line are to be provided with a non-return valve at the shell plating. This valve, unless required by **-3**, may be omitted if the piping is of substantial thickness.

5 Scupper pipes passing through the shell plating below the upper deck are to be of steel or other approved materials. Valves and shell fittings for scuppers passing through the shell plating below the upper deck are to be of steel, bronze or other approved ductile materials.

15.5 Emergency Stopping Device

15.5.1 Emergency Stopping of Boiler Fans and Ventilators

Mechanical ventilating fans for machinery space or cargo space and boiler fans are to be capable of being stopped from an easily accessible position outside the machinery space, as well as from another position.

15.5.2 Emergency Stopping of Fuel Oil Pumps

Fuel oil pumps except those having small capacity are to be capable of being stopped from an easily accessible position outside the machinery space, as well as from another position.

15.6 Tank Barges

15.6.1 General

Machinery of barges intended to carry crude oil or petroleum products having absolute vapour pressure less than 0.28 *MPa* at 38°*C*, or other similar liquid cargoes in bulk are to comply with the requirements in **15.6**.

15.6.2 Cargo Oil Pumps

1 In cases where prime movers, other than steam engines or hydraulic motors, for driving cargo oil pumps are installed in cargo oil pump rooms, information regarding the construction of these prime movers and their driving systems are to be submitted for Society approval.

2 In cases where deep well pumps, submerged pumps, etc. are installed, information regarding the construction of these pumps and their driving systems are to be submitted for Society approval.

3 In general, cargo oil pumps are not to be used for purposes other than the transferring of cargo oil or ballast in cargo oil tanks, the transferring of tank cleaning water for cargo oil tanks, or the discharge of ballast as specified in **15.6.14-2**.

15.6.3 Arrangement of Cargo Oil Piping Systems

1 Cargo oil pipes are classified as Group III pipes, except in cases where considered necessary by the Society.

2 Cargo oil tanks are to be provided with cargo oil suction pipes arranged so that cargo unloading can be carried out in cases where one of the cargo oil pumps is out of use.

3 Cargo oil pipes are to be arranged so as to be capable of loading cargo oil to cargo oil tanks without passing through cargo oil pumps.

In cases where loading pipes are led directly into tanks from above deck, the opening ends of these pipes are to be led into the lower parts of tanks as far as practicable in order to prevent any accidents caused by static electricity.

4 In cases where river water suction pipes for ballast purposes are connected to cargo oil pipes, stop valves are to be provided between river water suction valves and cargo piping.

5 Slip-on joints used in cargo oil pipes are to comply with the requirements specified in **10.3.3**.

6 River water suction pipes and the discharge pipes for permanent ballast tanks are not to be connected to river water suction pipes and the discharge pipes for cargo oil tanks.

7 All cargo oil tanks and cargo piping systems are to be electrically bonded to hull structures by suitable methods such as metal-to-metal contact using welding or bolts, or bonding straps, etc.

8 The bonding straps specified in **-7** above are to comply with the following requirements in **(1)** to **(3)**:

(1) Clearly visible so that any shortcomings can be clearly detected;

(2) Designed and sited so that they are protected against mechanical damage and that they are not affected by high resistivity contamination (*e.g.*, corrosive products or paint); and

(3) Easy to install and replace.

15.6.4 Alternative Use of Tanks

In cases where cargo oil tanks are designed so that they can also be used as ballast tanks or fuel oil tanks, such tanks are to be provided with any devices required by the Society, and approved drawings or documents including detailed operating manuals for these alternative uses are to be provided on board the ship.

15.6.5 Separation of Cargo Oil Pumps and Cargo Oil Pipes

1 Cargo oil pipes are to be completely separated from other pipes, except in cases where permitted in **15.6.3**, **15.6.13** and **15.6.14**.

2 Cargo oil pipes are not to be led through fuel oil tanks, engine rooms, accommodation spaces and any spaces in cases where sources of vapour ignition are normally present. In addition, these pipes are not to be led to spaces forward of collision bulkheads or aft of the front bulkheads of engine rooms.

3 Cargo oil pipes on weather decks are to be arranged sufficiently apart from any accommodation spaces.

4 In cases where ships are equipped for bow and/or stern loading and the discharge of cargo oil outside cargo areas, the connections of all cargo lines leading to cargo hose connections therein are to be welded joints except in the case of valve connections and cargo lines are to be clearly identified and segregated by the following means of **(1)** or **(2)** situated in cargo areas. Open ends of cargo lines are to be provided with blank flanges at their bow and/or stern end connections.

(1) Two valves which can be secured in closed positions and provided that the efficiency of the segregation can be checked

(2) One valve together with another closing appliance providing equivalent standards of segregation such as removable spool pieces or spectacle flanges

5 Cargo oil pipes and similar pipes to cargo oil tanks are not to pass through ballast tanks. However, these pipes may pass through ballast tanks provided that the sections of these pipes in ballast tanks are short in length and the connections of these pipes are of welded joints or flanged joints which have no risk of leakage.

6 In the case of tank barges other than double hull tank barges, cargo oil pipes may pass through 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.

15.6.6 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 bulkheads as practicable.

2 In cases where those valves prescribed in **-1** above are located inside pump rooms, they are to be made of steel and to be capable of being closed at the positions of valves and from readily accessible positions outside compartments in which they are located. However, in the case of valves, operated at positions above decks, which are fitted on cargo oil branch pipes, any valves located inside pump rooms may be of cast iron without remote control devices.

3 In cases where those valves prescribed in **-1** above are located inside tanks, they may be made of cast iron and need not be capable of being closed at the positions of valves. However, they are to be provided with remote control devices, and another valve is to be provided in pump rooms.

4 In cases where the valves are required to be remotely controlled according to those requirements given in **-2** and **-3** above, means are to be provided to show whether they are open or closed.

15.6.7 Valve Operation Rod penetrating through Decks

Stuffing boxes are to be provided at positions in which operating rods from cargo valves pass through gastight or oiltight decks.

15.6.8 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, or to have any connections to these spaces.

2 Pipes used for the remote control of cargo oil piping systems as well as 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 Society approval.

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 cargo oil tanks provided that the sections of these pipes in cargo oil tanks are short in length and the connections of these pipes are of welded joints or flanged joints which have no risk of leakage.

5 In the case of tank barges other than double hull barges, ballast pipes of ballast tanks adjacent to 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.

15.6.9 Sounding Devices of Cargo Oil Tanks

Suitable sounding devices approved by the Society are to be fitted onto all cargo oil tanks. These sounding devices are to be designed or arranged to prevent any outflow of flammable vapours into spaces such as engine rooms, accommodation spaces, etc. in cases where sources of vapour ignition are normally present.

15.6.10 Steam Pipes

1 Cargo oil heating steam supply and return pipes are not to penetrate cargo oil tank plating, other than at the tops of tanks, and main supply pipes are to be run above weather decks.

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 In order to detect any contaminated oil in steam drainage, cargo oil heating steam return pipes are to be led to observation tanks; or, other oil detectors installed in positions as far apart as possible from any hot surfaces such as boilers and ignition sources.

4 Steam temperatures in cargo areas are not to exceed 220*°C*.

5 In cargo oil pump rooms, drain pipes from steam or exhaust pipes or from the steam cylinders of pumps are to terminate well above bilge wells.

6 Branch connections of cleaning steam pipes of cargo oil tanks or other tanks to which cargo oil pipes are led are to be provided with screw-down non-return valves or two stop valves.

15.6.11 Thermal Oil Pipes

1 Thermal oil piping arrangements for cargo oil tanks are to comply with following requirements:

(1) All joints in cargo oil tanks are to be welded joints.

(2) Isolating shut-off valves or cocks are to be provided at the inlet and outlet connections to cargo oil tanks. In cases where thermal oil pipes penetrate oiltight bulkheads between cargo oil tanks and pump rooms, such shut-off valves or cocks may be installed as close to the bulkhead as practicable.

(3) Systems are to be arranged so that the pressure in coils is at least 3 *m* water head above the static heads of cargo in cases where circulating pumps are not operating.

(4) In the case of ships carrying oils having flashpoints below 60*°C*, the requirements given in **13.11.4, Part D of the Rules for the Survey and Construction of Steel Ships** are also to be applied.

2 Thermal oil temperatures in cargo areas are not to exceed 220*°C*.

15.6.12 Integrated Cargo and Ballast Systems Driven by Electrohydraulic Power

Emergency stopping devices and control systems of integrated cargo and ballast systems driven by electrohydraulic power (hereinafter referred to as “integrated systems”) are to comply with the following requirements in **(1)** to **(4)**:

(1) Emergency stopping devices of integrated systems are to be independent from control systems. The failure of a single emergency stopping device or control system is not to render the integrated system inoperative.

(2) Manual emergency stops of the cargo pumps are to be arranged in a way that they are not to cause the stop of the

hydraulic power source.

(3) Emergency stopping devices and control systems are to be provided with a backup power supply, which may be satisfied by a duplicate power supply from the main switch board. The failure of any power supply is to provide audible and visible alarms at each location where a control panel is fitted.

(4) Manual overriding or redundant arrangements are to be provided within any control systems made available for the operation of the integrated system in the event of the failure of any automatic or remote control system.

15.6.13 Bilge Piping Systems, etc. for Cargo Oil Pump Rooms and Cofferdams adjacent to Cargo Oil Tanks

Sounding pipes of cofferdams adjacent to cargo oil tanks are not to be less than 38 *mm* in internal diameter and, unless otherwise approved by the Society, they are to be led to above the weather deck.

15.6.14 Ballast Tanks adjacent to Cargo Oil Tanks

1 The requirements given in **15.6.14** are also applied to ballast tanks used as cofferdams at the fore and aft ends of cargo oil tanks in accordance with the requirements given in **3.5.2-3, Part 9**. However, other requirements will be applied, if the fore ends of these ballast tanks are located forward of the collision bulkhead.

2 Dangerous ballast pipes (*See*, Note 1 of **Table 7.10.6(1)**, in this Part), such as those ballast pipes of ballast tanks adjacent to cargo oil tanks, 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 de-ballasting these tanks is, generally, to be provided in the pump room. However, where specially approved by the Society, these cargo pumps may be used for the purpose of only de-ballasting in an emergency.

3 Slip joints used in the ballast pipes of ballast tanks adjacent to cargo oil tanks are to comply with the requirements specified in **10.3.3**.

4 Air pipes to ballast tanks adjacent to cargo oil tanks are to be provided with easily renewable wire gauze to prevent any passage of flame at their outlets. In cases where approved by the Society, the requirements given in **11.6.3** for the dimensions of air pipes will be properly modified.

5 Sounding pipes of ballast tanks adjacent to cargo oil tanks are to be led to above weather decks, unless otherwise approved by the Society.

15.6.15 Fuel Oil Tanks adjacent to Cargo Oil Tanks

Sounding pipes of fuel oil tanks adjacent to cargo oil tanks are to be led to above the weather deck, unless otherwise approved by the Society.

15.6.16 Pump Arrangements of Forward Compartments

Pumps used for bilge drainage or transfer of ballast water or fuel oil in compartments forward of cargo oil tanks are to be exclusive and, unless otherwise approved by the Society, to be installed in the forward parts of ships. However, in cases where approved by the Society, other suitable pumps than those specified above may be used for bilge drainage or the transfer of ballast water in compartments forward of the cargo oil tanks.

15.6.17 Barges only carrying Oils having Flashpoints above 60°*C*

In the case of ships only carrying oils having flashpoints above 60°*C*, the requirements given in **15.1.2** and **15.6.2** to **15.6.16** will be partially modified in accordance with the following **(1)** to **(3)**:

(1) The requirements given in **15.1.2** and **15.6.2** to **15.6.10** may be properly modified.

(2) Ballast pipes of ballast tanks adjacent to cargo oil tanks may be led to engine rooms (*See* **15.6.14-2**). Wire gauze, to prevent the passage of any flame, required for the outlets of air pipes to cargo oil tanks may be omitted (*See* **15.6.14-4**). Sounding pipes of these tanks may be arranged to have openings below weather decks (*See* **15.6.14-5**).

(3) Sounding pipes of fuel oil tanks adjacent to cargo oil tanks may not be led to above weather decks (*See* **15.6.15**).

15.7 Tests

15.7.1 Tests at the Manufacturer's Work

1 Boilers and pressure vessels are to be tested in accordance with the requirements in **Chapters 7** and **8**.

2 Pipes, valves and other fittings used for compressed air piping having a maximum working pressure exceeding

2*MPa* are to be tested with hydrostatic pressure of 1.5 *times* the maximum working pressure after completion of welding, bending or machining.

3 Valves, cocks fitted to the shell plating of the barge below the designed maximum load line are, after finished, to be tested with hydrostatic pressure of 0.5*MPa*.

4 Fuel oil tanks with their fittings which do not form a part of the hull construction are to be tested with a hydrostatic pressure corresponding to a head of water not less than 2.5 *m* above the top plates.

5 For tank barges, tests for piping systems are to be conducted in accordance with the requirements in **10.6**.

15.7.2 On Board Tests

1 Popping test and accumulation test for safety valve of boiler are to be carried out in accordance with the requirements in **9.9.3-14** and **-15, Part D of the Rules for the Survey and Construction of Steel Ships**.

2 Piping systems including pumps, strainers and heaters for fuel oil, lubricating oil, cargo oil and others used for inflammable oil are to be subjected to test, after installed on board, with hydrostatic pressure of 1.5 *times* the maximum working pressure. The pressure test of the piping connected to the pumps which have been subjected to hydrostatic test before assembled on board, may be omitted except for fuel oil piping systems, provided that the leakage tests are carried out at operating conditions.

3 Other piping systems together with fittings are, after installed on board, to be subjected to trial.

4 Important systems are, after installed on board, to be subjected to performance test synthetically.

5 Various safety devices prescribed in each Paragraph are, after installed on board, to be subjected to performance test.

6 For tank barges, the following tests are to be carried out in addition to those specified in **-1** through **-5** above.

(1) Cargo oil pipes, after the completion of their installation, are to be subjected to leak tests at pressures of 1.25 *times* or greater their design pressures.

(2) Heating pipes inside cargo oil tanks are to be subjected to leak tests at pressures of 1.5 *times* or greater their design pressures.

(3) After installation onboard, auxiliaries and piping systems are to be subjected to the following tests:

   (a) Function tests of cargo oil pumps.

   (b) Function tests of various systems concerning the safety measures specified in this Chapter.

15.7.3 Additional Tests

The Society may require, where considered necessary, other tests than those prescribed in this Chapter.

Part 8 ELECTRICAL INSTALLATIONS

Chapter 1 GENERAL

1.1 General

1.1.1 Scope

1 The requirements in this Part apply to the electrical equipment and wiring for ships (hereinafter referred to as “electrical installations”).

2 The requirements in **Chapter 1** through **Chapter 4** apply to tugs and pushers.

3 The requirements in **Chapter 1** and **Chapter 5** apply to barges.

1.1.2 Equivalency

Electrical installations which do not comply with the requirements of this Part may be accepted provided that they are deemed by the Society to be equivalent to those specified in this Part.

1.1.3 Electrical Installations with Novel Design Features

For those electrical installations manufactured or installed with novel design features, the Society may impose appropriate requirements of this Part to the extent that they are practically applicable as well as additional requirements made on design and test procedures other than those specified in this Part. The Society will accept such installations if they are proved to fit the intended service and are capable of maintaining ship propulsion and securing the safety of life and the ship to the satisfaction of the Society.

1.1.4 Modification of Requirements

1 For the electrical installations not exceeding either 50 *V* or 50 *kW* total generator capacity as well as electrical installations of ships other than those to which Society approval are given, the application of the requirements in this Part may partly be modified.

2 At the Owners request, some requirements in this Part may be modified appropriately by taking their navigating areas and operating mode into account provided that the Society considers such modifications acceptable.

1.1.5 Definitions

Terms used in this Part are defined as follows:

(1) “Selective tripping” are those arrangements such that only protective devices nearest to fault points are opened automatically in order to maintain power supplies to any remaining sound circuits, in the event of any faults in those circuit having protective devices connected in a series.

(2) “Normal operational and habitable conditions” are those conditions 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, etc. are in working order and functioning normally.

(3) “Emergency conditions” are those conditions under which any services needed for normal operational and habitable conditions are not in working order due to the failure of the main source of electrical power.

(4) “Main sources of electrical power” are those sources intended to supply electrical power to main switchboards for distribution to all services necessary for maintaining ships in normal operational and habitable conditions.

(5) “Main generating stations” are those spaces in which main sources of electrical power are situated.

(6) “Main switchboards” are those switchboards which are directly supplied by main sources of electrical power and are intended to distribute electrical energy to all ship services.

(7) “Semiconductor converters” are devices using semi conducting electronic elements to convert electric energy from one state to another. (*e.g.*, from *a.c.* to *d.c.*, *d.c.* to *a.c.*, *a.c.* to *a.c.* or *d.c.* to *d.c.*)

(8) “Hazardous areas” are those areas or the spaces where flammable or explosive substances are placed and where

it is likely that flammable or explosive gases or vapours will be given of by these substances.

(a) Zone 0: areas or spaces in which an explosive gas atmosphere is either continuously present or is present for long periods of time

(b) Zone 1: areas or spaces in which an explosive gas atmosphere is likely to occur under normal conditions

(c) Zone 2: areas or spaces in which an explosive gas atmosphere is likely to occur under abnormal conditions

(9) “Non-hazardous areas” are those areas or the spaces in which an explosive gas atmosphere is not expected to be present in quantities sufficient enough to require any special precautions be taken regarding the construction, installation and use of electrical apparatus.

(10) “Source of release” are those points or locations from which gases, vapours, mists or liquids may be released into the atmosphere so that an explosive gas atmosphere may be formed under normal operating conditions; for example, the seals of cargo pumps and cargo compressors, and the valves and flanges in cargo piping systems. Continuous fully welded parts are not considered as sources of release.

1.1.6 Drawings and Data

The drawings and data to be submitted are as follows. In cases where the Society deems it to be necessary, the submission of drawings and data other than those specified below may be requested.

1 Tugs and pushers

(1) Drawings:

(a) Sectional assembly of generators, motors and electromagnetic slip couplings for electric propulsion equipment including their complete ratings, main dimensions, main materials used and weights

(b) Key diagrams and explanations of electric propulsion controlgears

(c) Sectional assembly of generators (main and reserve) of 100 *kW* (or *kVA*) and over, including their complete ratings, main dimensions, main materials used and weights

(d) Arrangement plans (including specifications of main parts such as circuit breakers, fuses, instruments and cables) and circuit diagrams of main switchboards and emergency switchboards

(e) Plans of arrangement of electrical equipment and of cable installation

(f) Diagrams of wiring systems including normal working currents, rated currents, prospective short-circuit currents in circuits, line drop of voltages, type of cables, cable sizes, ratings and settings of circuit breakers, ratings of fuses and switches, and breaking capacities of circuit breakers and fuses

(g) Semiconductor converters for power for electric propulsion and for electric generators (including dimensions, electric equipment particulars, sectional assembly)

(2) Data:

(a) Explanations of electric propulsion systems

(b) Investigation tables of electrical power

2 Barges

(1) Drawings specified in **-1** above, as applicable

(2) Drawings indicating any hazardous areas and lists of any electrical equipment installed in such hazardous areas

1.1.7 Ambient Conditions

1 The ambient conditions given in **Table 8.1.1** and **Table 8.1.2** are to be applied, unless otherwise specified, to the design, selection and arrangement of electrical installations in order to ensure their proper operation.

2 All electrical equipment are to be designed sufficiently enough to withstand any vibrations that occur under normal conditions.

Table 8.1.1 Ambient Temperatures

Location, arrangement		Temperature (°*C*)	
		Ships which are not navigating tropical areas	Other ships
Air	In enclosed spaces	5 to 40	5 to 45
	In spaces subject to temperatures exceeding 45°*C* and below 0°*C*	According to design conditions	According to design conditions
	On open decks	-25 to 40	-25 to 45
Water	---	27	32

Table 8.1.2 Angles of Inclination

Installation Components	Athwartships[(1)]		Bow-and-stern[(1)]	
	Static inclination (List)	Dynamic inclination (Rolling)	Static inclination (Trim)	Dynamic inclination (Pitching)
Electrical installations excluding those items started below	15°	22.5°	5° [(2)]	7.5°
Switch gears (circuit breakers, etc.), electric appliances and electronic appliances	22.5°	22.5°	10°	10°

Notes:

1. Athwartships and bow-and-stern inclinations may simultaneously occur.
2. Where the length of the ship exceeds 100 *m*, the fore-and-aft static angle of inclination may be taken as follows:
   $\theta = 500/L$
   θ : The static angle of inclination (°)
   L : Length of the ship specified in **2.1.4, Part 1** (*m*)

1.2 Testing

1.2.1 Shop Tests

1 The electrical equipment specified below is to be tested in accordance with the respective requirements in this Part at the place of manufacture or at other locations having adequate apparatus for testing and inspections. However, tests for any equipment with small capacities as specified in **(4)** and **(5)** are to be conducted as deemed appropriate by the Society.

(1) Rotating machines for propulsion and their respective control equipment
(2) Main generators
(3) Main switchboards
(4) Motors for auxiliary machinery specified in **1.1.5-1(1)** to **1.1.5-1(3), Part 7** (hereinafter referred to as “motors for essential services” in this Part)
(5) Controlgears for those motors specified in **(4)** above
(6) Transformers for power and lighting of single phase 1 *kVA* or more and three phase 5 *kVA* or more. However, those transformers used only for special services such as those ones for Suez Canal Search Lights, etc. are to be excluded
(7) Power semiconductor converters of not less than 5 *kW* and their respective accessories that are used for supplying power to the electrical equipment specified in **(1)** to **(5)** above
(8) Other electrical equipment as deemed necessary by the Society

2 Any electrical equipment used for auxiliary machinery for specific use for those ships specified in **1.1.5-1(4)** and **1.1.5-1(5), Part 7** as well as those deemed necessary by the Society are to be tested in accordance with the respective requirements in this Part.

3 For those electrical equipment manufactured by mass production, test procedures suited to their production methods, notwithstanding the requirements given in **-1**, may be applied subject to Society approval.

4 Electrical equipment and cables shown in the following items **(1)** to **(4)** are to be subjected to type tests for each type of products.

(1) Circuit breakers

(2) Electromagnetic contactors

(3) Explosion-protected electrical equipment

(4) Cables for power, lighting and internal communications

5 Electrical equipment and cables having a certificate considered acceptable to the Society may be exempted partially or wholly from the tests and inspections.

1.2.2 Trials

After electrical equipment and cables have been installed on board ship, they are to be tested and inspected in accordance with the requirements given in **2.17**.

1.2.3 Additional Tests and Inspections

The Society may require, in cases where it deems necessary, tests and inspections other than those specified in this Part.

Chapter 2 ELECTRICAL INSTALLATIONS AND SYSTEM DESIGN

2.1 General

2.1.1 Scope

This chapter specifies the requirements for electrical equipment and cables and system design relating to electricity.

2.1.2 Voltage and Frequency

1 System voltages are not to exceed:

(1) 1,000*V* for generators, power equipment, and heating and cooking equipment connected to fixed wiring.

(2) 250*V* for lighting, heaters in cabins and public spaces, equipment other than those specified in **(1)** above.

(3) 15,000*V a.c.* and 1,500*V d.c.* for installations for electric propulsion.

2 A frequency of 60*Hz* is recognized as the standard for all alternating current systems.

3 Electrical equipment supplied from main switchboards is to be designed and manufactured so that it is capable of operating satisfactorily under the normally occurring voltage and frequency fluctuations. Unless otherwise specified, such electrical equipment is to operate satisfactorily under those fluctuations in voltage and frequency that are given in **Table 8.2.1**. Any special systems, *e.g.* electronic circuits, whose functions cannot operate satisfactorily, within the limits given in this table, are to be supplied by some suitable means, *i.e.* through some stabilized supply.

4 In cases where *a.c.* generators are driven at rated speeds, giving rated voltages and rated symmetrical loads, the Total Harmonic Distortion (THD) of distribution systems connected such generators is not to exceed values of 5%. However, in cases where specially approved by the Society, the Total Harmonic Distortion (THD) may exceed the requirement values.

Table 8.2.1 Voltage and Frequency Fluctuation

(a) Voltage and frequency fluctuations for *a.c.* distribution systems (Note 1)

Type of fluctuation	Fluctuation (Note 4)	
	Permanent	Transient
Voltage	+6%, -10%	± 20% (within 1.5 sec)
Frequency	± 5%	± 10% (within 5 sec)

(b) Voltage fluctuations for *d.c.* distribution systems (Note 2)

Type of fluctuation	Fluctuation (Note 4)
Voltage fluctuation (Permanent)	± 10%
Voltage cyclic fluctuation deviation	5%
Voltage ripple	10%

(c) Voltage fluctuations for battery systems

Systems	Fluctuation (Note 4)
Components connected to the battery during charging (Note 3)	+30%, -25%
Components not connected to the battery during charging	+20%, -25%

Note 1: *A.C*. distribution systems mean *a.c*. generator circuits and *a.c*. power circuits produced by inverters.

Note 2: *D.C*. distribution systems mean *d.c*. generator circuits and *d.c*. power circuits produced by converters.

Note 3: Different voltage fluctuations as determined by charging and discharging characteristics, including voltage ripples from the charging devices, may be considered.

Note 4: The numerical values given in the table, excluding those values for time, mean percentages of rated values.

2.1.3 Construction, Materials, Installations, etc.

1 Electric machinery parts which are required to possess strength are to be made of defect-free sound materials. Their proper fits and clearances are to be consistent with best maritime practices and experience.

2 All electrical equipment is to be constructed and installed so as not to cause injury when handled and touched in a normal manner.

3 Insulating materials and insulated windings are to be resistant to moisture, salty air and oil vapours.

4 Bolts, nuts, pins, screws, terminals, studs, springs and such other small parts are to be made of corrosion resistant material or to be suitably protected against corrosion.

5 All nuts and screws used in connection with current-carrying parts and working parts are to be effectively locked.

6 Electrical equipment is to be accessibly placed in well-ventilated and adequately lighted spaces where it is not likely to cause any bodily harm due to mechanical problems as well as suffer any damage caused by water, steam or oil. In cases where exposure to such risks is unavoidable, such equipment is to be so constructed so as to meet the specific conditions of the installation location.

7 No electrical installations are to be installed in spaces where explosive gases are liable to accumulate or in compartments assigned principally to accumulator batteries, in paint lockers, in acetylene stores or in similar spaces unless the following requirements **(1)** to **(4)** are satisfied:

(1) Electrical equipment essential for operational purposes

(2) Electrical equipment of a type which will not ignite the mixtures concerned

(3) Electrical equipment appropriate to the spaces concerned

(4) Electrical equipment which is appropriately certified for safe usage in dusts, vapours or gases likely to be encountered.

8 Electrical equipment and cables are to be placed at sufficiently safe distances from the magnetic compasses or are to be screened so that any interfering external magnetic fields do not exert negative affects, even when circuits are switched on and off.

9 Cables and apparatus for services required to be operable under fire conditions are to be arranged so that the loss of services in any one area due to localized fire is minimized.

10 Motors are to be provided with a terminal box.

2.1.4 Earthing

1 Non-current-carrying exposed metal parts of electrical equipment which are not intended to be live, but which are liable under fault conditions to become live are to be effectively earthed. However, the following cases are excluded:

(1) They are supplied at a voltage not exceeding 50*V d.c.* or 50*V a.c.* root mean square between conductors. However, auto-transformers are not to be used for the purpose of achieving this voltage.

(2) They are supplied at a voltage not exceeding 250*V* by safety isolating transformers which are supplying only one consuming device.

(3) They are constructed in accordance with the principle of double isolation.

2 Additional safety means are to be provided for portable electrical apparatus which are for use in confined or exceptionally damp spaces in cases where particular risks due to conductivity may exist.

3 In cases where earthing connections are necessary, earthing conductors are to be either of copper or other approved materials, and are to be properly protected against any damage as well as any erosion in cases where necessary. The size of these earthing conductors is to be deemed appropriate by the Society according to the cross sectional areas of current-carrying conductors and the installation of earthing lines.

2.1.5 Clearances and Creepage Distances

1 Clearances and creepage distances between live parts and between live parts and earthed metals (hereinafter in this Part referred to as “clearances and creepage distances”) are to be adequate for the working voltage with consideration given to the nature and service conditions of any insulating material.

2 Clearances and creepage distances inside the terminal boxes of rotating machines, switchboard busbars and control appliances are to comply with the relevant requirements given in this Part.

2.2 System Design (General)

2.2.1 Distribution Systems

The following **(1)** to **(5)** distribution systems are considered as a standard:

(1) Two-wire direct currents

(2) Three-wire direct currents (three-wire insulated systems or three-wire mid-wire earthed systems)

(3) Two-wire, single-phase alternating currents

(4) Three-wire, three-phase alternating currents

(5) Four-wire, three-phase alternating currents

2.2.2 Insulation Monitoring Systems

1 In cases where primary and secondary distribution systems with no connection to earth are used for power, heating or lighting, devices capable of continuously monitoring insulation levels to earth and of giving audible or visual indications of abnormally low insulation values are to be provided.

2 Notwithstanding the requirements given in **-1** above, insulation monitoring systems may be replaced with other earth indicating systems for ships.

2.2.3 Diversity Factor

1 Circuits supplying two or more final-subcircuits are to be rated in accordance with the total connected load subject. In cases where it has been recognized that no practical hindrances exists, such circuits can be rated in accordance to diversity factor.

2 The diversity factor specified in **-1** above may be applied to calculations of cross sectional areas of conductors and ratings of switchgears (including circuit breakers and switches) and fuses.

2.2.4 Motor Circuits

Separate final sub-circuits are to be provided, as a rule, for every motor for essential service and for every motor with a rating of 1kW or more.

2.2.5 Lighting Circuits

1 Final sub-circuits used for lighting circuits are to be supplied separately from those for heating and power except in cases where such sub-circuits are used for cabin fans and electrical appliances for domestic use.

2 The number of lighting points supplied by final sub-circuits of ratings 16A or less is not to exceed:

(1) 10 for those circuits up to 50V

(2) 14 for those circuits from 51V up to 130V

(3) 24 for those circuits from 131V up to 250V

In cases where the number of lighting points and total load currents are invariable, a number of points greater than those specified above may be connected to final sub-circuits provided that aggregate load currents do not exceed 80% of the ratings of protective devices in such circuits.

3 In final sub-circuits of ratings not exceeding 10A for panel lighting and electric signs, in cases where lampholders are closely grouped, the number of points supplied is unrestricted.

4 In spaces such as compartments where main engines or boilers are located, large machinery rooms, large galleys, corridors, stairways leading to boat-decks and public spaces, lighting is to be supplied from at least two circuits and to be arranged so that the failure of any one circuit will not leave these spaces in darkness. One of these circuits may be a reserve lighting circuit.

2.2.6 Circuits for Shore Connections

1 In cases where arrangements are made for the supply of electricity from sources on shore, connection boxes are to be installed in suitable positions. In cases where shore connection cables can be easily drawn into switchboards and put safely into service, such connection boxes may be omitted provided that those protective devices and checking devices specified in **-2** below are equipped on switchboards.

2 Connection boxes are to contain terminals to facilitate satisfactory connections and circuit-breakers or isolating switches with fuses. Means are to be provided for checking phase sequences (for three-phase alternating currents) or polarity (for direct currents).

3 In cases where power is supplied from three-wire neutral earthed systems, earth terminals are to be provided for connecting hulls to appropriate earths in addition to those specified in **-2** above.

4 At connection boxes, notices are to be provided giving information on the systems of supply and nominal voltages (and frequencies if *a.c.*) of such systems as well as those procedures for carrying out connections.

5 Cables between connection boxes and switchboards are to be permanently fixed and pilot lamps for sources and switches or circuit-breakers are to be provided on switchboards.

2.2.7 Disconnecting Switches of Circuits

1 Power circuits and lighting circuits terminating in cargo holds are to be provided with multipole linked switches situated outside these spaces. Provisions are to be made for locking in “off” positions any switches or switch boxes for these lighting circuits.

2 Feeder circuits for electrical equipment installed in hazardous areas are to be provided with multipole linked isolation switches in non-hazardous areas.

2.2.8 Remote Stopping of Ventilating Fans and Pumps

1 Remote stopping of ventilating fans and pumps is to comply with the requirements given in **4.1.1-2** and from **4.1.2-2** to **4.1.2-4**, **Part 9**.

2 In cases where fuses are used to protect a remote stopping circuit specified in **4.1.1-2** and from **4.1.2-2** to **-4**, **Part 9** and are only closed when they operates, consideration is to be given against the fuse element failure.

2.3 System Design (Protection)

2.3.1 General

Electrical installations of ships are to be protected against accidental overcurrents including short-circuits. Any protective devices used are to be capable of breaking any faulty circuits, thus preventing any other circuits from suffering damage or catching fire as well as to continuously serve those other circuits as far as possible.

2.3.2 Protection against Overload

1 Overcurrent trip characteristics of circuit-breakers and fusing characteristics of fuses are to be chosen suitably after taking into consideration the thermal capacity of electrical equipment and cables to be protected thereby. Fuses above 200*A* are not to be used for overload protection.

2 The ratings or appropriate settings of overload protection devices for each circuit are to be permanently indicated at the location of such protection devices. In addition, current-carrying capacities of each circuit are to be indicated.

3 Overload relays of circuit-breakers for generators and overload protections, except moulded-case circuit breakers, are to be capable of adjusting their current settings and time-delay characteristics.

2.3.3 Protection against Short-circuit

1 Breaking capacities of protective devices are to be not less than the maximum values of short circuit currents which can flow at installation points at the instant of constant separation.

2 Making capacities of circuit-breakers or switches intended to be capable of being closed, if necessary, on short-circuits, are not to be less than the maximum value of short-circuit currents at installation points. With respect to alternating currents, this maximum value corresponds to those peak values allowing for maximum asymmetry.

3 In cases where the rated breaking capacities and/or the rated making capacities of short-circuit protection are not in compliance with the requirements given in **-1** and **-2** above, fuses or circuit-breakers having breaking capacities not less than any prospective short-circuit currents are to be provided at power source sides of foregoing short-circuit protection. In such cases, circuit-breakers for generators are not to be used for this purpose. In addition, those circuit-breakers connected to load sides are not to be excessively damaged and are to be capable of further service in the following cases:

(1) In cases where short-circuit currents are broken by back-up circuit-breakers or fuses.

(2) In cases where circuit-breakers connected to load sides are closed on short-circuit currents while any back-up circuit-breakers or fuses breaks the current.

4 In cases where an absence of precise data regarding rotating machines makes it very difficult to anticipate short-circuit currents in machine terminals, the following **(1)** or **(2)** are to be used to determine the presence of short-circuit currents. In addition, in cases where motors are as loads, short-circuit currents of such motors are to be added to the short-circuit currents of generators:

(1) *D.C.* systems

10 *times* the sum of the rated currents of any generators which are connected (including spares).

6 *times* the sum of the rated currents of any motors simultaneously in service.

(2) *A.C.* systems

10 *times* the sum of the rated currents of any generators which are connected (including spares).

3 *times* the sum of the rated currents of motors simultaneously in service.

2.3.4 Protection of Circuits

1 Each pole and phase of all insulated circuits, except neutral and equalizer circuits, are to be provided with short-circuit protection.

2 All circuits liable to be overloaded are to be provided with overload protection as indicated below:

(1) Two-wire *d.c.* or single-phase *a.c.* systems: at least one line or phase

(2) Three-wire *d.c.* systems: both outer lines

(3) Three-phase, three-wire systems: one each for two phases

(4) Three-phase, four-wire systems: one each for each phase

3 Fuses, non-linked switches or non-linked circuit-breakers are not to be inserted into earthed conductors and neutral lines.

2.3.5 Protection of Generators

1 Generators are to be protected against short-circuits and overcurrents by multipole circuit-breakers arranged to simultaneously open all insulated poles, or in the case of generators less than 50*kW* not arranged to run in parallel, may be protected by multipole-linked switches with fuses or circuit-breakers in each insulated pole. Such overload protection is to be suitable to the thermal capacity of generators.

2 For *d.c.* generators arranged to operate in parallel, in addition to the requirements given in **-1** above, instantaneous reverse-current protections operating at fixed values of reverse-currents within the limits of 2% to 15% of the rated currents of generators are to be provided. However, this requirement does not apply to reverse-currents generated from load sides, *e.g.* cargo winch motors, etc.

3 For *a.c.* generators arranged to operate in parallel, in addition to the requirements given in **-1** above, reverse-power protection with time delay selected and set within the limits of 2% to 15% of full loads to values fixed in accordance with the characteristics of prime movers, are to be provided.

2.3.6 Protection of Feeder Circuits

1 Supply circuits to section boards, distribution boards, grouped starters, etc. are to be protected against overload and short-circuit by multi-pole circuit-breakers or fuses. In cases where fuses are used, switches complying with the requirements given in **2.14.3** are to be provided at power source sides of such fuses.

2 Each insulated pole of final sub-circuits is to be protected against short-circuit and overload by circuit-breakers or fuses. In cases where fuses are used, switches complying with the requirements given in **2.14.3** are, as a rule, to be provided at power source sides of such fuses. In addition, for the protection of the supply circuits of steering gears, the requirements given in **12.2.7, Part 7** are to apply.

3 Circuits which supply motors fitted with overload protection may be provided with short-circuit protection only.

4 In cases where fuses are used to protect three-phase *a.c.* motor circuits, consideration is also to be given to protection against any single phasing.

5 In cases where condensers for phase advances are used, overvoltage protective devices are to be installed as required.

2.3.7 Protection of Power and Lighting Transformers

1 Primary circuits of power and lighting transformers are to be protected against short-circuit and overcurrents by multipole circuit-breakers or fuses.

2 In cases where transformers are arranged to operate in parallel, means of isolation are to be provided on secondary circuits.

2.3.8 Protection of Electric Motors

1 Motors of rating exceeding 0.5*kW* and all motors for essential services, except those motors for steering gears, are to be individually protected against overload. The overload protection for motors for the steering gears is to comply with the requirements given in **12.2.7, Part 7**.

2 Protective devices are to have delay characteristics to enable motors to start.

3 In cases where motors are used for intermittent services, current settings and delays are to be chosen in relation to the load factors of such motors.

2.3.9 Protection of Lighting

Lighting circuits are to be protected against short-circuit and overload.

2.3.10 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 together with their connecting leads by means of fuses fitted to each insulating pole. Pilot lamps installed as integral parts of other items of equipment need not be individually protected provided that any damage to pilot lamp circuits does not cause any failures in the power supplies of essential equipment.

2 Insulated wires for control and instrument circuits directly led from busbars and generator mains are to be protected by fuses at locations that are nearest to connecting points. Insulated wires between the fuses and connecting points are not to be bunched together with any wires for other circuits.

3 Fuses in circuits such as those of automatic voltage regulators in cases where any loss of voltage might have serious consequences may be omitted. However, if omitted, proper means are to be provided to prevent any risk of fire in unprotected parts of such installations.

2.3.11 Protection of Batteries

Accumulator batteries other than engine starting batteries are to be protected against overload and short-circuit with devices placed as near as practicable to such batteries.

2.4 Rotating Machines

2.4.1 Prime Movers for Generators

Prime movers for generators are to be constructed in accordance with the requirements given in **Part 7** and, in addition, their governors are to be in accordance with the requirements given in **2.4.2**.

2.4.2 Characteristics of Governors

1 The characteristics of governors on prime movers for main generators are that such governors be capable of maintaining speeds within the following limits:

(1) Momentary speed variations are to be 10% or less of the maximum rated speed when the rated loads of generators are suddenly thrown off. In cases where it is difficult to meet the above requirements, the characteristics of such governors are to be deemed appropriate by the Society.

(2) Momentary speed variations are to be 10% or less of the maximum rated speed when 50% of the rated loads of generators are suddenly thrown on followed by the remaining 50% of such loads suddenly being thrown on after an interval to restore the steady state. Speeds are to return to within 1% of final steady speeds in not more than 5 *seconds*. In cases where it is difficult to meet the above requirements or in cases where certain installations require different characteristics, the characteristics of such governors are to be as deemed appropriate by the Society.

(3) At all loads in ranges between no loads and rated loads, any permanent speed variations are to be within $\pm 5\%$ of the maximum rated speed.

2 In the case of *a.c.* generating sets operating in parallel, the governor characteristics of prime movers are to be such that the load sharing specified in **2.4.14-4** and **-5** is ensured, and facilities are to be provided to adjust the governor sufficiently enough to permit adjustments of loads not exceeding 5% of rated loads at normal frequencies.

2.4.3 Limits of Temperature Rise

Temperature rise of rotating machines are not to exceed those values given in **Table 8.2.2**, in cases where they are operated continuously at rated loads or operated intermittently according to their duties. Temperature rise of static exciters for *a.c.* generators are to comply with the requirements given in **2.5.10-2**.

2.4.4 Modification of Limits of Temperature Rise

1 In cases where ambient temperatures exceed $45^{\circ}C$, limits of temperature rise are to be decreased by the difference from those values given in **Table 8.2.2**.

2 In cases where temperatures of primary coolants do not exceed $45^{\circ}C$, limits of temperature rise may be increased in those cases where deemed appropriate by the Society.

3 In cases where ambient temperatures do not exceed $45^{\circ}C$, limits of temperature may be increased by the difference from those values given by **Table 8.2.2**. In such cases, ambient temperatures are not to be set below $40^{\circ}C$.

Table 8.2.2 Limits of Temperature Rise for Rotating Machines (Based on ambient temperatures of 45 $^{\circ}C$)

Item	Part of rotating machine	Thermal class A			Thermal class E			Thermal class B			Thermal class F			Thermal class H		
		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
1a	*A.C.* windings of machines having outputs of 5,000*kW* (or *kVA*) or more	-	55	60	-	-	-	-	75	80	-	95	100	-	120	125
1b	*A.C.* windings of machines having outputs above 200*kW* (or *kVA*) but less than 5,000*kW* (or *kVA*)	-	55	60	-	70	-	-	75	85	-	100	105	-	120	125
1c	*A.C.* windings of machines having outputs of 200*kW* (or *kVA*) or less, other than those in items 1d or 1e *1	-	55	-	-	70	-	-	75	-	-	100	-	-	120	-
1d	*A.C.* windings of machines having rated outputs of less than 600*W* (or VA)*1	-	60	-	-	70	-	-	80	-	-	105	-	-	125	-
1e	*A.C.* windings of machines which are self-cooled without fan and/or with encapsulated windings*1	-	60	-	-	70	-	-	80	-	-	105	-	-	125	-
2	Windings of armatures having commutators	45	55	-	60	70	-	65	75	-	80	100	-	100	120	-
3	Field winding of *a.c.* and *d.c.* machines having *d.c.* excitation other than those in item 4	45	55	-	60	70	-	65	75	-	80	100	-	100	120	-
4a	Field windings of synchronous machines with cylindrical rotors having *d.c.* excitation winding embedded in slots except synchronous induction motors	-	-	-	-	-	-	-	85	-	-	105	-	-	130	-
4b	Stationary field windings, of *d.c.* machines, having more than one layer	45	55	-	60	70	-	65	75	85	80	100	105	100	120	130
4c	Low resistance field winding of *a.c.* and *d.c.* machines and compensating windings of *d.c.* machines having more than one layer	55	55	-	70	70	-	75	75	-	95	95	-	120	120	-
4d	Single-layer windings of *a.c.* and *d.c.* machines with exposed bare or varnished metal surfaces and single-layer compensating windings of *d.c.* machines*2	60	60	-	75	75	-	85	85	-	105	105	-	130	130	-
5	Permanently short-circuited windings	The temperature rise is in no case to reach such values that there are risks of damage to any insulating materials on adjacent parts.														
6	Commutators and slip-rings and their brushes and brush gear	The temperature rise is in no case to reach such values that there are risks of damage to any insulating materials on adjacent parts. In addition, temperatures are not to exceed that at which the combination of brush grade and commutator/slip-ring materials can handle the current over their complete operating range														
7	Magnetic cores and all structural components, whether or not in direct contact with insulation (excluding bearings)	The temperature rise is in no case to reach such values that there are risks of damage to any insulating materials on adjacent parts.														

Notes:

1. In cases where the Super Position Method is applied to windings of machines rated 200*kW* (or *kVA*) or less with Thermal Classes A, E, B and F, marked with *1, the limits for temperature rise given for the Resistance Method may be exceeded by 5*K*
2. Also includes multiple layer windings marked with *2 provided that their under layers are each in contact with the circulating primary coolant.
3. T = Thermometer Method, R = Resistance Method, E.T.D. = Embedded Temperature Detector

2.4.5 Overload Capability

Rotating machines are to withstand the following excess current or torque tests by maintaining their voltage, rotating speed and frequency as near to their rated values as possible. In the case of special types of deck machinery motors (winch, windlass, capstan, etc.), overload scaling may be dealt with as considered appropriate by the Society.

(1) Excess current capability

(a) *A.C.* generators

150% of rated current for 2 *minutes*

(b) *D.C.* generators

150% of rated current

Rated output (*kW*) / Rated rotating speed (*rpm*) ≤ 1 for 45 *seconds*

Rated output (*kW*) / Rated rotating speed (*rpm*) > 1 for 30 *seconds*

(2) Excess torque capability

(a) Polyphase induction motors and *d.c.* motors

160% of rated torque for 15 *seconds*

(b) Polyphase synchronous motors

i) Synchronous (wound rotor) induction motors

135% of rated torque for 15 *seconds*

ii) Synchronous (cylindrical rotor) induction motors

135% of rated torque for 15 *seconds*

iii) Synchronous (salient pole) induction motors

150% of rated torque for 15 *seconds*

2.4.6 Short-circuit Scaling

1 Ship service generators are to be capable of withstanding the mechanical and thermal effects of any faulty currents for the duration of any time delay which may be fitted in tripping devices for selective tripping.

2 Generators and their excitation systems are to be capable of maintaining currents of at least 3 *times* their rated full-load currents for durations of at least 2 *seconds* or for those durations of any time delays which may be fitted in tripping devices for selective tripping.

2.4.7 Overspeed Capability

Rotating machines are to withstand overspeed conditions for 2 *minutes* in accordance with the following:

(1) *A.C.* machines

(a) *A.C.* machines other than series and universal motors

120% of the maximum rated speed

(b) Series and universal motors

110% of the no-load speed at rated frequency

(2) *D.C.* machines

(a) Shunt-wound and separately excited motors

120% of the highest rated speed or 115% of the corresponding no-load speed, whichever is greater

(b) Compound-wound motors having speed regulation of 35% or less

120% of the highest rated speed or 115% of the corresponding no-load speed, whichever is greater, but not exceeding 150% of the highest rated speed

(c) Compound-wound motors having speed regulation greater than 35% and series-wound motors

110% of the maximum safe speed designated by the manufacturer

(d) Permanent-magnet excited motors

In the case of series winding, **(b)** or **(c)** is to be satisfied. In all other cases, **(a)** is to be satisfied.

(e) Generators

120% of the rated speed

2.4.8 Shaft Currents

In cases where there is a fear of harmful currents circulation between the shafts and bearings, suitable means are to be provided to prevent such from occurring.

2.4.9 Precaution to the Effect of Condensation of Moisture

In cases where there is a fear of deterioration of insulations due to condensation of moisture within rotating machines, suitable means are to be provided to prevent such from occurring.

2.4.10 Air Coolers

In cases where air coolers are provided for rotating machines, they are to be arranged so that there is no fear of any water ingress into such machines due to any leakage or condensation in the air coolers.

2.4.11 Shafts of Rotating Machine

1 The shafts for rotating machines used for essential services are to be made out of materials complying with standards deemed appropriate by the Society.

2 In cases where welding is applied to shafts and other torque members of rotating machines, the plans are subject to Society approval.

3 The shafts of generators are to comply with the following requirements:

(1) The diameters of generator shafts, in the length from those sections in cases where rotors are fixed to the shaft ends of prime movers, are not to be less than those values obtained from the formula specified in **4.2.2, Part 7**.

In such cases, the values H, N_0 and F_1 used in that formula mean as follows:

H: Output of rotating machines at maximum continuous rating (kW)

N_0: Number of revolutions of rotating machine shaft at maximum continuous rating (rpm)

F_1: Factor given in **Table 8.2.3**

However, in cases where bearings are arranged on both sides of generators, the diameter of shafts around those couplings on prime movers may be reduced gradually to 0.93 *times* those diameters obtained from the aforementioned formula.

(2) Due consideration is given to the amount of any bending of shafts so that their diameters are designed to maintain necessary air gaps between stators and rotors within their working ranges.

(3) In case where generators are driven by diesel engines, tortional vibrations of shaftings are to comply with those relevant requirements given in **Chapter 6, Part 7**.

Table 8.2.3 Values of F_1

Bearing arrangements of rotating machines	Generators driven by diesel engines through slip type couplings (Note)	Generator driven diesel engines other than those mentioned in the left-hand column
In cases where bearings are arranged at both sides of rotating machines	110	115
In cases where no bearings are arranged at prime movers or load sides of rotating machines	120	125

Note: Slip type couplings in this case refer to hydraulic couplings, electro-magnetic couplings or their equivalent.

2.4.12 Clearances and Creepage Distances inside Terminal Boxes

1 Clearances and creepage distances inside terminal boxes of rotating machines are not to be less than the values given in **Table 8.2.4**. Furthermore, the clearances and creepage distances for the terminal boxes of rotating machines with rated voltages exceeding 500V are to be adequate for the working voltage and to give consideration to the specifications of the terminal boxes.

2 The requirements specified in **-1** above are not to be applied in cases where insulating barriers are used and also they are not to be applied to small motors such as controlling motors, synchros, etc.

Table 8.2.4 Minimum Clearances and Creepage Distances inside Terminal Boxes of Rotating Machines

Rated voltage (*V*)	Clearance (*mm*)	Creepage (*mm*)
61 - 250	5	8
251 - 380	6	10
381 - 500	8	12

2.4.13 *D.C.* Generators

1 *D.C.* generators other than those specified in **-2** below are to be either:

(1) Compound-wound generators; or

(2) Shunt-wound generators with automatic voltage regulators.

2 *D.C.* generators used for charging batteries without series regulating resistors are to be either:

(1) Shunt-wound generators; or

(2) Compound-wound generators with switches arranged so that any series winding may be rendered inoperative.

3 Field regulators for *d.c.* generators are to be capable of adjusting the voltage of generators 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 loads and full loads at any temperature within their working range.

4 The overall voltage regulation of *d.c.* generators is to be in accordance with the following requirements and rotating speeds are to be adjusted to those rated speeds at full loads:

(1) Shunt-wound generators

After temperature testing, in cases where voltages are set at full loads, steady voltages at no loads are not to exceed 115% of their full-load values, and voltages obtained at any load values are not to exceed their no-load values.

(2) Compound-wound generators

After temperature testing, in cases where voltages at 20% loads are adjusted within ±1% of their rated voltages, those voltages at full loads are to be within ±1.5% of their rated voltages. In addition, the averages of the ascending and descending load/voltage curves between 20% loads and full loads are not to vary by more than 3% from their rated voltages.

Note: For compound-wound generators operated in parallel, drops in voltage may be acceptable up to 4% of their rated voltages in cases where such loads are gradually increased from 20% loads to full loads.

(3) Three-wire generators

In addition to compliance with the requirements in **(1)** and **(2)**, when operating at rated currents on heavier loaded sides, *i.e.* either positive or negative leads, with rated voltages between those positive and negative leads and currents of 25% of generator current ratings in neutral wires, the resulting difference in voltage between any positive and neutral leads or any negative and neutral leads is not to exceed 2% of the rated voltages between the positive and negative leads.

5 In cases where *d.c.* generators are operated in parallel, loads on generators are not to differ by more than ±10% of the rated output of the largest machine from its proportionate share, based on generator ratings, of combined loads, for steady-state conditions in those combined loads between 20% and 100% of the sums of rated outputs of all machines. In such cases, starting points for the determination of foregoing load distribution requirements are to be at 75% loads with each generator carrying its proportionate share.

6 Series field windings of each two-wire compound-wound generator are to be connected to negative terminals.

7 Equalizer connections of *d.c.* generators are to have cross sectional areas not less than 50% of that of any negative connections from generators to switchboards.

2.4.14 *A.C.* Generators

1 Each *a.c.* generator, except self-excited compound-wound types, are to be provided with automatic voltage regulators.

2 The overall voltage regulation of *a.c.* generators is to be such that at all loads from zero to full loads at rated power factors, the rated voltages are to be maintained under steady conditions within ± 2.5%.

3 In cases where generators are driven at rated speeds, giving rated voltages and they are subjected to sudden changes of symmetrical loads within the limits of specified currents and power factors (*See* **2.4.15-3**), voltages are not to fall below 85% nor exceed 120% of the rated voltages. Voltages of such generators are then to be restored to within ± 3% of their rated voltage in a period of not more than 1.5 *seconds*.

4 In cases where *a.c.* generators are operated in parallel, each generator is to be stable running within the limits of 20% and 100% total loads, the *kW* loads on such generators are not to differ from its proportionate share of their total loads by more than 15% of the rated output (*kW*) of the largest machine or 25% of the rating of the individual machine.

5 In cases where *a.c.* generators are operated in parallel, reactive loads of individual generators are not to differ from their proportionate share of total reactive loads by more than 10% of the rated reactive output of the largest machine, or 25% of the smallest machine in cases where this value is less than the former.

2.4.15 Shop Tests

1 Rotating machines are to be tested in accordance with the requirements given in this **2.4.15**. However, those tests required by **-6**, **-7** and **-8** below may be omitted subject to the Society's permission for each generator or motor which is produced in series having identical type with their unit. In addition, those tests required by **-5** below may be omitted for each generator or motor which is of small capacity and which is produced in a series of identical types with their unit.

2 No-load tests of rotating machines are to be carried out. During such tests, machine vibrations and bearing lubrication system operations are to be within the order.

3 In the case of generators, voltage regulation tests are to be carried out and comply with the requirements given in **2.4.13-4**, or **2.4.14-2** and **-3**. In the absence of precise information concerning the maximum values of any sudden loads when applying the requirement given in **2.4.14-3**, 60% of the rated current with a power factor of between 0.4 lagging and zero is to be suddenly switched on with the generator running at no load, and then switched off after attaining steady-state conditions.

4 Rotating machines with commutators are to work with fixed brushes settings from no loads to 50% overloads without any harmful sparking.

5 Overcurrent or excess torque tests for rotating machines are to be carried out in accordance with **2.4.5** and such machines are to have the capability to withstand such tests.

6 Steady short-circuit tests for synchronous generators are to be carried out and comply with the requirements given in **2.4.6-2**.

7 Overspeed tests for rotating machines are to be carried out and comply with the requirements given in **2.4.7**.

8 After rotating machines are run continuously under actual load methods at their rated output voltages, frequencies, and those duties for which they are being rated until their temperatures have reached a steady state, the temperature rise of each part is to be measured and is not exceed the value given in **2.4.3**. In cases where it is considered to be acceptable by the Society, such tests may be carried out in accordance with separately specified procedures.

9 The high voltage levels specified in **Table 8.2.5** are to be applied for a period of 1 *minute* between live parts and frames of rotating machines, with those cores and windings not under going testing connected to such frames. In cases where machines with rated voltage above 1*kV* having both ends of each phase individually accessible, test voltages are to be applied between each phase and frames. Furthermore, where those temperature rise tests specified in **-8** above are applied, high voltage tests are to be carried out after the test.

10 Immediately after those high voltage tests specified in **-9** above have been performed, the insulation resistance of such rotating machines is to be measured in accordance with **Table 8.2.6** and all values are not to be less than any of those specified in **Table 8.2.6**. In addition, during such measuring, temperatures of rotating machines are to be near operating temperature. However, in cases where this is difficult, appropriate methods of calculation may be used instead.

11 Machine winding resistance is to be measured.

12 Upon completion of the above tests, machines which have sleeve bearings are to be opened and examined in cases where deemed necessary by the Society.

Table 8.2.5 Testing Voltages

Item	Machine or part	Testing voltage (*rms*) (*V*)
1	Insulated windings of rotating machines of sizes less than 1*kW* (or *kVA*), and of rated voltages less than 100*V* with the exception of those in items 3 to 6	$2E + 500$
2	Insulated windings of rotating machines with the exception of those in item 1 and items 3 to 6	$2E + 1,000$ (Minimum 1,500)
3	Separately-excited field windings of *d.c.* machines	$2E_f + 1,000$ (Minimum 1,500)
4	Field windings of synchronous generators, synchronous motors and synchronous condensers a) $Ex \leq 500V$ $500V < Ex$ b) In cases where such machines are intended to be started with the field winding short-circuited or connected across a resistance of value less than 10 *times* the resistance of the winding c) In cases where such machines are intended to be started with the field winding on open circuit or connected across a resistance of value equal to, or more than, 10 *times* the resistance of the winding	 $10E_x$ (Minimum 1,500) $2E_x + 4,000$ $10E_x$ (Minimum 1,500, Maximum 3,500) $2E_y + 1,000$ (Minimum 1,500)
5	Secondary (usually rotor) windings of induction motors or synchronous induction motors if not permanently short-circuited (*e.g.* if intended for rheostatic starting) a) In the case of non-reversing motors or motors reversible from standstill only b) In the case of motors to be reversed or braked by reversing the primary supply while the motor is running	 $2E_s + 1,000$ $4E_s + 1,000$
6	Exciters with the exception of : Exciters of synchronous motors (including synchronous induction motors) if connected to earth or disconnected from field windings during starting; and separately excited field windings of exciters	$2E_i + 1,000$ (Minimum 1,500)

Notes:

1. E: Rated voltage
   E_f : Maximum rated voltage in field circuit
   E_x: Rated field voltage
   E_y: Induced terminal voltage between the terminals of field windings and starting rotor windings in cases where starting voltages are applied to armature windings while rotors are at a standstill and terminal voltages in cases where field windings or staring windings are started by connecting with such resistance
   E_s: Induced voltage between the terminals of secondary windings in cases where the machine is at a standstill
   E_i: Rated exciter voltage
2. In the case of two-phase windings having one terminal in common, the voltage in the formula is to be the highest r.m.s. voltage arising between any two terminals during operation.
3. High voltage tests on machines having graded insulation may be as deemed appropriate by the Society.
4. In the case of semiconductor elements for exciters, the requirements for semiconductor converters for power given in **2.12** are to be applied.

Table 8.2.6 Minimum Values of Test Voltages and Insulation Resistance

Rated voltage *Un* (*V*)	Minimum test voltage (*V*)	Minimum insulation resistance ($M\Omega$)
$Un \leq 250$	$2 \times Un$	1
$250 < Un \leq 1,000$	500	1
$1,000 < Un \leq 7,200$	1,000	$Un/1,000 + 1$
$7,200 < Un$	5,000	$Un/1,000 + 1$

2.5 Switchboards, Section Boards and Distribution Boards

2.5.1 Location

Switchboards are to be installed in dry places and be located as far away as possible from any steam pipes, water pipes, oil pipes and other similar pipes.

2.5.2 Safety Precautions to Operators

1 Switchboards are to be arranged so as to give easy access to each component without danger to any personnel.

2 The sides, rear and, in cases where necessary, the front of switchboards are to be suitably guarded.

3 In cases where the voltage between poles or to earths exceeds $50V\ d.c.$ or $50V\ a.c.$ root mean square, switchboards are to be of a dead front type.

4 Insulated handrails are to be provided on the front and the rear faces of switchboards and, in cases where necessary, insulated mats or gratings are to be provided on the floor of passageways.

5 Sufficient space for operation is to be provided in front of switchboards. In addition, in cases where it is necessary for the operation and the maintenance of any disconnecting switches, switches, fuses and other parts, passageways of more than $0.5m$ in width are to be provided at the rear of switchboards.

6 Section boards and distribution boards are to have suitable protective enclosures depending on their location. If they are installed in locations where they are readily accessible to persons other than their responsible operators, proper protection is to be arranged so that safety can be ensured during normal operation.

2.5.3 Construction and Materials

1 Cable entries of switchboards are to be so constructed that no ingress of water into the switchboard is permitted along such cables.

2 In cases where supply circuits having different voltages are installed in the same spaces as switchboards, section boards or distribution boards, all appliances are to be arranged so that the cables of different rated voltages can be laid without coming to contact with each other within such boards.

3 The enclosures are to be of robust construction and any materials used are to be incombustible and non-hygroscopic.

4 Insulating materials are to be durable, flame-retardant and non-hygroscopic.

5 Wiring materials are to conform to the following requirements:

(1) Insulated wires for switchboards are to be flame-retardant and non-hygroscopic which have maximum permissible conductor temperatures of not less than $75^{\circ}C$.

(2) Ducts and straps for wiring are to be made of flame-retardant materials.

(3) Insulated wires for control and instrument circuits are not to be bunched together with wires for main circuits and not to be in the same duct. However, if the rated voltages and maximum permissible temperatures of conductors are the same and it has been recognized that no harmful effects will be caused by the main circuits, this requirement may be omitted.

6 Except in cases where isolation switches are provided, circuit breakers are to be such that any repairing and replacing of them can be made without disconnecting them from busbar connections and switching off power sources.

2.5.4 Busbars

1 Busbars are to be of copper or of copper-surrounded aluminum alloy.

2 Busbar connections are to be so made as to inhibit any corrosion and oxidization.

3 Busbars and busbar connections are to be supported so as to withstand any electromagnetic forces resulting from short-circuiting.

4 Temperature rises of busbars, connecting conductors and their connections are not to exceed $45K$ at ambient temperatures of $45^{\circ}C$ in cases where they are carrying full-load currents. However, in cases where deemed appropriate by the Society, these requirements do not apply.

5 Air clearances (phase-to-phase, pole-to-pole and phase-to-earth) of non-insulated busbars are not to be less than the values given in **Table 8.2.7**.

Table 8.2.7 Minimum Air Clearances for Busbars

Rated voltage (*V*)	Air clearance (*mm*)
250 or less	15
over 250 to 690 inclusive	20
over 690 to 1,000 inclusive	35

2.5.5 Equalizers

1 Current ratings of equalizer connections and equalizer switches are not to be less than half the rated full-load current of generators.

2 Current ratings of equalizer busbars are not to be less than half the rated full-load current of the largest generator in the group.

2.5.6 Measuring Instruments for *d.c.* Generators

Ship service *d.c.* generator panels are to be at least provided with the instruments given in **Table 8.2.8**.

Table 8.2.8 Instruments for *d.c.* Generator Panels

Operations	Instruments	Number required	
		2-wire systems	3-wire systems
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 the case of compound winding, between equalizers and armatures, and in the case of shunt winding, for positive and negative poles)
	Voltmeter	2 busbars and each generator	2 (voltage measurement between busbars and positive and negative poles of each generator, or between positive poles and neutral poles)

Notes:

1. In cases where neutral line earthed systems are employed, zero centre ammeters for such earth lines are to be added to those numbers marked with a * in the above table.
2. One of the voltmeters is to be capable of measuring shore supply voltages.
3. In cases where control panels are provided for automatic control of generators, the instruments in the above table may be installed on such control panels. However, in cases where such control panels are installed outside engine rooms, the minimum number of instruments required to carry out single or parallel operations of generators is to be mounted on switchboards.

2.5.7 Measuring Instruments for *a.c.* Generators

Ship service *a.c.* generator panels are at least to be provided with the instruments given in **Table 8.2.9**.

Table 8.2.9 Instruments for *a.c.* Generator Panels

Operations	Instruments	Number required
Not parallel	Ammeter	1 for each generator (current measurement of each phase)
	Voltmeter	1 for each generator (measurement of each line voltage)
	Wattmeter	1 for each generator (it may be omitted for 50*kVA* or less.)
	Frequency meter	1 (frequency measurement of each generator)
	*Ammeter	1 for the exciting circuit of each generator
Parallel	Ammeter	1 for each generator (current measurement of each phase)
	Voltmeter	2 (measurement of busbar voltage and each line voltage of generators)
	Wattmeter	1 for each generator
	Frequency meter	2 (frequency measurement of each generator and busbar)
	Synchroscope and synchronizing lamps	1 set each In cases where automatic synchroscopes are provided, either one of these may be omitted
	*Ammeter	1 for the exciting circuit of each generator

Notes:

1. In the above table, ammeters marked with a * are to be provided only in those cases where necessary.
2. One of the voltmeters is to be capable of measuring shore supply voltages.
3. In cases where control panels are provided for automatic control of generators, those instruments given in the above table may be installed on such control panels. However, in cases where such control panels are installed outside engine rooms, the minimum number of instruments required to carry out single or parallel operations of generators is to be mounted on switchboards.

2.5.8 Instrument Scales

1 The upper limits of the scale of voltmeters are to be approximately 120% of the normal voltage of their respective circuits.

2 The upper limits of the scale of ammeters are to be approximately 130% of the normal rating of their respective circuits.

3 Ammeters for use with *d.c.* generators and wattmeters for use with *a.c.* generators which may operate in parallel are to be capable of indicating reverse currents or reverse power up to 15% respectively.

2.5.9 Transformers for Instruments

The secondary windings of transformers for instruments are to be earthed.

2.5.10 Shop Tests

1 Switchboards are to be tested and inspected in accordance with the requirements given in this **2.5.10**. However, those tests required by **-2** below may be omitted subject to the Society's permission for each switchboard which is produced in series having the identical type with its first unit.

2 Temperature rises of switchboards are not to exceed those values given in **Table 8.2.10** under the specified currents and/or rated voltages, except in those cases specified in the chapters of this Part.

3 Functions of instruments, circuit breakers, switchgears, etc. on switchboards are to be confirmed as normal.

4 Switchboards as well as all components are to be able to withstand high voltages by applying the following voltages at commercial frequencies for a period of 1 *minute* between all current-carrying parts connected together and earths as well as between current-carrying parts of opposite polarities or phases. Instruments and auxiliary apparatus may be disconnected during these high voltage tests:

Rated voltage of 60*V* or below: 500*V*

Rated voltage exceeding 60*V*: 1,000*V* + twice the rated voltage (minimum 1,500*V*)

5 Immediately after such high voltage tests have been performed, the insulation resistance between all current-carrying parts connected, earths and between current-carrying parts of opposite polarities or phases is not to be less than $1M\Omega$ when tested with *d.c.* voltages of at least 500*V*.

Table 8.2.10 Limits of Temperature Rise of Electrical Appliances for Switch Boards

(Based on ambient temperatures of 45°*C*))

<table>
<tr><th colspan="3">Item and part</th><th>Limits of temperature rise (*K*)</th></tr>
<tr><td rowspan="5">Coils</td><td colspan="2">Thermal class *A*</td><td>45</td></tr>
<tr><td colspan="2">Thermal class *E*</td><td>60</td></tr>
<tr><td colspan="2">Thermal class *B*</td><td>75</td></tr>
<tr><td colspan="2">Thermal class *F*</td><td>95</td></tr>
<tr><td colspan="2">Thermal class *H*</td><td>120</td></tr>
<tr><td rowspan="3">Contact pieces</td><td rowspan="2">Mass forms</td><td>Copper or copper alloys</td><td>40</td></tr>
<tr><td>Silver or silver alloys</td><td>70</td></tr>
<tr><td>Multilayer forms or Knife forms</td><td>Copper or copper alloys</td><td>25</td></tr>
<tr><td colspan="3">Terminals for external cables</td><td>45</td></tr>
<tr><td rowspan="4">Metallic resistors</td><td colspan="2">Moulded-case types</td><td>245</td></tr>
<tr><td rowspan="2">Those other than moulded-case types</td><td>For continuous service</td><td>295</td></tr>
<tr><td>For intermittent service</td><td>345</td></tr>
<tr><td colspan="2">Exhaust (approx. 25*mm* above exhaust ports)</td><td>170</td></tr>
</table>

2.6 Circuit-breakers, Fuses and Electromagnetic Contactors

2.6.1 Circuit-breakers

1 Circuit-breakers are to comply with *IEC Publication* 60947-1 and 60947-2, or any equivalent thereto, amended in cases where necessary for ambient temperature; furthermore, they are also to comply with the requirements given in **-2** and **-3** below.

2 The construction of circuit-breakers is to comply with the following **(1)** to **(6)**:

(1) All circuit-breakers are to be trip-free types and depending upon the field of their application, trip attachments are to have time-delays or instantaneous overcurrent trip features or both.

(2) Main contacts of circuit-breakers are to be such as to have no undue burning or pitting. Arcing contacts, except those of moulded case circuit-breakers, are to be easily replaceable.

(3) Instantaneous trip devices other than those electronic types having suitable testing arrangements are to be of constructions capable of tripping associated breakers directly by short-circuit currents.

(4) Circuit-breakers are to be such that no accidental opening and closing occur due to ship vibrations, and, furthermore, no malfunctions caused by lists of angles of 30° in any direction.

(5) Fused circuit-breakers of moulded-case types are to be constructed so that single phasing does not occur in the event of blowing of fuses and that the fuses can be easily replaced without any risk of operating personnel accidentally touching any live-parts.

(6) Rated (operational) voltages, rated (thermal) currents, etc. as well as rated breaking capacities, rated making currents and rated short-time currents are to be clearly indicated on each circuit-breaker according to their type. In addition, each time-delay overcurrent trip device is to have its operating characteristics indicated except for moulded-case circuit-breakers.

3 Circuit-breaker performance is to comply with the following **(1)** to **(4)**:

(1) Temperature rises in connecting terminals of cables are not to exceed 45*K* at ambient temperatures of 45°*C* in cases where 100% of rated currents are carried therethrough.

(2) All circuit-breakers, according to their kind, are to be such as to be able to securely break any over-currents not more than rated-braking capacities and safely make such circuit able to carry currents not more than those rated making currents under the circuit conditions specified in the standards referred to in **-1**.

(3) Time-delay over-current trip devices of circuit-breakers for generator circuits are to be such that any readjustment of current settings does not cause any remarkable changes in such time-delay features.

(4) The characteristics of time-delay overcurrent trip devices are not to be excessively affected by ambient

temperatures.

2.6.2 Fuses

1 Fuses are to comply with *IEC Publication* 60269, or any equivalent thereto, amended in cases where necessary for ambient temperature; furthermore, they are also to comply with the requirements given in **-2** and **-3** below.

2 The construction of fuses is to comply with the following **(1)** to **(3)**:

(1) Fuses are to be enclosed types and their construction is to be such that such enclosures are neither broken nor burnt and any adjacent insulation cannot be damaged by any flowing of fused metal or emitting of gases in cases where fuse elements blow out.

(2) Fuses are to be easily replaceable with spares without any risk of electric shock or burning to any personnel replacing such fuses.

(3) Rated voltages, rated currents, etc. are to be clearly indicated on each fuse. In addition, rated breaking capacities, fusing characteristics and current-limiting characteristics according to its kind are also to be indicated. All such indications are to be clearly made using either values or symbols.

3 The performance of fuses and fuse-holders are to comply with the following **(1)** and **(2)**:

(1) Temperature rises in connecting terminals of cables are not to exceed 45K at ambient temperatures of $45^{\circ}C$ in cases where fuses are fitted to fuse-holders; furthermore, 100% of rated currents are carried therethrough.

(2) Fuses are to have those fusing characteristics corresponding to their kind; furthermore, under those circuit conditions specified in the standards given in **-1** above, such fuses are to be capable of securely breaking all currents whichever is below their rated breaking capacity and above their fusing current.

2.6.3 Electromagnetic Contactors

1 Electromagnetic contactors are to comply with *IEC publications* 60947-1 and 60947-4-1, or any equivalent thereto, amended in cases where necessary for ambient temperature; furthermore, they are also to comply with the requirements given in **-2** and **-3**.

2 The construction of electromagnetic contactors is to comply with the following **(1)** to **(3)**:

(1) Electromagnetic contactors are to be such that no accidental opening and closing occurs due to ship vibration; furthermore, no malfunction is to be caused by any list of an angle of 30° in any direction.

(2) Contact pieces and magnetic coils are to be easily replaceable.

(3) Rated operational voltages, rated capacities or full-load currents corresponding to rated capacities, etc. as well as rated operational voltages and frequencies for control circuits, interruption current capacities and closed circuit current capacities are to be indicated on each electromagnetic contactor. Such indications are to be clearly made in either values or symbols.

3 The performance of electromagnetic contactors is to comply with the following **(1)** to **(3)**:

(1) Temperature rises in connecting terminals of cables are not to exceed 45K at ambient temperatures of $45^{\circ}C$ in cases where full-load currents corresponding to rated capacities are carried therethrough.

(2) Electromagnetic contactors are to have suitable interruption current capacities and closed-circuit current capacities depending on their application.

(3) Electromagnetic contactors are not to accidentally open circuits at voltages exceeding 85% of rated voltages.

2.6.4 Overcurrent Relays for Motors

Overcurrent relays for motors are to have suitable characteristics in relation to the thermal capacities of motors.

2.7 Control Appliances

2.7.1 Clearances and Creepage Distances

1 Clearances and creepage distances of control appliances (*e.g.*, contactors, rheostats, control switches, limit switches, motor protection and control relays, terminal boards, appliances incorporating semiconductors and their combinations) are to comply with the requirements given in **-2** and **-3** below depending on the degree of protection of enclosures of such appliances or those ambient conditions in which such appliances are installed.

2 Minimum clearances and creepage distances of control appliances (*e.g.*, electromagnetic contactors, control switches, terminal boards) are not to be less than those values given in **Table 8.2.11** if such appliances are designed and constructed in consideration of moisture, dust, etc. or if they are operated in ambient conditions not affected by extremely high humidity and heavy deposit of dusts.

3 Minimum clearances and creepage distances of small control appliances having rating currents not exceeding 16*A* may be shortened to values deemed appropriate by the Society, depending on the degree of protection of the enclosures of such appliances or those ambient conditions in which such appliances are installed.

4 The requirements given in **-2** and **-3** above may not apply to the following:

(1) Clearance distances between contacts generating arcs

(2) Appliances used in secondary windings of induction motors

(3) Oil-immersed appliances

(4) Caps and lamp-holders of indicator lamps

(5) Small switches in accommodation spaces

(6) Filled portion of gas-filled appliances

Table 8.2.11 Minimum Clearances and Creepage Distances for Control Appliances

Rated insulating voltage (*V*) (*d.c* & *a.c.*)	Clearance (*mm*)						Creepage(3)(4)(*mm*)					
	Less than 16 *A*(5)		16 *A* or over and 63 *A* or under(5)		Exceeding 63 *A*(5)		Less than 16 *A*(5)		16 *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	3	5	5	6	3	4	3	4	5	8
Exceeding 250 and 380 or under	4	6	4	6	6	8	4	6	4	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 and 800 or under	10	14	10	14	10	14	10	14	10	14	14	20
Exceeding 800 and 1,000 or under	14	20	14	20	14	20	14	20	14	20	20	28

Notes:

1. "*L-L*" applies to those clearances between bare live parts and between live parts and earthed metal parts.
2. "*L-A*" applies to those clearances between live parts and insulated metal parts which become a live part due to insulation deterioration.
3. Creepage distances are to be determined by insulation thermal class and shape.
   "*a*" applies to ceramic insulators (steatite and porcelain) and other comparable insulators, provided with ribbed construction or vertical partitions especially deigned to prevent any electricity leaks, which are recognized by experimentation to be equally as effective as ceramic insulators and which have tracking indices greater than 140*V*, *e.g.* phenol resins formed items.
   "*b*" applies to all other insulation materials.
4. In cases where "*L-A*" is greater than the corresponding creepages "*a*" or "*b*", creepage distances between live parts and insulated metals which operators may easily come in contact with and which become live parts by due to insulation deterioration are to be "*L-A*" or more.
5. Current values are to be expressed by rated current-carrying values.

2.7.2 Ambient Conditions

1 Electrical appliances incorporating semiconductors are to be suitable for proper operation at ambient temperatures of 55 $^{\circ}C$.

2 Control appliances are not to cause any malfunctions such as undesired switching motions or change in status in cases where they are inclined to angles of 45° in any direction. However, electromagnetic contactors are to comply with **2.6.3-2(1)**.

2.8 Controlgears for Motors and Magnetic Brakes

2.8.1 Controlgears for Motors

1 Controlgears for motors are to be durably constructed and provided with efficient means for starting, stopping, reversing and controlling speed as well as be equipped with all essential safety devices.

2 Controlgears for motors are to be provided with protective enclosures suitable for their location and to allow for safe operation by their personnel.

3 All wearing parts of controlgears are to be easily replaceable and accessible for inspection and maintenance.

4 Motors above 0.5*kW* are to be provided with the controlgears complying with those requirements given in **-1**, **-2** and **-3** above and in the following **(1)** to **(3)**:

(1) Means are to be provided to prevent any undesired restarting after stoppages due to low voltage or complete loss of voltage. This requirement does not apply to those motors continuous availability of which are essential to the safety of the ship and to those motors operated automatically.

(2) Primary means of isolation are to be provided so that all power may be cut off from motors, except in cases where such means of isolation (provided at switchboards, section boards, distribution boards, etc.) are adjacent to motors.

(3) Means to automatically disconnect power supplies are to be provided in the event of excess current due to mechanical overloading of motors. This requirement does not apply to those motors for steering gears.

5 In cases where primary means of isolation are remote from motors, either of the following means or their equivalent is to be provided:

(1) Additional means of isolation fitted adjacent to motors are to be provided.

(2) Provisions are to be made for locking primary means of isolation in “off” positions.

6 In cases where fuses are used to protect three-phase *a.c.* motor circuits, consideration is to be given to protect against any single phasing.

2.8.2 Magnetic Brakes

1 Electrical parts of magnetic brakes applied to watertight-type motors are to be watertight.

2 *D.C.* shunt-wound brakes are to satisfactorily release at 85% of their rated voltage at maximum working temperatures, and *d.c.* compound-wound brakes under the same conditions as above are to satisfactorily release at 85% of their starting currents.

3 *D.C.* series-wound brakes are to satisfactorily release at 40% or more of their full-load currents and in every case at their starting current; furthermore, they are to satisfactorily dampen in cases where they are at 10% or less of their full-load currents.

4 *A.C.* magnetic brakes are to comply with the following **(1)** and **(2)**:

(1) *A.C.* magnetic brakes are to satisfactorily release at 80% of their rated voltages at working temperatures.

(2) *A.C.* magnetic brakes are not to be noisy due to any magnetic action under working conditions.

2.8.3 Temperature Rise

Temperature rises of controlgears for motors are not to exceed, under specified currents or rated voltages, the values given in **Table 8.2.12**, except as separately specified in this Part.

Table 8.2.12 Limits of Temperature Rise of Controlgears for Motors (Based on ambient temperatures of 45°*C*)

<table>
<tr><th colspan="4">Item and part</th><th>Limits of temperature rise (*K*)</th></tr>
<tr><td rowspan="6">Coils (air)</td><td colspan="3">Thermal class *A*</td><td>60</td></tr>
<tr><td colspan="3">Thermal class *E*</td><td>75</td></tr>
<tr><td colspan="3">Thermal class *B*</td><td>85</td></tr>
<tr><td colspan="3">Thermal class *F*</td><td>110</td></tr>
<tr><td colspan="3">Thermal class *H*</td><td>135</td></tr>
<tr><td colspan="3">Thermal class *N*</td><td>155</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></tr>
<tr><td>Silver or silver alloy</td><td>70</td></tr>
<tr><td rowspan="2">Switch on & off one attempt or more in about 8 *hours*</td><td>Copper or copper alloy</td><td>60</td></tr>
<tr><td>Silver or silver alloy</td><td>70</td></tr>
<tr><td colspan="2">Multilayer form or knife form</td><td>Copper or copper alloy</td><td>35</td></tr>
<tr><td colspan="4">Busbar and connecting conductor (bare or Thermal class *A* and higher)</td><td>60</td></tr>
<tr><td colspan="4">Terminals for external cables</td><td>45</td></tr>
<tr><td rowspan="5">Metallic resistors</td><td colspan="3">Moulded-case type</td><td>245</td></tr>
<tr><td colspan="2" rowspan="3">Those other than moulded-case type</td><td>For continuous use</td><td>295</td></tr>
<tr><td>For intermittent use</td><td>345</td></tr>
<tr><td>For starter use</td><td>345</td></tr>
<tr><td colspan="3">Exhaust (approx. 25*mm* above exhaust port)</td><td>170</td></tr>
</table>

Note:

The term “moulded-case type metal resistor” refers to those resistors which are to be buried in the insulation so that no surfaces of any metallic resistors are exposed.

2.8.4 Shop Tests

1 Controlgears for motors are to be tested in accordance with the requirements given in this **2.8.4**. However, those tests required by **-2** below may be omitted subject to the Society’s permission for each controlgear and magnetic brakes which is produced in series having identical type with its first unit.

2 Controlgears for motors are to undergo the temperature tests under normal working condition, and any temperature rise of each is not to exceed those values given in **2.8.3**.

3 Functions of instruments, switching gears, protective devices, etc. of controlgears for motors are to be verified.

4 Controlgears for motors as well as all components, are to be able withstand high voltages by applying the following voltages at commercial frequencies for a period of 1 *minute* between all current-carrying parts of switchgears, including control devices and earths as well as between poles or phases. Instruments and auxiliary apparatus may be disconnected during these high voltage tests.

Rated voltage of 60*V* or less: 500*V*

Rated voltage exceeding 60*V*: 1,000*V* + twice the rated voltage (minimum 1,500*V*)

5 Immediately after such high voltage tests have been performed, the insulation resistance between all current-carrying parts connected and earths as well as between current-carrying parts of opposite polarities or phases are not to be less than $1M\Omega$ in cases where tested with *d.c.* voltage of at least 500*V*.

2.9 Cables

2.9.1 General

Cables are to comply with *IEC Publication* 60092 or any equivalent thereto. Installation of cables is to comply with the requirements given in this **2.9**.

2.9.2 Choice of Cables

1 The rated voltage of any cable is not to be lower than the nominal voltage of the circuit for which it is used.

2 Separate cables are, as a rule, to be used for those power supply circuits requiring individual short-circuits and overcurrent protection.

3 Maximum rated conductor temperatures of materials used in cables are to be at least $10^{\circ}C$ higher than those maximum ambient temperatures likely to exist, or be normally produced, in those spaces where such cables are installed.

2.9.3 Choice of Protective Coverings

Cables are to be protected by sheaths and/or metal armour in accordance with the following **(1)** to **(3)**:

(1) Cables fitted on weather decks, in bath rooms, cargo holds, machinery spaces, or any other locations where water, oil or explosive gases may be present are to be sheathed.

(2) In permanently wet situations, metallic sheaths are to be used for those cables with hygroscopic insulation.

(3) Cables fitted on weather decks, in cargo holds, in machinery spaces, etc., in locations where they can easily suffer from mechanical damage are to be protected by metal armour except in those cases where effective metallic casings or non-metallic casings complying with the requirements specified in **2.9.13-3(4)** are provided.

2.9.4 Flame Retardancy

Cables, except special types of cables such as radio frequency cables, as a rule, are to be of flame retardant types.

2.9.5 Maximum Continuous Load

The maximum continuous load carried by a cable is not to exceed its current rating specified in **2.9.9**. The diversity factor of the individual loads may be taken into account in estimating the maximum continuous load.

2.9.6 Voltage Drop

The voltage drop from main or emergency switchboard busbars to any points in installations except navigation lighting circuits, in cases where cables are carrying maximum current under normal conditions of service, are not to exceed 6% of nominal voltages. However, the voltage drop on supply circuits from batteries with voltages not exceeding 24*V* may be permitted up to 10%.

2.9.7 Assessment of Lighting Loads

In assessing the current rating of lighting circuits, lampholders are to be assessed at those maximum loads which they are likely to be connected to, with a minimum of 60*W*, unless such fittings are so constructed as to take only one lamp rated at less than 60*W*.

2.9.8 Current Rating for Short-time or Intermittent Loads

Cables supplying motors used for cargo winches, windlass, capstan, etc. are to be suitably rated for their duties. In such cases, consideration is to be given to voltage drop.

2.9.9 Current Rating of Cables

The current rating of cables is to comply with the following **(1)** to **(5)**.

(1) The current rating of cables for continuous service is not to exceed the values given in **Table 8.2.13**.

(2) The current rating of cables for short-time services (30 *minutes* or 60 *minutes*) may be increased by multiplying the value given in **Table 8.2.13** by the following correction factor.

correction factor: $\sqrt{1.12/(1-exp(-ts/0.245/d^{1.35}))}$

ts: 30 or 60 (*min*)

d: overall diameter of the finished cable (*mm*)

(3) The current rating of cables for intermittent services (for periods of 10 *minutes*, of which 4 *minutes* are with constant loads and 6 *minutes* without any loads at all) may be increased by multiplying the value given in **Table 8.2.13** by the following correction factor.

correction factor: $\sqrt{\dfrac{1-exp(-10/0.245/d^{1.35})}{1-exp(-4/0.245/d^{1.35})}}$

d: overall diameter of the finished cable (*mm*)

The current rating for other intermittent ratings is to be deemed appropriate by the Society.

(4) In cases where more than 6 cables belonging to the same circuit are bunched together, a correction factor of 0.85 is to be applied.

(5) In cases where ambient temperatures are different from those specified in **(1)** to **(3)**, the correction factor in **Table 8.2.14** may be applied.

Table 8.2.13 Current Ratings of Cables (for continuous service) (Based on ambient temperatures of 45 °*C*)

Nominal sectional area of conductor (mm^2)	Current rating in amperes											
	PVC insulation (general purpose) (70 °*C*)			*PVC* insulation (heat resisting) (75 °*C*)			*EP* rubber insulation and Cross-linked polyethylene Insulation (90 °*C*)			Silicon rubber insulation and Mineral insulation (95 °*C*)		
	1 core	2 cores	3 cores	1 core	2 cores	3 cores	1 core	2 cores	3 cores	1 core	2 cores	3 cores
1.5	12	13	11	17	14	12	23	20	16	26	22	18
2.5	17	18	15	24	20	17	30	26	21	32	27	22
4	22	25	20	32	27	22	40	34	28	43	37	30
6	29	31	26	41	35	29	52	44	36	55	47	39
10	51	43	36	57	48	40	72	61	50	76	65	53
16	68	58	48	76	65	53	96	82	67	102	87	71
25	90	77	63	100	85	70	127	108	89	135	115	95
35	111	94	78	125	106	88	157	133	110	166	141	116
50	138	117	97	150	128	105	196	167	137	208	177	146
70	171	145	120	190	162	133	242	206	169	256	218	179
95	207	176	145	230	196	161	293	249	205	310	264	217
120	239	203	167	270	230	189	339	288	237	359	305	251
150	275	234	193	310	264	217	389	331	272	412	350	288
185	313	266	219	350	298	245	444	377	311	470	400	329
240	369	314	258	415	353	291	522	444	365	553	470	387
300	424	360	297	475	404	333	601	511	421	636	541	445

Note: The values in this table are not applied to cables which do not satisfy the maximum rated conductor temperature of the concerned insulation.

Table 8.2.14 Correction Factor for Various Ambient Temperatures

Maximum rated conductor temperature of insulation	Correction factor									
	40 °*C*	45 °*C*	50 °*C*	55 °*C*	60 °*C*	65 °*C*	70 °*C*	75 °*C*	80 °*C*	85 °*C*
70 °*C*	1.10	1.00	0.89	0.77	0.63	–	–	–	–	–
75 °*C*	1.08	1.00	0.91	0.82	0.71	0.58	–	–	–	–
90 °*C*	1.05	1.00	0.94	0.88	0.82	0.74	0.67	0.58	0.47	–
95 °*C*	1.05	1.00	0.95	0.89	0.84	0.77	0.71	0.63	0.55	0.45

2.9.10 Installation of Cables

1 Cable runs are to be, as far as possible, straight and accessible.

2 The installation of cables across expansion joints within ship structure is to be avoided as far as possible. In cases where such installations are unavoidable, loops of cable of lengths proportional to the expansion of such joints are to be provided. The internal radius of such loops is to be at least 12 *times* the external diameter of the cable.

3 In cases where duplicate supplies are required, those two cables are to follow different routes which are to be as far apart as practicable.

4 Cables having insulating materials with different maximum-rated conductor temperatures are not to be bunched together, or, in cases where such bunching is unavoidable, such cables are to be operated so that no cable may reach a temperature higher than that permitted for the lowest temperature-rated cable in the group.

5 Cables having protective coverings which may damage the coverings of other cables are not to be bunched together with those other cables.

6 When installing cables, the minimum inside radius of bends are to be in accordance with the following:

(1) Armoured rubber insulated and *PVC* insulated cables: 6*d*

(2) Unarmoured rubber insulated and *PVC* insulated cables: $4d\left(d \le 25mm\right)$ or $6d\left(d > 25mm\right)$

(3) Mineral insulated cables: 6*d*

(*d*: overall diameter of the finished cable (*mm*))

7 Intrinsically safe circuit installations are to comply with the following:

(1) Cables for intrinsically safe circuits associated with intrinsically safe type electrical equipment are to be of exclusive use, being installed separately from other cables used for general circuits.

(2) Intrinsically safe circuits associated with different intrinsically safe type electrical equipment are, as a rule, to be wired individually using different cables. In cases where it is necessary to use multi-core cables in common, cables which have shields for each core or each pair of cores are to be used and such shields are to be effectively earthed. However, intrinsically safe circuits associated with category '*ia*' types of intrinsically safe type electrical equipment are not to be contained in cables associated with category '*ib*' types of intrinsically safe type electrical equipment.

2.9.11 Cables in Hazardous Areas

In cases where cables installed in hazardous areas are at risk of fire or explosions due to electrical faults in such areas, proper protections against such risks are to be provided.

2.9.12 Earthing of Metallic Coverings

1 Metallic coverings of cables are to be effectively earthed at both ends unless otherwise stated in this Part. However, in the case of final sub-circuits, earthing may be at supply ends only. This does not necessarily apply to any instrumentation cables in cases where single point earthing may be desirable for technical reasons.

2 Effective means are to be taken to ensure that all metallic coverings of cables are made electrically continuous throughout their entire length.

3 Lead sheaths of lead-sheathed cables are not to be used as the sole means of earthing any non-current carrying parts of electrical equipment.

2.9.13 Supports and Fixing of Cables

1 Cables and wires are to be supported and secured so that they may not be injured by any chafing or other mechanical damage.

2 Distances between supporting and fixing points are to be suitably chosen according to cable type and vibration probabilities, and are not to exceed 40*cm*. With respect to horizontal cable runs, except for those along weather decks, in cases where such cables are laid on cable supports in the form of hanger ladders, etc., spacing between any fixing points may be up to 90*cm* provided that there are supports which have a maximum spacing of 40*cm*. Cable runs in cases where cables are installed in ducts or pipes are to be as deemed appropriate by the Society.

3 Clips, supports and accessories are to comply with the following **(1)** to **(4)**:

(1) Clips are to be robust and are to have surface areas large enough and shaped in ways so that cables remain tight without their coverings being damaged.

(2) Clips, supports and accessories are to be made of corrosion-resistant materials or to be suitably corrosion inhibited before erection.

(3) Non-metallic clips are to be in accordance with the following **(a)** and **(b)**:

- (a) They are to be made of flame-retardant material.
- (b) They are to be arranged so as to prevent any cables from becoming slack in the event of fire except in cases where they are laid horizontally on supports.

(4) Non-metallic supports are to be in accordance with the following **(a)** to **(g)**:

- (a) They are to be of types that have passed any tests otherwise specified by the Society.
- (b) They are to be sufficiently durable under any possible surrounding conditions.
- (c) They are to be suitable for ambient temperatures.
- (d) They are to be electrically conductive in cases where they are used in dangerous spaces.
- (e) They are to be protected against UV light in cases where they are used on open decks.
- (f) They are to be fixed with support spacing which is not to be greater than that used in those tests referred to in **(a)** above or 2*m*, whichever is less.

(g) They are to be supplemented by metallic fixings to prevent any supports and cables from falling in the event of fire.

2.9.14 Penetration of Bulkheads and Decks

1 Penetration of bulkheads and decks, which are required to have some degree of strength and tightness, is to be carried out by means of cable glands or boxes so as to ensure that strength and tightness are not impaired.

2 In cases where cables pass through non-watertight bulkheads or steel structures, holes are to be bushed with suitable materials in order to avoid any damage to such cables. If the thickness of the steel is sufficient ($\geq 6mm$) and there is no risk of damage to any cables, adequately rounded edges may be accepted as the equivalent of bushing.

3 The choice of the materials for glands and bushings is to be such that there is no risk of corrosion.

2.9.15 Mechanical Protection of Cables

1 Cables without metal armour which are exposed to risks of mechanical damage are to be protected by means of effective metallic casings or non-metallic casings complying with the requirements specified in **2.9.13-3(4)**.

2 Cables in cargo holds and other spaces, in cases where there are exceptional risks of mechanical damage, are to be protected by means of effective metallic casings or non-metallic casings complying with the requirements specified in **2.9.13-3(4)**, even in those cases where such cables are protected by metal armour.

2.9.16 Installation of Cables in Pipes and Conduits

1 Metallic or electrically conductive non-metallic pipes and conduits are to be effectively earthed as well as be mechanically and electrically continuous across joints.

2 The internal radius of bend of pipes and conduits is not to be less than those values specified (*See* **2.9.10-6**). However, in cases where such pipes exceed 64*mm* in diameter, the internal radius of bends is not to be less than twice the diameter of such pipes.

3 The internal cross-sectional area of a pipe is to be at least 2.5 *times* the total cross-sectional area of any cables installed within.

4 Horizontal pipes or conduits are to have suitable means of drainage.

5 In cases where pipe arrangements are long, expansion joints are to be provided where necessary.

2.9.17 Cables in Refrigerated Spaces

Cables installed in refrigerated spaces are to comply with the following **(1)** to **(5)**:

(1) In cases where *PVC* insulated cables are used, they are to be capable of withstanding the low temperatures of refrigerated spaces.

(2) Cables are to have lead sheaths or sheaths made out of materials with good water resistant properties and be capable of withstanding the low temperatures of refrigerated spaces.

(3) Cables are not to be, as a rule, embedded in structural heat insulation.

(4) In cases where cables have to pass through structural heat insulation, they are to be installed at right angles to such insulation and are to be protected by pipes, which are sealed at each end.

(5) Cables are to be installed with sufficient space behind the face of any chambers or air duct casings and are to be supported by plating, hangers or cleats. In cases where cables have corrosion-proof layers covering their armour, they may be placed directly on the faces of such chambers or air ducts.

2.9.18 Cables for Alternating Current

In cases where it is necessary to use single-core cables for alternating current circuits rated in excess of 20*A*, the following requirements **(1)** to **(8)** are to apply:

(1) Cables are to be either non-armoured or armoured with non-magnetic materials. In cases where cables are armoured, they are to be earthed at single points.

(2) In cases where they are installed in a pipes or conduits, all cables belonging to the same circuit are to be installed in the same pipes or conduits unless such metallic pipes or conduits are made out of non-magnetic material.

(3) Cable clips are to include cables of all phases of circuits unless such clips are made out of non-magnetic materials.

(4) In cases where two or three single-core cables forming respectively single-phase circuits or three-phase circuits are installed, such cables are to, as far as possible, be in contact with one another. In any case, any distance between adjacent cables is not to be greater than the diameter of such cables.

(5) In cases where single-core cables of current rating greater than 250*A* are run along steel bulkheads, such cables are to be run apart from the steel bulkheads, as far as practicable.
(6) In cases where single-core cables, having a sectional area of 185 mm^2 or over and exceeding 30*m* in length, are used, phases are to be transposed at regular intervals of approximately 15*m* in order to obtain the same degree of impedance of circuits, unless such cables are installed in trefoil formations.
(7) In cases where circuits involving 2 or more single-core cables running in parallel per phase, such cables are to be of the same length and have the same sectional area.
(8) Magnetic materials are not to be placed between single-core cables of a group. In cases where cables pass through steel plates, all cables of the same circuit are to pass through plates or glands constructed so that any distance between such cables and magnetic materials is not less than 75*mm*, unless such cables are installed in trefoil formations.

2.9.19 Terminals, Joints and Branches of Cables

1 Cables are to be jointed by terminals. However, in cases where deemed appropriate by the Society, these requirements do not apply. Soldering fluxes containing corrosive substances are not to be used.
2 Terminals are to have sufficient contacting surfaces and pressures.
3 The length of any soldered parts of copper tube terminals and other terminals is not to be less than 1.5 *times* the diameter of conductors.
4 Cables not having moisture-resistant insulation (*e.g.* mineral insulation) are to have their ends effectively sealed against any ingress of moisture.
5 Terminals and joints (including branches) of all cables are to be made so as to retain the original electrical, mechanical, and flame-retardant.
6 Terminals and conductors are to be of dimensions adequate for the relevant cable ratings.

2.10 Transformers for Power and Lighting

2.10.1 Scope

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 given in this **2.10**.

2.10.2 Construction

1 Transformers in accommodation spaces are to be of dry, naturally cooled types. In machinery spaces, they may be of oil-immersed, naturally cooled types.
2 Transformers, except those for motor starting, are to be double wound (two separate windings).
3 Oil-immersed transformers rated at 10*kVA* or more are to be provided with oil gauges and drain cocks or plugs, and those rated at 75*kVA* or more are also to be provided with thermometers.
4 All transformers are to be capable of withstanding, without suffering any damage, thermal and mechanical effects of short-circuits at terminals of any winding for a period of 2 *seconds*.
5 Transformers are to have current limiting devices as needed in order to prevent excessive voltage drop on the system caused by current inrush when the transformers are switched on.

2.10.3 Temperature Rise

Temperature rises of transformers are not to exceed those values given in **Table 8.2.15** during any continuous operation at rated outputs.

2.10.4 Modification of the Limits of Temperature Rise

1 In cases where ambient temperatures exceed 45 $^{\circ}C$, limits of temperature rise are to be decreased by the difference from those values given in **Table 8.2.15**.
2 In cases where temperatures of primary coolants do not exceed 45 $^{\circ}C$, the limits of temperature rise may be increased in those cases deemed appropriate by the Society.
3 In cases where ambient temperatures do not exceed 45 $^{\circ}C$, limits of temperature rise may be increased by the difference from those values given by **Table 8.2.15**. In such cases, ambient temperatures are not to be set below 40 $^{\circ}C$.

Table 8.2.15 Limits of Temperature Rise of Transformers (Based on ambient temperatures of 45 °C)

Part		Limits of temperature rise (K)					
		Measuring method	Thermal class A	Thermal class E	Thermal class B	Thermal class F	Thermal class H
Windings	Dry type transformer	Resistance method	55	70	75	95	120
	Oil-immersed transformer	Resistance method	60	-	-	-	-
Oil		Thermometer method	45				
Core		Thermometer method	Not exert injurious effects on adjacent insulations				

2.10.5 Voltage Regulation

Voltage regulation of transformers is not to exceed the following values at full loads and 100% power factors:

Single phase 5kVA or more and three-phase 15kVA or more: 2.5%

Single phase less than 5kVA and three-phase less than 15kVA: 5%

2.10.6 Shop Tests

1 Transformers are to be tested in accordance with the requirements in this **2.10.6**. However, those tests required by **-2** may be omitted for those transformers which are produced in a series of identical types from the second unit onward subject to Society approval.

2 Temperature rises of transformers under rated full loads are not to exceed those values given in **2.10.3**.

3 Transformers are to undergo voltage regulation tests and are to comply with the requirements given in **2.10.5**. However, it may be permissible to obtain such information from calculations.

4 Immediately after such temperature tests have been performed, transformers are to be able to withstand high voltages by applying *a.c.* 1,000V plus twice the maximum line voltages of commercial frequencies, between windings and between windings and earths for a period of 1 *minute*. Test voltages in these tests are to be at least 1,500V.

5 Transformers are to be able to withstand for the duration of the test given by the following formula those cases where twice the normal voltage is induced on the winding at any frequency between 100 and 500Hz. However, the duration of such tests is to be for a period of at least 15 *seconds*, but not more than 60 *seconds*:

$$\text{Testing time } (second) = 60 \times \frac{2 \times \text{Rated frequency}}{\text{Test frequency}}$$

2.11 Accumulator Batteries

2.11.1 General

1 The requirements given in this **2.11** apply to all permanently-installed vented type secondary batteries. Vented type secondary batteries are those ones in which electrolytes can be replaced and which may release gases when they are being charged and/or overcharged.

2 Any usage of types of secondary batteries other than vented types is required to be as deemed appropriate by the Society.

3 Accumulator batteries are to be able suitably perform with respect to their intended service.

2.11.2 Construction

Cells of all batteries are to be constructed and secured so as to prevent any spilling of electrolytes due to ship motion as well as to prevent any emission of acid or alkaline spray.

2.11.3 Location

1 Alkaline batteries and lead acid batteries are not to be installed in the same compartment.

2 Large batteries are to be only installed in those compartments assigned to them. They may be installed in boxes on deck if adequately ventilated and provided with means to prevent any ingress of water.

3 Engine starting batteries are to be located as close as practicable to those engines served. If such batteries cannot be accommodated in battery rooms, they are to be installed at places where adequate ventilation is ensured.

4 Batteries are not to be placed in accommodation spaces.

2.11.4 Installation Procedures and Protection from Corrosion

1 Batteries are to be arranged to permit ready access for replacing, inspecting, testing, replenishing and cleaning.

2 Cells or crates are to be placed on non-absorbent isolating supports. They are to be fitted to prevent any movement due to ship motion.

3 In cases where acid is used as the electrolyte, trays made out of acid resisting materials are to be provided below such cells unless those decks below are similarly protected.

4 The interior of battery compartments including any shelves is to be coated with corrosion-resistant paint.

5 The interior of ventilating ducts and impellers of ventilating fans are to be coated with corrosion-resistant paint unless such ducts and fans are made of corrosion-resisting material.

2.11.5 Ventilation

1 Battery compartments are to be adequately ventilated by independent ventilation systems.

2 In cases where natural ventilation is employed, ventilation ducts are to be run directly from the top of battery compartments to the open air above, with no parts of the ducts at angles of more than 45° from vertical.

3 If natural ventilation is impracticable, mechanical exhaust-ventilation is to be provided. Electric motors for the ventilating fans are not to be placed inside any ducts. Ventilating fans are to be constructed and to be made of such materials so as to render any sparking impossible in the event of impellers touching fan casings.

2.11.6 Electrical Installations

1 Switches, fuses and other electrical installations liable to cause arcs are not to be installed in battery compartments.

2 Lighting fittings provided within battery compartments are to comply with the requirements given in **2.16** and to be suitable for use in explosive atmospheres classified into gases and vapours group *IIC* and temperature class *T*1 as specified in *IEC Publication* 60079 or any equivalent thereto.

3 Cables other than those for batteries and electrical installations specified in **-2** above are, as a rule, not to be installed in battery compartments except in cases where installation in other locations is impracticable.

2.11.7 Charging Facilities

1 Suitable charging facilities are to be provided. Battery charging facilities by means of *d.c.* generators and series resisters are to be provided with protection against any reversal of currents when charging voltages are at 20% of line voltages or higher.

2 In the case of floating service or for any other conditions where loads are connected to batteries while they are charging, maximum battery voltages under any conditions of charging are not to exceed those safe values of any connected apparatus. Voltage regulators or other means of voltage control may be provided for this purpose.

2.12 Semiconductor Converters for Power

2.12.1 General

1 The requirements given in this **2.12** are to apply to semiconductor converters for power (hereinafter referred to as “converters”) not less than 5*kW*.

2 Converters are to be in accordance with all applicable requirements given in this Part, and standards are, as far as practicable, to be deemed appropriate by the Society.

2.12.2 Construction and Location

1 Semiconductor valve units, semiconductor stacks or semiconductor elements are to be arranged so that they can be removed from equipment without dismantling the complete unit.

2 Effective means are to be provided in convertors to prevent any accumulation of moisture and condensation unless such convertors are located in air-conditioned spaces.

3 Transformers for converters are to be of two separate windings.

4 In case where semiconductor elements are connected in a series or in parallel, they are to be arranged so that voltages or currents for each element will become equal as far as practicable.

5 Converters are to be installed with effective cooling devices in order to maintain temperature rises of semiconductor elements or semiconductor stacks below allowable levels. In such cases, such equipment is to be installed in such a manner that coolant circulation is not impeded and that the temperature of the air at inlets to air-cooled semiconductor elements or semiconductor stacks does not exceed allowable values.

6 Converters are to be separated from resistors, steam pipes or other sources of radiant heat as far as practicable.

2.12.3 Protective Devices, etc.

1 In cases where forced cooling devices are provided, converters are to be arranged so that they can not remain loaded unless effective cooling is maintained.

2 In case where necessary, means are to be provided to guard against any transient over-voltage caused by switching and breaking of circuits and any *d.c.* voltage rise due to regenerative power.

3 Protecting fuses for semiconductor elements are to be co-ordinated with characters of semiconductor elements as far as practicable.

4 Over voltages in those supply systems to which convertors are connected are to be limited by suitable devices to prevent any damage.

5 Semiconductor elements and filter circuits are to be protected by fuses, etc.

2.12.4 Shop Tests

1 Converters and their accessories are to be tested in accordance with the requirements in this **2.12.4**. However, those tests required by **-2** below may be omitted, subject to Society approval, for those products which are produced in a series of identical types from the second unit onward.

2 Temperature rise tests for converters and their accessories are to be carried out under normal working conditions, and test results are not to exceed those values specified in the requirements given in **2.8.3**. Furthermore, temperature test methods for semiconductor element connections are to be as deemed appropriate by the Society.

3 Instruments, switching devices and protective devices fitted in converters are to be checked for normal operation under operating conditions.

4 Converters are to withstand high voltages by applying the following *a.c.* voltages for a period of 1 *minute* between semiconductor elements or live parts of accessories charged with main circuit potential and earths.

Testing voltage (V) = $1.5EP_i + 1{,}000$ (minimum 2,000V)

EP_i : Maximum voltage values are to be impressed on the reverse side of convertor circuit arms

In cases where *d.c.* voltages are less than 100V, minimum testing voltages may be 1,500V. Semiconductor elements are to be short-circuited before such tests.

5 High voltage tests between live parts and earths for accessories charged with auxiliary circuit potential are to be in accordance with the requirements given in **2.8.4-4**.

6 Immediately after such high voltage tests have been performed, insulation resistance between live parts of converters and their accessories and earths is not to be less than $1M\Omega$ when tested with *d.c.* voltages of at least 500 V.

2.13 Lighting Fittings

2.13.1 General

Lighting fittings are to comply with the requirements given in this **2.13**.

2.13.2 Construction

1 Ratings of lampholders are to be in accordance with *IEC Publication* 60092 or other standards that are deemed appropriate by the Society.

2 Lampholders are to be constructed of non-hydroscopic and flame-retardant or incombustible materials.

3 Large lampholders are to be provided with means for locking lamps into their holders.

4 Enclosures are to be composed of metal, glass or synthetic resins having sufficient mechanical, thermal and chemical resistant properties; furthermore, they are to have a suitable degree of protection depending on their location. Synthetic resin enclosures which support current-carrying parts are to be flame retardant.

5 Terminal boxes and leading-in parts of cables are to be of construction suitable for maritime applications. Consideration is to be given so that the insulation of cables does not deteriorate at an early stage due to any temperature rises of terminals and other parts.

6 The internal wiring of lighting fittings is to use wiring which takes into account the effects of ultraviolet rays and heat in order to prevent the early-stage degradation of the cable insulation cover.

7 Lighting fittings installed in machinery spaces or similar other spaces which are exposed to risks of mechanical damage are to be provided with suitable grilled metallic guards to protect their lamps and glass globes against such damage.

2.13.3 Arrangements

Lighting fittings are to be arranged so as to prevent any temperature rises which could damage cables and wiring, and to prevent any surrounding materials from becoming excessively hot.

2.13.4 Fluorescent Lighting Fittings

1 Reactors, capacitors and other auxiliaries are not to be mounted on surfaces which are liable to be subjected high temperatures.

2 Capacitors of $0.5 \mu F$ or more are to be provided with protective leaks or other protective means which reduces the voltage of capacitor to not more than 50*V* within a period of 1 *minute* after disconnection from the supply sources.

3 Transformers are to be installed as close as practicable to their associated discharge lamps.

2.14 Wiring Accessories

2.14.1 General

1 Enclosures are to be made of metal or flame-retardant materials.

2 Insulating materials of live parts are to be made of flame-retardant and non-hygroscopic materials.

2.14.2 Temperature Rises

Temperature rises of live parts are not to exceed 30*K*.

2.14.3 Switches

Switches are to be capable of breaking and making safe load currents equal to 150% of their rated currents at their rated voltages.

2.14.4 Socket-outlets and Plugs

Socket-outlets and plugs are to comply with the following **(1)** to **(5)**:

(1) Socket-outlets and plugs are to be such that they cannot be easily short-circuited regardless of whether plugs are in or out.

(2) Inserting only one pin of plugs into any socket-outlets is to be made impossible.

(3) Socket-outlets of rated currents exceeding 16*A* are to be provided with switches so interlocked that plugs cannot be inserted or withdrawn in cases where switches are in the “on” position.

(4) In cases where distribution systems of different voltages are in use, socket-outlets and plugs are to be of such design that incorrect connections cannot be made.

(5) In cases where socket-outlets with earthing contacts are required, such socket-outlets and plugs are to be provided with additional contacts for earthing casings or frames of appliances. In addition, these earthing contacts are to make contact before live contact pins when inserting the plug.

2.15 Heating and Cooking Equipment

2.15.1 Construction

1 Heating elements are to be suitably protected.

2 Space heaters are to be constructed so as to reduce fire risks to a minimum, and no such space heaters are to be fitted with any elements so exposed that clothing, curtains or other similar materials can be scorched or set on fire by heat from such elements.

2.15.2 Installation

Space heating appliances are to be mounted so that there will be no risk of the dangerous heating of decks, bulkheads or other surroundings.

2.16 Explosion-protected Electrical Equipment

2.16.1 General

Explosion-protected electrical equipment is to be in accordance with the standard deemed appropriate by the Society or any equivalent.

2.17 Tests after Installation on Board

2.17.1 Insulation Resistance Test

1 In the case of circuits of electric propulsion, auxiliary power and lighting, insulation resistance between conductors and earths as well as between conductors is to be measured and its value is not to be less than those values specified in **Table 8.2.17**.

2 Insulation resistance of internal communication circuits is to comply with the following **(1)** and **(2)**. In such cases, any or all appliances connected thereto may be disconnected.

(1) In the case of circuits of $100V$ and above, insulation resistance between conductors and earths as well as between conductors is to be measured, using methods deemed appropriate by the Society, and its value is not to be less than $1\,M\Omega$.

(2) In the case of circuits below $100V$, insulation resistance is to be at least $1/3M\Omega$.

3 The insulation resistance of generators and motors under working temperatures is to be those values specified in **Table 8.2.6**.

Table 8.2.17 Minimum Insulation Resistance

Rated voltage Un (V)	Minimum test voltage (V)	Minimum insulation resistance ($M\Omega$)
$Un \le 250$	$2 \times Un$	1
$250 < Un \le 1{,}000$	500	1
$1{,}000 < Un \le 7{,}200$	1,000	$Un/1{,}000 + 1$
$7{,}200 < Un$	5,000	$Un/1{,}000 + 1$

Note:
During the above tests, any or all electric heaters, small appliances and the like which are connected may be disconnected from any circuits.

2.17.2 Performance Tests

1 Generators are to be tested in accordance with the requirements **(1)** to **(3)** given below. In addition, during these tests, governor characteristics, voltage regulations and load balances are to satisfy those requirements given in **2.4.2**, **2.4.13** and **2.4.14**:

(1) The operation of overspeed trips and other safety devices is to be demonstrated.

(2) Tests are to be made to demonstrate that voltage regulation and parallel operation are satisfactory.

(3) All generating sets are to be run at full rated loads for durations sufficient enough to demonstrate that temperature rises, communication, absence of vibrations and others are satisfactory.

2 All switches, circuit-breakers and associated equipment on switchboards are to be operated on loads to demonstrate suitability, and also section boxes and distribution boxes are to be tested as above.

3 Motors are to be tested in accordance with the following requirements **(1)** to **(3)**:

(1) Motors and their controlgears are to be examined under working conditions to demonstrate that wiring, capacity, speed and operation are satisfactory.

(2) Motor driving auxiliary machinery is to be run to demonstrate that operating characteristics are satisfactory.

(3) All motors driving cargo winches and windlasses are to hoist and lower their specified loads.

4 Lighting systems are to be tested in accordance with the following:

All circuits are to be tested to demonstrate that lighting fittings, branch boxes, switches, socket-outlets and other accessories are effectively connected and function satisfactorily.

5 Internal communication systems are to be thoroughly tested to demonstrate they are suitable and specified functioning. Particular attention is to be paid to those tests of operation of the essential electrical communication systems of ships which include engine order telegraphs, helm indicators, fire alarms, emergency signals, Morse signal lamps, navigation light indicator panels and telephones.

2.17.3 Voltage Drop

During then above tests, it is to be ascertained that any voltage drop of feeder circuits do not exceed those values specified in **2.9.6**.

Chapter 3 DESIGN OF INSTALLATIONS

3.1 General

3.1.1 General

This chapter specifies the requirements regarding design for installations of main sources of electrical power, reserve sources of electrical power and other electrical installations on board ships.

3.1.2 Design and Construction

Electrical installations are to comply with the following:

(1) All electrical auxiliary services necessary for maintaining ships in normal operational and habitable conditions are to be ensured without recourse to any reserve sources of electrical power;

(2) Electrical services essential for safety are to be ensured under various emergency conditions; and

(3) The safety of passengers, crews and ships from electrical hazards is to be ensured.

3.2 Sources of Electrical Power and Lighting Systems

3.2.1 Main Sources of Electrical Power

1 Main sources of electrical power of sufficient capacity to supply all those services specified in **3.1.2(1)** are to be provided.

2 Those arrangements of ships main sources of electrical power are to be such that those services referred to in the requirement given in **3.1.2(1)** can be maintained regardless of the speed and direction of propulsion machinery or shafting.

3.2.2 Lighting Systems

1 Main electric lighting systems supplied from main sources of electrical power are to be provided in those spaces or compartments which crew and personnel normally use and where they work while on duty.

2 Reserve lighting is to provide sufficient illumination necessary for safety in the following locations:

(1) Launching stations of life rafts as well as the outboard sides in the vicinity

(2) All corridors, stairs and exits

(3) Machinery spaces and places where reserve sources of electrical power are installed

(4) Control stations of main engines

(5) Other locations where the Society deems necessary

3.2.3 Reserve Source of Electrical Power

A reserve source of electrical power capable of supplying simultaneously the services listed in the following for 3 *hours* (for continuous 30 *minutes* for intermittent operation services of signals and alarms) is to be provided.

(1) All internal communication equipment as required in an emergency

(2) Navigation lights and other lights, and sound signals

(3) Reserve lighting specified in **3.2.2-2**

(4) Fire detection and alarm systems required by **5.1.1-1, Part 9**

(5) Intermittent operation of daylight signaling lamps, the ship whistles, manual fire alarms as well as all internal signals required during emergencies

(6) Other electrical equipment as deemed necessary by the Society

3.3 Steering Gear

3.3.1 General

See **Chapter 12, Part 7**.

3.4 Navigation Lights, Other Lights, Internal Signals, etc.

3.4.1 Navigation Lights

1 Navigation lights are to be connected separately to the navigation light indicator panel.

2 Each navigation light is to be controlled and protected in each insulated pole by a switch with fuses or a circuit breaker fitted on the navigation light indicator panel.

3 Switches and fuses are not to be provided on the feeder circuits of navigation lights, except the switchboards and indicator panel.

4 The navigation light indicator panel is to be placed in an accessible position on the navigation bridge.

5 In the event of the failure of navigation lights due to blown bulbs, short-circuits, etc., visual and audible alarms are to activate on navigation light indicator panels. Such alarm devices are to be fed from the main sources and reserve sources of power and their feeder circuits are to be independent of the feeder circuits from navigation light indicator panels to navigation lights.

3.4.2 Not Under Command Lights, Anchor Lights and Signal Lights

Not under command lights, anchor lights and signal lights are to be power supplied from both main source of electrical power and reserve source of electrical power.

3.4.3 General Emergency Alarm Systems

General emergency alarm systems are to be power supplied from both main source of electrical power and reserve source of electrical power.

3.4.4 On-board Communication Systems

Those on-board communication systems are to be supplied power from electrical source(s) suitably located for use during emergencies.

3.5 Lightning Conductors

3.5.1 General

Lightning conductors are to be fitted on each mast of ships having wooden masts or topmasts.

3.5.2 Construction

1 Lightning conductors are to be composed of continuous copper tape or rope having sections not less than 75 mm^2 which are riveted with copper rivets or fastened with copper clamps to suitable copper spikes not less than 12 mm in diameter, projecting at least 150 mm above the top of masts. At lower ends, this copper tape or rope is to be securely clamped to the nearest metal forming part of ships.

2 Lightning conductors are to be run as straight as possible and any sharp bends in these conductors are to be avoided. All clamps used are to be made of brass or copper, preferably of the serrated contact type, and effectively locked. No connections are to be dependent on soldered joints.

3 The resistance of lightning conductors between mast tops and those points on earth plates or hulls is not to exceed $0.02\,\Omega$.

Chapter 4 ADDITIONAL REQUIREMENTS FOR ELECTRIC PROPULSION PLANTS

4.1 General

4.1.1 Scope

1 Electrical installations for ships which rely solely on propulsion motors for their propulsion (hereinafter referred to as electric propulsion ships in this Chapter) are to meet the relevant requirements specified in this Part, in addition to those given in this Chapter.

2 Semiconductor convertors for propulsion motors are to comply with those requirements given in **-1** above and any other requirements deemed necessary by the Society.

3 Machinery for electric propulsion ships is to meet the relevant requirements in **Part 7** in addition to those given in this Chapter.

4.1.2 Additional Requirements for the Prime Movers Driving Propulsion Generators

1 In cases where ships are manoeuvring from propeller speeds ahead to astern while making ahead, prime movers driving propulsion generators are generally to be provided with control systems capable of absorbing or limiting any regenerated power without tripping any of the overspeed protection devices specified in **2.4.1-2, Part 7**. Furthermore, such prime movers and generators are to be constructed to withstand any revolutions up to the setting revolutions of such overspeed protection devices.

2 All characteristics of governors on prime movers are to be as deemed appropriate by the Society, except in cases where propulsion generators are also used as main generators.

3 In cases where engine speeds are regulated to control propeller speeds, governors are to be capable of being controlled remotely as well as locally. However, in cases where deemed appropriate by the Society, these requirements do not apply.

4 In cases where *d.c.* generators which are to be separately driven are connected electronically in a series, means are to be provided to prevent any reverse running of these generators in the event of the loss of driving power of any single unit in the series.

4.2 Propulsion Electrical Equipment

4.2.1 General

1 Excessive electromagnetic interference of propulsion electrical equipment (*e.g.*, sources of electrical power devices for propulsion, propulsion transformers, propulsion semiconductor convertors, propulsion motors) is not to occur under normal manoeuvring conditions.

2 Propulsion electrical equipment connected to circuits with propulsion semiconductor convertors is to be designed considering the harmonic content effects occurring on such circuits.

4.2.2 General Requirements for Propulsion Motors

1 Propulsion motors are to perform as specified in the following **(1)** to **(5)**:

(1) The amount of available torque is to be sufficient enough for stopping or reversing such ships in a reasonable amount of time when such ships are running at maximum service speeds.

(2) Adequate torque margins are to be provided in *a.c.* propulsion systems to guard against any motors being pulled out of sync during rough weather and at times of turning operations in multiple-screw ships.

(3) Motors are not to produce any harmful torsional vibrations within normal ranges of rotational speeds.

(4) Propulsion motors are to be capable of withstanding a sudden short circuit at their terminals under rated conditions without suffering damage.

(5) Permanent exited motors and their current carrying components are to be capable of withstanding any steady state short circuit currents.

2 In the case of *d.c.* motors liable to go over those speeds specified in **2.4.7** because of propeller missing or propeller racing, overspeed protection devices are to be provided. In such cases, rotors are to be suitably constructed to prevent any damage due to excessive overspeeding.
3 In cases where arrangements permit propulsion motors to be connected to generating plants having a continuous rating greater than the motor ratings, means are to be provided to prevent any continuous operation at the overload or overtorque conditions not permitted for such motors and shaftings.
4 Propulsion motor shafts are to conform to those requirements given in **2.4.11**. In such cases, diameters of rotor shafts in the lengths from those sections where rotors are fixed to the shaft ends of propeller sides are to conform to those requirements given in **2.4.11-3(1)**. The value of F_1 is to comply with those values specified either in **(1)** or **(2)** below:
(1) In cases where motors have bearings at both ends: 110
(2) In cases where motor have no bearings at their propeller sides: 120
5 In cases where the coolers of propulsion motors fail, but restricted service is to be possible.
6 Breaking or blocking systems or decupling systems which can fix the shafts of propulsion motors are to be provided in preparation for those cases where such propulsion motors failure.
7 In cases where the temperature rise for the windings of propulsion motors mentioned above in **4.2.3-3** exceed design allowance values, means of decreasing nominal propulsion power are to be provided.

4.2.3 Construction and Arrangement of Propulsion Rotating Machines

1 Means are to be provided to prevent any accumulation of bilgewater under propulsion motors, generators, exciters or electromagnetic slip-couplings (hereinafter referred to as "propulsion rotating machines" in this Chapter).
2 Slip rings and commutators of propulsion rotating machines are to be suitably arranged so that they can be easily maintained. For the purpose of inspection and repair, easy access is to be provided to each kind of coil and bearing. In cases where the Society considers it necessary, propulsion rotating machines are to be constructed in a way that permits the removal and replacement of their field windings.
3 Temperature sensors for monitoring and alarming are to be provided for the stator windings of *a.c.* machines or the interpoles, mainpoles and compensation windings of *d.c.* machines which exceed ratings of 500 *kW* (or *kVA*).
4 Propulsion rotating machines provided with forced ventilation systems, air ducts or air filters etc., are to have thermometers for measuring cooling air temperatures and visible and audible alarm systems responsible for detecting excessive bearing temperatures. Especially, in cases where water coolers are adopted, additional leakage monitoring systems are to be provided and located so that any leakage water is kept away from the windings.
5 Effective means are to be provided in rotating machines to prevent any accumulation of moisture and condensation.
6 The lubrication of bearings is to be effective at all operational speeds including creep speeds. In cases where forced lubrication systems for bearings are used, such systems are to be provided with alarm devices which give visible and audible alarms in the event of any failure of lubricating oil supplies or any appreciable reduction in lubricating oil pressure. In addition, devices to automatically stop the operation of motors after such alarms have sounded are to be provided as well.
7 Bearings are to be provided with monitoring systems for bearing temperatures and with alarm systems responsible for detecting excessive bearing temperatures.
8 In order to protect generator circuits from electrical failures located on the generator side of generator breakers, differential current protection devices are to be provided for propulsion generators with ratings exceed 1,500 *kW* (or *kVA*).

4.2.4 Temperature Rise of Rotating Machines

In cases where variable speed propulsion rotating machines are fitted with integral fans and have to be operated at speeds below rated speeds at full-load torque, full-load current, full-load excitation or the like, temperature limits according to **Table 8.2.2** of **2.4.3** are not to be exceeded.

4.2.5 Propulsion Semiconductor Convertors

1 Propulsion semiconductor convertors are to be designed to withstand any overcurrents which may be generated during turning and astern motions of ships (under conditions specified in **1.3.2, Part 7**).
2 In cases where semiconductor elements are cooled by forced ventilation, etc., the following preventive measures

are to be provided to respond to any failure of such cooling systems:

(1) Output reduction or decupling measures for propulsion semiconductor convertors, and

(2) In cases where semiconductor elements are connected in parallel, divided into groups, and provided with independent group cooling systems, measures to separate the concerned group from others.

3 Forced cooled propulsion semiconductor convertors are to be provided with means for monitoring effective forced cooling, and alarming in the event of any cooling system failure.

4 In cases where propulsion semiconductor convertors are cooled by the forced ventilation of coolant, alarms are to be given in the event of any coolant leakage.

5 In cases where the sensors which detects speeds and rotor positions of propulsion motors are provided, alarms are to be connected to such sensors and respond in cases of the sensors failure.

6 Semiconductor elements and protective fuses for filter circuits installed in propulsion semiconductor convertors are to be monitored at all times.

4.2.6 Propulsion Transformers

1 Propulsion transformers are to be provided with means for monitoring winding temperatures.

2 In cases where the temperature rise for the windings of propulsion transformers exceed design allowance values, means of decreasing propulsion power are to be provided.

3 In cases where liquid cooled transformers are used as propulsion transformers, the following requirements **(1)** to **(3)** are to apply:

(1) Means of monitoring liquid temperatures are to be provided. In addition, prealarms are to be actuated before maximum permissible temperature is attained. In cases where the maximum permissible temperature limit is reached, transformers are to be switched off.

(2) Means of monitoring liquid filling levels by two separate sensors are to be provided. In addition, prealarms are to be actuated before liquid levels below permissible levels. In cases where liquid levels fall below permissible levels, supplies for transformers are to be switched off.

(3) Gas-actuated protection devices are to be provided.

4 Forced ventilated propulsion transformers are to be provided with means of monitoring the operation condition of ventilation devices and cooling air temperatures.

5 Propulsion transformers with closed circuit cooling methods for heat exchangers are to be provided with thermometers for monitoring cooling air temperatures. Especially, in cases where water cooling methods are adopted, additional leakage monitoring systems are to be provided and located so that any leakage water is kept away from the windings.

6 Propulsion transformers are to be protected from short circuit at their secondary also.

4.2.7 Measuring Instruments

Measuring instruments specified below are to be installed on the control panels of propulsion motors or local control positions:

(1) Voltmeters for propulsion motors (only in the case of variable speed control)

(2) Ammeters for propulsion motors (Ammeters for field currents and armatures in the case of *d.c.* motors, Ammeters for main circuits in the case of *a.c.* motors)

4.3 Composition of Electrical Equipment for Propulsion and Electrical Power Supply Circuits

4.3.1 Composition of Electrical Equipment for Propulsion and Auxiliary Machinery for Propulsion

1 Means are to be provided to ensure that the installations or equipment are to be capable of starting propulsion motors and obtaining navigable speeds for ships even though one of those mentioned below becomes inoperative.

(1) Sources of electrical power for propulsion

(2) Transformers for propulsion

(3) Semiconductor convertors (or propulsion motor control devices)

(4) Propulsion motors (including cooling systems and lubricating systems)

(5) Other installations and equipment which the Society deems necessary

2 In cases where sources of electrical power for propulsion correspond to **(1)** and **(2)** below, they may be used as those main sources of electrical power specified in **3.2.1**.

(1) In cases where one set of the sources of electrical power for propulsion is out of operation, those capacities specified in **3.2.1-2** are to be secured by the remaining sources of electrical power for propulsion, which at the same time has a capacity sufficient enough to obtain navigable speeds for ships.
(2) At times of load fluctuations and braking of the propeller, variations of voltage and frequency are to comply with the requirements given in **2.1.2-3**.

4.3.2 Electrical Power Supply Circuits

1 Electrical equipment or installations, in duplicate, in accordance with the requirements given in **4.3.1-1** are to be supplied with electrical power by mutually independent circuits. In such cases, wiring cables are to be separated as far apart as practicable throughout their length.

2 Propulsion systems having two or more generators or motors respectively on single propeller shafts, are to be arranged so that any one unit of them can be taken out of service and isolated electronically.

3 The safety measures specified in the following **(1)** to **(5)** are to be implemented for electrical power supply circuits.

(1) Overcurrent protective devices, if any, in main circuits are to be sufficiently high so that there is no possibility of their operating due to overcurrent caused by manoeuvring in rough weather conditions, turning operations or astern operations (under the conditions specified in **1.3.2, Part 7**).
(2) Means for earth leakage detection are to be installed on electrical power supply circuits to propulsion motors.
(3) Excluding brushless exciting circuits and exciting circuits of rotating machines of less than 500kW, earth leakage detection is to be installed at insulated exciting circuits.
(4) It is to be provided with means of suppressing voltage rises in cases where switches in excitation circuits are opened.
(5) In excitation circuits, there is to be no overload protection that causes the opening of any circuits.

4 In cases where generators are running in parallel and one of them is tripping, power supply systems are to be provided with suitable means of load reductions to protect the remaining generators against unacceptable load steps.

Chapter 5 BARGES

5.1 General

5.1.1 Scope

The requirements of this chapter apply to electrical equipment installed on barges.

5.1.2 General

1 The electrical equipment is to be capable of operating satisfactorily, under the service conditions and environmental conditions on board.

2 The rotating, reciprocating and high temperature parts of electrical equipment and live parts of electrical apparatus for which the operators or other persons are liable to inadvertently touch to, are to be arranged with suitable protections from becoming injured.

3 The electrical equipment is to be so constructed and installed as to be capable of maintenance easily.

4 The electrical equipment used for important system is to be capable of operating easily and certainly, and to be capable of operating satisfactorily except the mooring system, when the barge inclined from the normal at any angle up to 15 *degrees* transversely and 10 *degrees* longitudinally, and when rolling up to 22.5 *degrees* from the vertical.

5 The design and installation of electrical equipment are to be such as to minimize the risk of fire or other electrical accidents due to its failure.

6 Electrical equipment is to be suitable for onboard use and provided with effective protective enclosures for the environmental conditions of the locations where the equipment is installed.

7 The insulation materials and insulated windings of electrical equipment are to be resistant to moisture, salty air and oil vapour.

5.1.3 System Voltage

1 System voltage is not to exceed:

(1) 1,000 *V* for generators, power equipment, cooking and heating equipment connected to fixed wiring;

(2) 250 *V* for lightings, heaters in cabins and public spaces, and other appliances than mentioned in **(1)**.

2 In case where system voltage exceeding the required prescribed in **-1** is adopted, they are to be subject to the approval by the Society in advance.

5.1.4 Clearance and Creepage

1 The clearances and creepages between live parts and between live parts and earthed metals are to be adequate for the working voltage having regard to the nature of the insulating materials and operating conditions.

2 The clearances and creepages inside the terminal box of rotating machinery, switchboard busbars and the controlling equipment, etc. are to comply with the requirements in **2.4.12**, **2.5.4-5** and **2.7.1**.

5.1.5 Limits of Temperature Rise

1 Ambient temperature

For all electrical equipment, the following ambient temperatures are recognized as standard:

(1) For all equipment located in compartment where the boilers are installed and on weather decks: 45°*C* (for rotating machinery 50 °*C*);

(2) For all equipment located in other spaces than specified in **(1)**: 40 °*C*

2 Limits of temperature rise

The limits of temperature rise of generators, motors, switchboards, transformers and starters for motors are to comply with the requirements in this Part.

5.2 Earthing

5.2.1 Earthing of Electrical Equipment

Non-current-carrying metallic parts of fixed electrical equipment and portable electrical apparatus having the rated voltage of 100 *V* and over are to be effectively earthed.

5.2.2 Earthing of Cables

Metallic coverings of cables are to be electrically continuous throughout their length and to be effectively earthed at both ends, except that in final sub-circuits earthing may be at the supply end only.

5.2.3 Exception in Application

Notwithstanding the requirements in **5.2.1**, the earthing of non-current-carrying metallic parts may be dispensed with for double insulated portable apparatuses and for, where approved, other electrical equipment.

5.3 Protective Devices of Electrical Equipment

5.3.1 General

1 Electrical Equipment is to be protected against accidental overcurrents including short-circuit. The protective devices are to be capable of continuously servicing other circuits which are used for the electrical source and/or other important feeder circuit as far as practicable by breaking fault circuit and to be capable of eliminating damage to the systems and hazard of fire.

2 Circuit-breakers and fuses used for the protective devices are to comply with the requirements in **2.6** or equivalent thereto.

5.3.2 Protection against Short-circuit

1 Short-circuit protection is to be provided in each live pole of a direct-current system and in each phase of an alternating current system.

2 Short-circuit protective device is to be capable of breaking short-circuit current in the circuit satisfactorily.

5.3.3 Protection against Overload

1 Overload protection is to be provided in the following line or phase:

(1) Two-wire *D.C*. or single-phase *A.C*. system - at least one line or phase;

(2) Three-wire *D.C*. system - both outer lines;

(3) Three-phase *A.C*. system - at least two phase.

2 Tripping characteristics of overload protective devices (blowing out characteristics for fuse) are to be adequate for the thermal capacity of the electrical equipment and wirings protected.

5.3.4 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. In the case of generators less than 50 *kW* and not arranged to operate in parallel, they may be protected by a multipole-linked switch with fuses or a circuit-breaker in each insulated pole.

2 In the case of generators arranged to operate in parallel, they are to be provided with reverse power protection for *A.C.* system or reverse current protection for *D.C.* system.

5.3.5 Protection of Motors

Each motor used for important system is to be protected from short-circuit and overload. Overload protective device of motor is to have a delay characteristic to enable the motor to start.

5.4 Source of Electrical Power

5.4.1 Generator

1 Aggregate capacity of generators used for important system is to be sufficient to supply the total necessary electrical power for the barge. In *A.C.* generators, they are to have sufficient capacity to permit the starting of the largest motor in the barge during normal operation satisfactorily.

2 Generators used for important system are to withstand any load fluctuation in normal operating condition and always be capable of supplying stable electrical power.
3 Prime movers for generators used for important system are to be provided with speed regulators which will maintain the speed withstanding the load fluctuation of generators.

5.4.2 Switchboards

1 Switchboards are to be constructed and installed in accordance with the requirements in **2.5**, **2.6.1-1** and **2.6.2-1** in general.
2 Switchboards used for important system are to be provided with the instruments prescribed in **2.2.2** and **2.5.6** to **2.5.8** as far as applicable. Where two or more generators are provided but not arranged to operate in parallel, the instruments of switchboard are to be in accordance with the discretion of the Society.

5.4.3 Section Boards and Distribution Boards

Section boards and distribution boards are to be constructed in accordance with the requirements in **2.5**.

5.4.4 Transformers for Lighting and Power

1 Transformers for lighting and power are to be constructed in accordance with the requirements in **2.10.2**.
2 Transformers are to withstand any load fluctuation in normal operating condition and always be capable of supplying stable electrical voltage.

5.4.5 Accumulator Batteries

1 Batteries and their charging facilities are to comply with the requirements in **2.11**.
2 In the case of barge whose navigation lights are solely operated by electrical power, and where the power source is batteries without means of charging during normal navigation, the batteries are to have sufficient capacity for operating hours of navigation lights and operating conditions of themselves.
3 Batteries prescribed in **-2** may be used for starting the internal combustion engines unless this does not give any insecure effect to the function of these batteries.

5.4.6 Reserve Source of Electrical Power

1 The barges whose navigation lights are solely operated electrical power except those for which the electrical power is supplied from pusher are to be provided with at least one set of independent reserve source of electrical power device which has the capacity to supply the power to the navigation lights at least 16 *hours* continuously. This device is to be available immediately instead of main source of electrical power, in the event of failure of the main source of electrical power.
2 In the case of unmanned barge, arrangements are to be made to ensure that reserve source of electrical power specified in **-1** will automatically come into operation in the event of failure of the main source of electrical power.
3 For barge which has two or more generators, one of them may be regarded as a reserve source of electrical power. In this case, all generators are to be so arranged as to be available for the source of electrical power for the navigation lights.
4 Notwithstanding those requirements given in **-1** above, the reserve source of electrical power system may be omitted where the navigation lights having own batteries approved by the Society are used.

5.5 Cables

5.5.1 General

1 Construction, application and current carrying capacity of cable are to be in accordance with the requirement in **2.9.1** to **2.9.16**, respectively.
2 In the case of barge whose electrical power is supplied from the pusher, these feeder cables are to have sufficient strength depending upon the connecting method of the pusher and barge.

5.5.2 Installation of Cables

1 Cable are to be so installed as to avoid damages due to deflection of the hull.
2 When installing cables, the minimum internal radius of bend is to be of adequate to prevent the cables from damage.
3 Where cables having different insulating materials each other are bunched together, considerations are to be

given to the maximum rated conductor temperatures of each cable.

4 Where cables pass through watertight or airtight bulkheads or decks, considerations are to be given to maintain the watertightness or airtightness of these bulkheads or decks.

5.5.3 Mechanical Protection of Cables

Cables fitted in locations, such as cargo holds, where they are likely to suffer mechanical damage, are to be suitably protected by pipes or ducts.

5.5.4 Cable Pipes and Ducts

1 Cable pipes and ducts are to have suitable drainage.

2 Metallic pipes and ducts in above **-1** are to be efficiently protected against corrosion and to be earthed effectively. Non-metallic pipes and ducts are to be of flame-retardant materials.

5.5.5 Securing of Cables

Cables are to be effectively supported and secured by supports and clips which are of corrosion-resistant metallic materials or those protected against corrosion or of flame-retardant non-metallic materials taking account of kind of cable, electrical magnetic force caused by short circuit current, vibration and their installing condition except cables which are portable cords or installed in pipes.

5.5.6 Cable Joint and Branch

Cables is to be jointed or branched in a suitable box with terminals, except where method of connection has no risk of deteriorating water-proof characteristics, flame retardant, mechanical strength or electrical characteristics of cables.

5.6 Distribution

5.6.1 Shore Connections

1 A connection box is to be provided in a suitable position where arrangements are made for the supply of electrical power from a source on shore except those prescribed in **-4**.

2 The connection box is to contain terminals of suitable size 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 system or checking the polarity for direct current system.

3 The cables between the connection box and the switchboard are to be permanently fixed and a pilot lamp for source and a switch or circuit-breaker are to be provided on the switchboard.

4 The switchboard may be used for a shore connection box. In this case, the fittings described in **-2** and **-3** are to be provided on this switchboard.

5 Where the electrical power source on board is a generator, interlocking device is to be provided on the switchboard to prevent parallel operation of the generator on board with the shore main.

5.6.2 Navigation Light Circuits

1 Each navigation light is to be connected independently to the navigation light control panel.

2 Each navigation light is to be controlled and protected in each pole by a switch with fuses or a circuit-breaker fitted on the navigation light control panel.

3 The navigation light control panel is to be served by independent circuit fed from the switchboard or other electrical power source panel for navigation lights.

4 Switches and fuses are not to be provided on the feeder circuits of navigation lights, except on the switchboard or on the control panel. However, automatic control devices for the navigation lights may be provided to them.

5 Navigation light control panel is to be installed at the suitable manned place except for unmanned barges.

5.7 Control Gears

5.7.1 Starters

Starters for motors are to be constructed in accordance with the requirements in **2.7.1** and **2.8.1** as far as applicable.

5.8 Explosion-protected Electrical Equipment

5.8.1 General

Explosion-protected electrical equipment is to be in accordance with the requirements in **2.16**.

5.9 Tank Barges

5.9.1 Scope

Electrical equipment installed on barges intended to carry crude oil or petroleum products having absolute vapour pressures of less than 0.28 *MPa* at 37.8 *°C*, as well as liquid cargoes of a flammable nature are to comply with the requirements in **5.9** and **5.10**.

5.9.2 Distribution Systems

1 Distribution systems are to be one of the following:

(1) Two-wire insulated *d.c*. systems

(2) Single-phase two-wire insulated *a.c*. systems

(3) Three-phase three-wire insulated *a.c*. systems

2 Notwithstanding the requirements given in **-1** above, hull return distribution systems may be used for the systems given in the following **(1)** to **(3)**.

(1) Impressed current cathodic protection systems for external hull protection

(2) Limited and locally earthed systems, provided that any possible resulting currents do not flow directly through any dangerous spaces

(3) Insulation monitoring systems, provided that circulation currents do not exceed 30 *mA* under any circumstances

3 Notwithstanding those requirements given in **-1** above, earthed distribution systems may be used for the following systems:

(1) Intrinsically safe circuits

(2) Power supplies, control circuits and instrumentation circuits in cases where, for technical or safety reasons, earthed systems are necessary. However, this is only provided that currents in hulls are limited to not more than 5 *A* in both normal and fault conditions

(3) Locally earthed systems for limited use or *a.c*. power networks of 1,000 *V* root mean square line voltages and over. However, this is only provided that any arising earthing currents do not flow directly through any hazardous areas

4 Those neutral or earth conductors required for protection against electric shock are not to be bound together with single conductors in hazardous areas.

5.9.3 Hazardous Areas

1 Hazardous areas for tank barges are to be categorized in accordance with those requirements given in **5.10.1**.

2 Areas and spaces not mentioned in **-1** above, but considered to present risks because of the presence of explosive gas atmospheres, are to be categorized as hazardous areas in accordance with those requirements otherwise specified by the Society.

3 Access doors or other openings are not to be provided in the following boundaries except in cases where required for operational purposes and safety reasons. In cases where access doors or other openings are provided, any areas connected to the boundaries of hazardous areas are to be categorized as hazardous areas as well in accordance with those requirements otherwise specified by the Society.

(1) Boundaries between Zone 1 and Zone 2 hazardous areas

(2) Boundaries between hazardous areas and non-hazardous areas

5.9.4 Electrical Installations in Hazardous Areas

1 Electrical installations are not to be installed in hazardous areas unless such installations are important for operational purposes or safety reasons. However, in cases where such installation is necessary, this restriction does not apply to the following electrical installations:

(1) Zone 0

(a) Category '*ia*' intrinsically safe type electrical equipment including simple electrical apparatus

(thermocouples, switching devices, etc.) and their associated cables
(b) Submerged cargo pump motors and their supply cables (In such cases, motors are to be automatically stopped by alarms from at least two independent detecting methods for pump delivery low pressures, lower currents of motors or low liquid levels.)

(2) Zone 1
(a) Those electrical installations specified in **(1)** above
(b) Category '*ib*' intrinsically safe type electrical equipment including simple electrical apparatus (thermocouples, switching devices, etc.) and their associated cables
(c) Flameproof type or pressurized type electrical equipment and their associated cables
(d) Increased safety type, encapsulated type, powder filling type or oil immersion type electrical equipment and their associated cables
(e) Hull fittings (terminals or shell-plating penetrations for anodes or electrodes of impressed current cathodic protection systems, or transducers such as those for depth-sounding or log systems) and their associated cables
(f) Through runs of cables

(3) Zone 2
(a) Those electrical installations specified in **(2)** above
(b) Other electrical equipment deemed appropriate by the Society and their associated cables

2 In cases where electrical equipment is installed in hazardous areas in accordance with the requirement given in **-1** above, it is to be confirmed that such equipment is safe to use in explosive gas atmospheres.

3 Aerials and associated riggings are to be located well clear of any gas or vapour outlets.

4 As a rule, no portable electrical equipment is to be located in any hazardous areas. In cases where it is unavoidable to locate such equipment in hazardous areas, Society approval is needed.

5 All cables are to be one of the following types. In cases where some corrosion is to be expected, *PVC* or chloroprene sheaths are to be applied over any armour or metallic sheaths of cables for corrosion protection.

(1) Mineral insulated and copper sheathed
(2) Lead alloy sheathed and metal armoured
(3) Non-metallic sheathed and metal armoured

6 Installation of cables is to comply with the following:

(1) Cables are to be installed as close to hull centre lines as practicable.
(2) Cables are to be installed sufficiently apart from decks, bulkheads, tanks and each kind of pipe.
(3) Cables are, as a rule, to be protected against mechanical damage. Especially those cables installed on open decks are to be protected by metallic casings or non-metallic casings complying with those requirements specified in **2.9.14-3(4)**. Furthermore, cables and their supports are to be fitted in such a manner as to withstand expansion, contraction and any other effects of hull structures.
(4) Penetration parts of cables or cable pipes through decks and bulkheads of hazardous areas are to be constructed so as to maintain gas-tightness and liquid-tightness as necessary.
(5) In cases where mineral insulated cables are used, special precautions are to be taken to ensure sound terminations.
(6) Cables are to be connected to explosion-protected electrical equipment only by means of glands or equivalent devices.
(7) In cases where cable joints are used, Society approval is necessary. In such cases, cable joints are permitted to be used in Zones 1 and 2. However, with respect to intrinsically-safe circuits, they are permitted to be used in Zone 0.
(8) In cases where cables are immersed in cargoes, the construction of these cables is to be such as to allow them to withstand any substances to which they are exposed, or these cables are to be enclosed in casings, e.g. metallic pipes, which are capable of withstanding any such substances.
(9) In cases where cables run through cargo pump room entrances, they are to be installed in heavy gauge steel pipes or steel ducts with gastight joints.

7 Metallic coverings of power and lighting cables, as listed below, are to be at least earthed at both ends. In cases where it is necessary to use single-core cables for alternating current circuits rated in excess of 20 *A*, metallic coverings of cables are to be earthed at single points. In such cases, no non-earthing points are to be located in hazardous areas.

(1) Cables passing through hazardous areas

(2) Cables connected to equipment installed in hazardous areas

8 Electrical circuits passing through Zone 0 are to be provided with the following measures:

(1) Circuits other than intrinsically-safe circuits are to be automatically disconnected in the event of abnormally low levels of insulation resistance and high levels of leakage current.

(2) Protective systems are to be arranged so that manual intervention is necessary in order to reconnect any circuits after being disconnected as a result of short circuits, overloads or earth-fault conditions.

9 In case where flame-proof type electrical motors for cargo handling equipment are installed in cargo pump rooms located within hazardous areas, motors are to be arranged so that they can be easily approached as well as to allow the carrying out of proper maintenance and inspections.

5.9.5 Lighting in Hazardous Areas

1 In cases where hazardous areas are lit by lighting fittings located in adjacent non-hazardous areas through glazed ports fitted into bulkheads or decks, such glazed ports are to be constructed so as not to impair any of the water-tight, gastight, fireproof and strength integrity properties of such bulkheads and decks. Due consideration is to be given to the ventilation of these lighting fittings so that any excessive temperature rises are not caused on these glazed ports.

2 Lighting fittings installed in cargo pump rooms are to be divided between at least two branch circuits.

3 All switches and protective devices related to those circuits specified in **-2** above are to interrupt all poles or phases and to be located in non-hazardous areas.

5.9.6 Ventilation in Hazardous Areas

1 Ventilators installed in cargo pump rooms are to be arranged in order that no discontinuities of ventilation are expected to occur for long periods of time and so that no accumulation of gas or vapours occurs. In cases where of ventilation failures, alarms are to be activated in continually manned spaces, *e.g.* navigation bridges or machinery control rooms, in addition to those relevant cargo pump rooms.

2 The ventilators specified in **-1** above for tank barges are to be ones that do not to produce any source of ignition in compliance with the requirements given in **3.5.5-1, Part 9**.

3 The ventilation air change ratios in cargo pump rooms are to comply with the requirements given in **3.5.5-1, Part 9**.

5.9.7 Maintenance for Explosion-protected Electrical Equipment

Maintenance deemed appropriate by the Society for explosion-protected electrical equipment in hazardous areas is to be periodically carried out by experienced personnel who are sufficiently trained for such tasks. Documentation for such maintenance is to be kept on board.

5.10 Tank Barges Carrying Liquid Cargoes Having Flashpoint Not Exceeding 60 *°C*

5.10.1 Classification of Hazardous Areas

The following areas or spaces in tank barges carrying liquid cargoes having flashpoints not exceeding 60 *°C* are to be classified as Zone 0, 1 and 2 as shown below:

(1) Zone 0
- (a) Cargo tanks and slop tanks
- (b) Interior of pipes for pressure-relief or venting systems for cargo and slop tanks
- (c) Interior of cargo pipes

(2) Zone 1
- (a) Void spaces adjacent to integral cargo tanks
- (b) Hold spaces containing independent cargo tanks
- (c) Cofferdams and segregated ballast tanks adjacent to cargo tanks (fuel oil tanks, lubricating oil tanks, etc. are regarded as cofferdams; hereinafter, referred to in the same way.)
- (d) Cargo pump rooms
- (e) Enclosed or semi-enclosed spaces (means those spaces separated by decks and bulkheads in cases where conditions of ventilation are significantly different from that of the exposed spaces of tank barges)

immediately above cargo tanks or having bulkheads above and in line with cargo tank bulkheads

(f) Spaces other than cofferdams and segregated ballast tanks, adjacent to and below the top of cargo tanks (for example, trunks, passage-ways, holds, etc.; hereinafter, referred to in the same way.)

(g) Areas on open decks or semi-enclosed spaces on open decks, within a sphere with a 3 *m* radius from any ventilation outlets, cargo tank openings, gas or vapour outlets (for example, cargo tank hatches, sight ports, tank cleaning openings, sounding pipe openings, etc.; hereinafter, referred to in the same way), cargo manifold valves, cargo valves, cargo pipe flanges and cargo pump-room ventilation outlets for pressure release which permits the flow of small volumes of gas or vapour caused by thermal variations

(h) Areas on open decks or semi-enclosed spaces on open decks, within a vertical cylinder of unlimited height and with a 6 *m* radius from the outlet centre, and within a hemisphere with a 6 *m* radius below those outlet which permit the flow of large volumes of gas or vapour during loading, discharging or ballasting

(i) Areas on open decks or semi-enclosed spaces on open decks, within 1.5 *m* from cargo pump room entrances, within a sphere with a 1.5 *m* radius from cargo pump room ventilation inlets and those openings specified in **(2)** above

(j) Areas on open decks within spillage coamings surrounding cargo manifold valves and for 3 *m* beyond these valves, up to a height of 2.4 *m* above such decks

(k) Areas on open decks over all cargo tanks (including all ballast tanks within cargo tank blocks; hereinafter, referred to in the same way) in cases where structures are restricting natural ventilation and to the full breadth of tank barges plus 3 *m* fore and aft on open decks, up to a height of 2.4 *m* above such decks

(l) Compartments for cargo hoses

(m) Enclosed or semi-enclosed spaces in which pipes containing cargo are located

(3) Zone 2

(a) Areas on open decks or semi-enclosed spaces on open decks, within 1.5 *m* surrounding the areas specified in **(2)** above (except those hazardous areas otherwise specified in the Rules; hereinafter, referred to in the same way).

(b) Spaces within 4 *m* surrounding those areas specified in **(2)(h)** above

(c) Spaces forming air-locks between those areas specified in **(2)** above and non-hazardous areas

(d) Areas on open decks within spillage coamings intended to keep spillages clear of accommodation and service spaces and for 3 *m* beyond these spaces, up to a height of 2.4 *m* above such decks

(e) Areas on open decks over cargo tanks in cases where unrestricted natural ventilation is guaranteed and to the full breadth of tank barges plus 3 *m* fore and aft on open decks, up to a height of 2.4 *m* above such decks

(f) Spaces forward of open decks specified in **(e)** and **(2)(k)** above, below levels of open decks, and having openings at levels less than 0.5 *m* above open decks (However, in cases where such openings are situated at least 5 *m* from the foremost cargo tank and at least 10 *m* measured horizontally from any cargo tank outlet or gas or vapour outlet, and spaces are mechanically ventilated; hereinafter, referred to as the same.)

(g) Ballast pump rooms adjacent to cargo tanks

5.11 Tests

5.11.1 Tests at the Manufacturer's Work

1 Generators, switchboards, motors and their starters and transformers used for important system are to be tested in accordance with the requirements in relevant Chapter of this Part. Voltage regulation of generators and transformers at load characteristics test is to be in accordance with the discretion of the Society.

2 Cables are to be tested in accordance with the requirements in **2.9**.

3 Explosion-protected electrical equipment is to be subjected to the tests prescribed in **1.2.1-3**.

5.11.2 On Board Tests

1 Important systems are, after installed on board, to be subjected to performance test synthetically.

2 Electrical equipment is, after installed on board, to be subjected to insulation resistance test in accordance with the requirements in **2.17.1**.

5.11.3 Additional Tests

The Society may require, where considered necessary, other tests than those prescribed in this Chapter.

Part 9 FIRE PROTECTION, DETECTION AND EXTINCTION

Chapter 1 GENERAL

1.1 General

1.1.1 Application

1 Construction and arrangement for fire protection, detection and extinction are to be in accordance with those specified in this Part.

2 Unless expressly provided otherwise in this Part:

(1) requirements not referring to a specific ship type are to apply to ships of all types. However, **8.1** and **8.2** do not apply to barges;

(2) notwithstanding **(1)** above, the extent and degree of application of the relevant requirements of **Chapters 3** to **9** may be modified to a reasonable extent depending on the construction, purpose, etc. of barges. These requirements (except **3.5** and **7.3**) need not apply to unmanned barges.

(3) requirements referring to "tank barges" are to apply to barges intended to carry the following liquid cargoes in bulk;

  (a) crude oils, petroleum products having a vapour pressure less than 0.28 *MPa* absolute at 37.8°*C* having a flashpoint not exceeding 60°*C*, and or other similar liquid cargoes;

  (b) petroleum products having a vapour pressure less than 0.28 *MPa* absolute at 37.8°*C* having a flashpoint exceeding 60°*C*;

  (c) liquid cargoes having a vapour pressure less than 0.28 *MPa* absolute at 37.8°*C* having a flashpoint not exceeding 60°*C* other than those referred to in above **(a)** and **(b)**; and

(4) For the purpose of this paragraph, barges carrying a liquid cargo with a vapour pressure greater than 0.1013 *MPa* (1.013 *bar*) absolute at 37.8°*C* are to comply with **15.14, Part S of the Rules for the Survey and Construction of Steel Ships**. When ships operate in restricted areas and at restricted times, the Society may agree to waive requirements for refrigeration systems in **15.14.3, Part S of the Rules for the Survey and Construction of Steel Ships**.

3 The Society may require additional construction and arrangement for fire protection, detection and extinction for tugs and pusher of 500 *gross tonnage* and above.

1.2 Barges intended to carry dangerous goods, etc.

1.2.1 General

Barges intended to carry dangerous goods and barges fitted with vehicle and ro-ro spaces are to comply with national regulation of the country in which ships registered, that of the government of sovereign nation in which barges navigate, regional regulations contracted among sovereign nations around inland waterways in which ships navigate in addition to the requirements in this Part.

1.3 Use of Toxic Substances

1.3.1 Use of Toxic Extinguishing Media

The use of a fire-extinguishing medium which either by itself or under expected conditions of use gives off toxic gases, liquids and other substances in such quantities as to endanger persons is not to be permitted.

1.4 Miscellaneous

1.4.1 General

Ships other than barges are to be provided with fire control plans and fire safety operational booklets.

1.5 Modification of Requirements

1.5.1 General

In cases where the owner of ships request modification of requirements with its reasons, the Society may permit the modification.

Chapter 2 DEFINITIONS

2.1 General

2.1.1 General Rules

For the purpose of this Part, unless expressly provided otherwise, the following definitions are to apply.

2.2 Definitions

2.2.1 Accommodation Spaces

Accommodation spaces are those spaces used for public spaces, corridors, lavatories, cabins, offices, hospitals, cinemas, games and hobby rooms, barber shops, pantries containing no cooking appliances and similar spaces.

2.2.2 Bulkhead Deck

Bulkhead deck is the uppermost deck up to which the transverse watertight bulkheads are carried.

2.2.3 Cargo Area

Cargo area is that part of the ship that contains cargo holds, 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.

2.2.4 Cargo Spaces

Cargo spaces are spaces used for cargo, cargo oil tanks, tanks for other liquid cargo and trunks to such spaces.

2.2.5 Combustible Material

Combustible material is any material other than a non-combustible material.

2.2.6 Control Stations

Control stations are those spaces in which the 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. Spaces where the fire recording or fire control equipment is centralized are also considered to be a fire control station.

2.2.7 Crude Oil

Crude oil is any oil occurring naturally in the earth whether or not treated to render it suitable for transportation and includes crude oil where certain distillate fractions may have been removed from or added to.

2.2.8 Deadweight

Deadweight is the difference in tonnes between the displacement of a ship in fresh water of a specific gravity of 1 at the load waterline corresponding to the load line as defined in **2.1.13, Part 1** and the lightweight of the ship.

2.2.9 Fire Test Procedures Code

Fire Test Procedures Code (*FTP* Code) means the International Code for Application of Fire Test Procedures, 2010 (2010 *FTP* Code) as adopted by the *MSC* of the *IMO* by resolution *MSC*.307(88), as may be amended by the *IMO*, provided that such amendments are adopted, brought into force and take effect in accordance with the provisions of article VIII of the present *SOLAS* concerning the amendments procedures applicable to the annex other than chapter I thereof.

2.2.10 Flashpoint

Flashpoint is the temperature in degrees Celsius (closed cup test) at which a product will give off enough flammable vapour to be ignited, as determined by an approved flashpoint apparatus.

2.2.11 Lightweight

Lightweight is the displacement of a ship in tonnes without cargo, fuel, lubricating oil, ballast water, fresh water and feed water in tanks, consumable stores, and passengers and crew and their effects.

2.2.12 Machinery Spaces

Machinery spaces are machinery spaces of category *A* and other spaces containing propulsion 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.

2.2.13 Machinery Spaces of Category *A*

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

(1) internal combustion machinery used for main propulsion;

(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, or any oil-fired equipment other than boilers, such as inert gas generators, incinerators, etc.

2.2.14 Non-combustible Material

Non-combustible material is a material which neither burns nor gives off flammable vapours in sufficient quantity for self-ignition when heated to approximately 750°*C*, this being approved by the Society or organizations deemed appropriate by the Society in accordance with the Fire Test Procedures Code.

2.2.15 Oil Fuel Unit

Oil fuel unit is the following equipment. However, oil fuel transfer pumps are not considered as oil fuel units.

(1) Equipment used for the preparation of oil fuel for delivery to oil-fired boilers (including fired inert gas generators)

(2) Equipment used for the preparation for delivery of heated oil to internal combustion engines (including gas turbines)

(3) Equipment used for the preparation for delivery of oil to internal combustion engines (including gas turbines) at a pressure of more than 0.18 *MPa*

(4) Oil pressure pumps, filters and heaters dealing with oil at a pressure of more than 0.18 *MPa*.

2.2.16 Public Spaces

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

2.2.17 Steel or Other Equivalent Material

Steel or other equivalent material means any non-combustible material which, by itself or due to insulation provided, has structural and integrity properties equivalent to steel at the end of the applicable exposure to the standard fire test (*e.g.* aluminium alloy with appropriate insulation).

2.2.18 Service Spaces

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

2.2.19 Standard Fire Test

A standard fire test is 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 in accordance with the test method specified in the Fire Test Procedures Code.

2.2.20 Weather Deck

Weather deck is a deck which is completely exposed to the weather from above and from at least two sides.

Chapter 3 PROBABILITY OF IGNITION

3.1 General

3.1.1 Pipes, Valves and Pipe Fittings, etc.

With respect to the design and fabrication of pipes, valves and pipe fittings, etc., the relevant requirements in **Part 7** are to apply, in addition to the requirements in this Part.

3.2 Arrangements for Oil Fuel, Lubrication Oil and Other Flammable Oils

3.2.1 Limitations in the Use of Oils as Fuel

The following limitations are to apply to the use of oil as fuel:

(1) Except as otherwise permitted by this paragraph, no oil fuel with a flashpoint of less than 60°*C* is to be used;

(2) In emergency generators oil fuel with a flashpoint of not less than 43°*C* may be used;

(3) The use of oil fuel having a flashpoint of less than 60°*C* but not less than 43°*C* may be permitted (*e.g.*, for feeding the emergency fire pump's engines and the auxiliary machines which are not located in the machinery spaces of category *A*) subject to the following:

  (a) fuel oil tanks except those arranged in double bottom compartments are to be located outside of machinery spaces of category *A*;

  (b) provisions for the measurement of oil temperature are to be provided on the suction pipe of the oil fuel pump;

  (c) stop valves and/or cocks are to be provided on the inlet side and outlet side of the oil fuel strainers;

  (d) pipe joints of welded construction or of circular cone type or spherical type union joint are to be applied as much as possible; and

  (e) other requirements when deemed appropriate by the Society.

(4) The use of fuel having a lower flashpoint than otherwise specified in this paragraph, for example crude oil, may be permitted provided that such fuel is not stored in any machinery space and subject to the approval by the Society of the complete installation.

(5) Fuel oil is not to be heated to the temperature within 10°*C* below the flash point of the fuel oil in the oil tanks, unless considered appropriate by the Society.

3.2.2 Arrangements for Oil Fuel

In a ship in which oil fuel is used, the arrangements for the storage, distribution and utilization of the oil fuel are to be such as to ensure the safety of the ship and persons on board and are to at least comply with the following provisions.

(1) As far as practicable, parts of the oil fuel system containing heated oil under pressure exceeding 0.18 *MPa* are not to be placed in a concealed position such that defects and leakage cannot readily be observed. The machinery spaces in way of such parts of the oil fuel system are to be adequately illuminated.

(2) The ventilation of machinery spaces is to be sufficient under normal conditions to prevent accumulation of oil vapour.

(3) Fuel oil tanks are to comply with the following requirements:

  (a) Fuel oil, lubrication oil and other flammable oils are to not be carried in forepeak tanks.

  (b) As far as practicable, oil fuel tanks are to be part of the ships structure and are to be located outside machinery spaces of category *A*. Where oil fuel 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 are to be contiguous to the machinery space boundaries, and are to preferably have a common boundary with the double bottom tanks, and the area of the tank boundary common with the machinery spaces is to be kept to a minimum. Where such tanks are situated within the boundaries of machinery spaces of category *A* they are not to contain oil fuel having a flashpoint of less than 60°*C*. In general, the use of free-standing oil fuel tanks are to be avoided. Where permitted, 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.

(c) No oil fuel tank is to be situated where spillage or leakage therefrom can constitute a fire or explosion hazard by falling on heated surfaces. Valves, cocks and other fittings fitted on fuel oil tanks are to be located in safe positions so as to be protected from external damage. The distance between tanks of flammable oil and high temperature positions of machinery installations is to be enough to prevent the oil from being heated more than the flash point of the oil.

(d) Oil fuel pipes, which, if damaged, would allow oil to escape from a storage, settling or daily service tank having a capacity of 500 *l* and above situated above the double bottom, are to be fitted with a cock or valve directly on the tank capable of being closed from a safe position outside the space concerned in the event of a fire occurring 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 tank 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 an additional valve is fitted in the machinery space it is to be operated from a position outside this space. The controls for remote operation of the valve for the emergency generator fuel tank are to be in a separate location from the controls for remote operation of other valves for tanks located in machinery spaces.

(e) Safe and efficient means of ascertaining the amount of oil fuel contained in any oil fuel tank are to be provided.

i) Where sounding pipes are used, they are not to terminate in any space where the risk of ignition of spillage from the sounding pipe might arise. In particular, they are not to terminate in passenger or crew spaces. As a general rule, they are not to terminate in machinery spaces. However, where the Society considers that these latter requirements are impracticable, it may permit termination of sounding pipes in machinery spaces on condition that all the following requirements are met:

1) the sounding pipes terminate in locations remote from ignition hazards unless precautions are taken, such as the fitting of effective screens, to prevent the oil fuel in the case of spillage through the terminations of the sounding pipes from coming into contact with a source of ignition; and

2) the termination of sounding pipes is fitted with a self-closing blanking device 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. Provision is to be made so as to ensure that any spillage of oil fuel through the control cock involves no ignition hazard.

ii) Oil-level gauges used in place of sounding pipes are to comply with the following requirements. In addition, gauges are to be of ones approved by the Society or to comply with the standard deemed approved by the Society.

1) The gauges are to be maintained in the proper condition to ensure their continued accurate functioning in service.

2) The failure of the gauges or overfilling of the tank are not to permit release of fuel into the space.

3) The glasses used for the gauges are to be of heat resistant quality, and adequately protected from mechanical damage. However, the use of cylindrical gauge glasses is prohibited.

4) The self-closing valves are to be provided between the gauges and tanks where flat glass level glasses or other gauges deemed necessary by the Society are used.

(4) Provision are to be made to prevent overpressure in any oil tank or in any part of the oil fuel system, including the filling pipes served by pumps on board. Air and overflow pipes and relief valves are to discharge to a position where there is no risk of fire or explosion from the emergence of oils and vapour and are not to lead into crew spaces, passenger spaces, machinery spaces or similar spaces. Where a level switch is provided, its penetration part is to be protected from a fire by means of a steel enclosure or other enclosures.

(5) Oil fuel piping is to comply with the following requirements:

(a) Oil fuel pipes and their valves and fittings are to be of steel or other approved material, except that restricted use of flexible hoses is permissible in positions where the Society is satisfied that they are necessary. Such flexible hoses and end fittings are to comply with **10.1.6** and **10.3.4, Part 7**. Use of ordinary cast iron valves in piping systems is to comply with the requirements of **10.1.5, Part 7**.

(b) 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 incorporates 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 of a fuel line failure. However, the requirements may not apply; in case of diesel engines installed outside machinery spaces of Category *A* whose maximum continuous power output is less than 375 *kW* and whose fuel injection piping systems are provided with reasonable enclosures, or when these pipes are deemed by the Society to have appropriate designs, constructions and arrangements for minimizing the fire risk.

(c) Oil fuel lines are not to be located immediately above or near units of high temperature including boilers, steam pipelines, exhaust manifolds, silencers or other equipment required to be insulated by **(6)**. As far as practicable, oil fuel lines are to be arranged far apart from hot surfaces, electrical installations or other sources of ignition and are to be screened or otherwise suitably protected to avoid oil spray or oil leakage onto the sources of ignition. The number of joints in such piping systems is to be kept to a minimum.

(d) Components of a diesel engine fuel system are to be designed considering the maximum peak pressure which will be experienced in service, including any high pressure pulses which are generated and transmitted back into the fuel supply and spill lines by the action of fuel injection pumps. Connections within the fuel supply and spill lines are to be constructed having regard to their ability to prevent pressurized oil fuel leaks while in service and after maintenance.

(e) Where the Society may permit the conveying of oil and combustible liquids through accommodation and service spaces, the pipes conveying oil or combustible liquids are to be of a material approved by the Society having regard to the fire risk.

(6) Protection of high temperature surfaces is to be in accordance with the followings:

(a) Surfaces with temperatures above 220°*C* which may be impinged as a result of a fuel system failure are to be properly insulated.

(b) Precautions are to 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) Sight-flow glasses where used in the oil fuel system are to be approved to have a suitable degree of fire resistance.

3.2.3 Arrangements for Lubricating Oil

The arrangements for the storage, distribution and utilization of oil used in pressure lubrication systems are to be such as to ensure the safety of the ship and persons on board. The arrangements made in machinery spaces of category *A*, and whenever practicable in other machinery spaces, are at least to comply with the provisions of **(1)**, **(2)**, **(3)(c)**, **(3)(d)**, **(3)(e)**, **(4)**, **(5)(a)**, **(5)(c)**, **(6)** and **(7)** of **3.2.2** except that:

(1) this does not preclude the use of sight - flow glasses in lubricating systems provided that they are shown by testing to have a suitable degree of fire resistance; and

(2) sounding pipes may be approved in machinery spaces; however, the requirements of **3.2.2(3)(e)i)2)** need not be applied on condition that the sounding pipes are fitted with appropriate means of closure;

(3) the provisions of **3.2.2(3)(d)** are also to apply to lubricating oil tanks except those having a capacity less than 500 *l*, storage tanks on which valves are closed during the normal operation mode of the ship, or where it is determined that an unintended operation of a quick closing valve on the oil lubricating tank would endanger the safe operation of the main propulsion and essential auxiliary machinery.

3.2.4 Arrangements for Other Flammable Oils

1 The arrangements for the storage, distribution and utilization of other flammable oils employed under pressure in power transmission systems, control and activating systems and heating systems are to be such as to ensure the safety of the ship and persons on board. In locations where means of ignition are present, such arrangements are at least to comply with the provisions of **(1)**, **(2)**, **(3)(c)**, **(3)(e)**, **(5)(c)** and **(6)** of **3.2.2** and with the provisions of **(4)** and **(5)(a)** of **3.2.2** in respect of strength and construction. With respect to thermal oil systems, such arrangements are to comply with the provisions of **3.2.2(3)(d)** in addition to the above. Suitable oil collecting arrangements for leaks are to be fitted below hydraulic valves and cylinders except those having no danger of fire caused by the spillage.

2 Hydraulic units with working pressure above 1.5 *MPa* are preferably to be placed in separate spaces. If it is impracticable to locate such units in a separate space, adequate shielding is to be provided.

3.2.5 Arrangements for Oil Fuel in Periodically Unattended Machinery Spaces

In addition to the requirements of **3.2.1** to **3.2.4**, the oil fuel and lubricating oil systems in a periodically unattended machinery space are to comply with the following:

(1) where daily service oil fuel tanks are filled automatically, or by remote control, means are to be provided to prevent overflow spillages. Other equipment which treats flammable liquids automatically (*e.g.* oil fuel 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; and

(2) where daily service oil fuel tanks or settling tanks are fitted with heating arrangements, a high temperature alarm is to be provided if the flashpoint of the oil fuel can be exceeded. However, in cases where fuel oil is heated by steam, etc.; the preset temperature of the alarm may be above the flash point if the fuel oil is not likely to be heated to or more than the preset temperature of heating, the alarm may be omitted if the fuel oil is not likely to be heated to or more than the flash point.

3.3 Arrangements for Gases for Domestic Purpose

3.3.1 Arrangements for Gaseous Fuel for Domestic Purpose

Gaseous fuel systems used for domestic purposes are to be of suitable type to the satisfaction of the Society. Storage of gas bottles is to be located on the open deck or in a well ventilated space which opens only to the open deck.

3.3.2 Arrangements for Gas Welding Equipment

Gas welding equipment are to be of suitable type to the satisfaction of the Society. Storage of gas bottles is to be located on the open deck or in a well ventilated space which opens only to the open deck.

3.4 Miscellaneous Items of Ignition Sources and Ignitability

3.4.1 Electric Radiators

Electric radiators, if used, are to be fixed in position and so constructed as to reduce fire risks to a minimum. No such radiators is to 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.

3.4.2 Waste Receptacles

Waste receptacles are to be constructed of non-combustible materials with no openings in the sides or bottom.

3.5 Special Requirements for Tank Barges

3.5.1 General

For tank barges, additional measures are to be taken in accordance with **3.5**.

3.5.2 Cofferdams

1 In tank barges intended to carry oils having a flashpoint not exceeding 60°*C*, cofferdams are to be provided between cargo tanks and other spaces such as accommodation spaces, general cargo holds under upper decks and machinery spaces being regarded as source of ignition, etc.

2 The cofferdams prescribed in **-1** may be concurrently used as pump-rooms.

3 Fuel oil or ballast water tanks may be concurrently used as cofferdams prescribed in **-1** subject to the approval by the Society.

3.5.3 Airtight Bulkheads

Airtight bulkheads are to be provided for the isolation of liquid cargo (flashpoint not exceeding 60°*C*) pumps and piping from electric installations or machinery where source of ignition is normally present.

3.5.4 Cargo Tank Venting

1 Cargo tanks (including slop tanks) are to be provided with venting systems for clearing the cargo tanks of dangerous vapours. Tank barges intended to carry liquid cargoes having a flashpoint not exceeding 60°*C* are to comply with the following requirements **-2** to **-6**.

2 The venting systems of cargo tanks (including slop tanks) are to be entirely distinct from the air pipes of the other compartments of the tank barge. The arrangements and position of openings in the cargo tank deck from which emission of flammable vapours can occur are to be such as to minimize the possibility of flammable vapours 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 accordance with this general principle, the criteria in **-3** to **-6** below and **7.3.2** will apply.

3 Venting arrangements are to comply with the following requirements:

(1) The venting arrangements in each cargo tank may be independent or combined with other cargo tanks and may be incorporated into the inert gas piping.

(2) Where the arrangements are combined with other cargo tanks, either stop valves or other acceptable means are to be provided to isolate each cargo tank. Where stop valves are fitted, they are to be provided with locking arrangements which are to be under the control of the responsible ship's officer. There is to be a clear visual indication of the operational status of the valves or other acceptable means. Where tanks have been isolated, it is to be ensured that relevant isolating valves are opened before cargo loading or ballasting or discharging of those tanks is commenced. Any isolation must continue to permit the flow caused by thermal variations in a cargo tank in accordance with **7.3.2-1(1)**.

(3) The venting arrangements are to be connected to the top of each cargo tank and are to be self - draining to the cargo tanks under all normal conditions of trim and list of the tank barge. 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 tank.

4 The venting system is to be provided with devices to prevent the passage of flame into the cargo tanks. The design, testing and locating of these devices is to be of a type approved by the Society in accordance with the procedure deemed appropriate by the Society. Ullage openings are not to be used for pressure equalization. They are to be provided with self-closing and tightly sealing covers. Flame arresters and flame screens are not permitted in these openings.

5 Vent outlets for cargo handling and ballasting

(1) Vent outlets for cargo loading, discharging and ballasting required by **7.3.2-1(2)** are to:

(a) permit the free flow of vapour mixtures or the throttling of the discharge of the vapour mixtures to achieve a velocity of not less than 30 *m/s*;

(b) be so arranged that the vapour mixture is discharged vertically upwards;

(c) 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, which may include anchor windlass and chain locker openings, and equipment which may constitute ignition hazards; and

(d) 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, which may include anchor windlass and chain locker openings, and equipment which may constitute an ignition hazard. These outlets are to be provided with high velocity devices of an approved type.

(2) The arrangements for the venting of all vapours displaced from the cargo tanks during loading and ballasting are to comply with **3.5.4** and **7.3.2** and are to consist of either one or more mast risers, or a number of high-velocity vents. The inert gas supply main may be used for such venting.

6 In tank barges intended to carry both oil and solid cargoes in bulk, the arrangement to isolating slop tanks containing oil or oil residues from other cargo tanks is to consist of blank flanges which will remain in position at all times when cargoes other than liquid cargoes referred to in **1.1.1-2(3)(a)** are carried.

3.5.5 Ventilation

Ventilation systems in cargo pump-rooms, etc. are to comply with the following requirements:

(1) Cargo pump-rooms, etc. are to be mechanically ventilated and discharges from the exhaust fans are to be led to a safe place on the open deck. The ventilation of these rooms is to have sufficient capacity to minimize the

possibility of accumulation of flammable vapours. The number of air changes is to be at least 20 *per hour*, based upon the gross volume of the space. However, in tank barges carrying oils having a flashpoint exceeding 60*°C*, the capacity of ventilation in the pump-rooms may be modified. The air ducts are to be arranged so that all of the space is effectively ventilated. The ventilation is to be of the suction type using fans of the non-sparking type. The outlets of exhaust ducts are to be led to atmosphere and to be fitted with wire mesh screens with mesh of suitable size. Where ventilation systems are driven by shafts passing through a pump-room bulkhead or deck, gastight stuffing boxes of a type approved by the Society are to be fitted to shafts at the position of passing.

(2) Effective venting systems are to be provided to spaces adjacent to a cargo 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 **(1)** above. Air holes are to be cut in every part of the structure where there might be a change of gases being pocketed.

3.5.6 Inert Gas Systems

1 For tank barges of 20,000 *tonnes deadweight* and upwards intended to carry liquid cargoes having a flashpoint not exceeding 60*°C*, the protection of the cargo tanks (including slop tanks) is to be achieved by a fixed inert gas system in accordance with the requirements of **Chapter 35, Part R of the Rules for the Survey and Construction of Steel Ships**, except that, in lieu of the above, the Society, after having given consideration to the tank barge's arrangement and equipment, may accept other fixed installations if they afford protection equivalent to the above, in accordance with **Chapter 17, Part R of the Rules for the Survey and Construction of Steel Ships**. The requirements for alternative fixed installations are to comply with the requirements in **-6** below.

2 Tank barges operating with a cargo tank cleaning procedure using crude oil washing are to be fitted with an inert gas system complying with the requirements of **Chapter 35, Part R of the Rules for the Survey and Construction of Steel Ships** and with fixed tank washing machines. However, such system need not be fitted in addition to the systems required in **-1** above.

3 Tank barges required to be fitted with inert gas systems are to comply with the following provisions:

(1) double hull spaces are to be fitted with suitable connections for the supply of inert gas;

(2) where hull spaces 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; and

(3) where such spaces are not permanently connected to an inert gas distribution system, appropriate means are to be provided to allow connection to the inert gas main.

4 The requirements for inert gas systems of **Chapter 35, Part R of the Rules for the Survey and Construction of Steel Ships** need not be applied to the following tank barges:

(1) tank barges to which **1.1.5, Part 1** applies when carrying cargoes described in **1.1.1-2(3)(a)**, provided that they comply with the requirements for inert gas systems deemed appropriate by the Society; or

(2) tank barges to which **1.1.5, Part 1** applies when carrying flammable cargoes other than crude oil or petroleum products such as cargoes listed in **Chapters 17** and **18, Part S of the Rules for the Survey and Construction of Steel Ships**, provided that the capacity of tanks used for their carriage does not exceed 3,000 m^3 and the individual nozzle capacities of tank washing machines do not exceed 17.5 m^3/h and the total combined throughput from the number of machines in use in a cargo tank at any one time does not exceed 110 m^3/h.

5 The inert gas systems are to comply with the followings:

(1) The inert gas system is to be capable of inerting, purging and gas-freeing empty tanks and maintaining the atmosphere in cargo tanks with the required oxygen content.

(2) The inert gas system referred to in **(1)** above is to be designed, constructed and tested in accordance with **Chapter 35, Part R of the Rules for the Survey and Construction of Steel Ships**.

(3) Tank barges fitted with a fixed inert gas system are to be provided with a closed ullage system.

6 Where an installation equivalent to a fixed inert gas system is installed, it is to:

(1) be capable of preventing dangerous accumulations of explosive mixtures in intact cargo tanks during normal service throughout the ballast voyage and necessary in-tank operations; and

(2) be so designed as to minimize the risk of ignition from the generation of static electricity by the system itself.

3.5.7 Inerting, Purging and Gas-freeing

1 Arrangements for purging and/or gas-freeing are to be such as to minimize the hazards due to dispersal of flammable vapours in the atmosphere and to flammable mixtures in a cargo tank (including slop tanks).

2 The procedure for cargo tank purging and/or gas-freeing is to be carried out in accordance with the following **(1)** to **(4)**:

(1) When the tank barge is provided with an inert gas system, the cargo tanks are first to be purged in accordance with the provisions of **3.5.7** and **Chapter 35, Part R of the Rules for the Survey and Construction of Steel Ships** until the concentration of hydrocarbon vapours in the cargo tanks has been reduced to less than 2% by volume. Thereafter, gas-freeing may take place at the cargo tank deck level.

(2) When the tank barge is not provided with an inert gas system, the operation is to be such that the flammable vapour is discharged initially through:

  (a) the vent outlets as specified in **3.5.4-5**;

  (b) 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

  (c) outlets at least 2 *m* above the cargo tank deck level with a vertical efflux velocity of at least 20 *m/s* and which are protected by suitable devices to prevent the passage of flame.

(3) The above outlets are to be 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, which may include anchor windlass and chain locker openings, and equipment which may constitute an ignition hazard.

(4) When the flammable vapour concentration at the outlet has been reduced to 30% of the lower flammable limit, gas-freeing may be continued at cargo tank deck level.

3 The arrangements for inerting, purging or gas-freeing of empty tanks as required in **3.5.6-5(1)** are to be to the satisfaction of the Society and to be such that the accumulation of hydrocarbon vapours in pockets formed by the internal structural members in a tank is minimized and that:

(1) on individual cargo 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 **3.5.4** and **7.3.2**. 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;

(2) the cross-sectional area of such gas outlet pipe referred to in **(1)** above is to be such that an exit velocity of at least 20 *m/s* 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; and

(3) each gas outlet referred to in **(2)** above is to be fitted with suitable blanking arrangements.

3.5.8 Gas Measurement

In tank barges intended to carry liquid cargoes having a flashpoint not exceeding 60°*C*, the following measures are to be provided for gas measurement. However, these requirements need not apply to unmanned barges.

(1) Tank barges are to be equipped with two portable instruments for measuring flammable vapour concentrations and two portable instruments for measuring oxygen concentrations, together with suitable means for the calibration of such instruments. These instruments for measuring flammable vapour concentrations are to be deemed appropriate by the Society.

(2) Arrangements of gas measurement in double hull and double bottom spaces, deemed appropriate by the Society, are to comply with the following requirements in **(a)** to **(c)**.

  (a) At least two of suitable portable instruments for measuring oxygen and flammable vapour concentrations are to be provided. In selecting these instruments, due attention is to be given to their use in combination with the fixed gas - sampling - line systems referred to in **(b)** below.

  (b) Where the 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 gas sampling lines is to be adapted to the design of such spaces.

  (c) 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.

(3) Arrangements for fixed hydrocarbon gas detection systems in double-hull and double-bottom spaces of tank barges

  (a) Tank barges of 20,000 *tonnes deadweight* and above are to be provided with a fixed hydrocarbon gas detection system complying with the **Chapter 36, Part R of the Rules for the Survey and Construction of Steel Ships** for measuring hydrocarbon gas concentrations in all ballast tanks and void spaces of double-hull and double-bottom spaces adjacent to the cargo tanks, including the forepeak tank and any other tanks and spaces under the bulkhead deck adjacent to cargo tanks.

(b) Oil tankers provided with constant operative inerting systems for such spaces need not be equipped with fixed hydrocarbon gas detection equipment.

(c) Notwithstanding the above, cargo pump-rooms subject to the provisions of **3.5.11** need not comply with the requirements of this paragraph.

3.5.9 Air Supply to Double Hull and Double Bottom Spaces

1 In tank barges intended to carry liquid cargoes having a flashpoint not exceeding 60°*C*, double hull and double bottom spaces are to be fitted with suitable connections for the supply of air.

2 In tank barges intended to carry liquid cargoes having a flashpoint not exceeding 60°*C*, suitable numbers and sizes of fixed ventilation ducts or pipes are to be arranged in double hull and double bottom spaces for efficient venting as deemed necessary by the Society. Configuration of such ducts or pipes is to be suitable to the design of such spaces.

3.5.10 Protection of Cargo Area

In tank barges intended to carry liquid cargoes having a flashpoint not exceeding 60°*C*, drip pans for collecting cargo residues in cargo lines and hoses are to be provided in the area of pipe and hose connections under the manifold area. Cargo hoses and tank washing hoses are to have electrical continuity over their entire lengths including couplings and flanges (except shore connections) and are to be earthed for removal of electrostatic charges.

3.5.11 Protection of Cargo Pump-rooms

Tank barges intended to carry liquid cargoes having a flashpoint not exceeding 60°*C* are to comply with the following requirements. However, these requirements need not apply to unmanned barges.

(1) for cargo pumps, ballast pumps and stripping pumps installed in cargo pump-rooms and driven by shafts passing through pump-room bulkheads, gas-tight stuffing boxes approved by the Society are to be fitted to the shafts at the bulkheads and flexible couplings are to be provided between the shafts and the pumps. The stuffing boxes are to be efficiently lubricated from outside the pump-room. The seal parts of stuffing boxes are to be of material that will not initiate sparks. These pumps are to be fitted with temperature sensing devices for bulkhead shaft glands, bearings and pump casings. A continuous audible and visual alarm signal is to be automatically effected in the cargo control room or the pump control station;

(2) lighting in cargo pump-rooms, except emergency lighting, is to be interlocked with ventilation such that the ventilation is to be in operation when switching on the lighting. Failure of the ventilation system is not to cause the lighting to go out;

(3) a system, as deemed appropriate by the Society, for continuous monitoring of the concentration of hydrocarbon gases is to be fitted. Sampling points or detector heads are to be located in suitable positions in order that potentially dangerous leakages are readily detected. When the hydrocarbon gas concentration reaches a pre-set level which is not to be higher than 10% of the lower flammable limit (*LFL*), a continuous audible and visual alarm signal is to be automatically effected in the pump-room and a place where a responsible member of the crew is on duty to alert personnel to the potential hazard; and

(4) all pump-rooms are to be provided with bilge level monitoring devices together with appropriately located alarms.

Chapter 4 FIRE GROWTH POTENTIAL

4.1 Control of Air Supply and Flammable Liquid

4.1.1 Closing Appliances and Stopping Devices of Ventilation

1 The main inlets and outlets of all ventilation systems are to be capable of being closed from outside the spaces being ventilated. The means of closing are to be easily accessible as well as prominently and permanently marked and are to indicate whether the shutoff is open or closed.

2 Power ventilation of accommodation spaces, service spaces, cargo spaces, control stations and machinery spaces is to be capable of being stopped from an easily accessible position outside the space being served. This position is not to be readily cut off in the event of a fire in the spaces served.

4.1.2 Means of Control in Machinery Spaces

1 Means of control are to be provided for opening and closure of skylights, closure of openings in funnels which normally allow exhaust ventilation, and closure of ventilator dampers.

2 Means of control are to be provided for stopping ventilating fans. Controls provided for the power ventilation serving machinery spaces are to be grouped so as to be operable from two positions, one of which is to be outside such spaces, where they will not be cut off in the event of fire in the space they serve. The means provided for stopping the power ventilation of the machinery spaces are to be entirely separated from the means provided for stopping ventilation of other spaces.

3 Means of control are to be provided for stopping forced and induced draught fans, oil fuel transfer pumps, oil fuel unit pumps, lubricating oil service pumps, thermal oil circulating pumps, cargo pumps and oil separators (purifiers). Such controls 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, in addition to inside such space. However, this requirement need not apply to oily water separators.

4 The controls required in **-1** above and in **3.2.2(3)(d)** 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.

4.1.3 Additional Requirements for Means of Control in Periodically Unattended Machinery Spaces

For periodically unattended machinery spaces, the Society may give special consideration to maintaining the fire integrity of the machinery spaces, the location and centralization of the fire-extinguishing system controls, the required shutdown arrangements (*e.g.* ventilation, fuel pumps, etc.) and may require additional fire-extinguishing appliances and other fire fighting equipment and breathing apparatus.

Chapter 5 DETECTION AND ALARM

5.1 Fixed Fire Detection and Fire Alarm Systems

5.1.1 Installation

1 A fixed fire detection and fire alarm system is to be installed in the following spaces. However, liquid fire extinguishers of automatic release type of sufficient capacity deemed appropriate by the Society may be provided in lieu of a fixed fire detection and fire alarm system.

(1) periodically unattended machinery spaces;

(2) machinery spaces where the installation of automatic and remote control systems and equipment has been approved in lieu of continuous manning of the space;

2 For the protection of the machinery spaces defined in **-1(1)** above, the following means are to be provided.

(1) Manually operated call points are to be installed in:

  (a) at least two places near by entrances of the passageways with access door openings to spaces where main propulsion machinery, boilers, electric generating sets, etc. are installed;

  (b) wheel house or centralized monitoring and control stations on bridge; and

  (c) centralized control stations for main propulsion, including the stations placed in machinery spaces.

(2) Where a switch to open temporarily a specific loop or circuit of fire detection systems is fitted, means are to be provided to indicate such a condition clearly and to restore the circuit automatically after elapsing a preset period of time.

(3) In case where fire detectors are provided with means to adjust their sensitivity, the arrangements are to be capable of fixing and identifying the set point.

5.1.2 Design

The fixed fire detection and fire alarm system required in **5.1.1** is to be so designed and the detectors so positioned as to detect rapidly the onset of fire in any part of those spaces and under any normal conditions of operation of the machinery and variations of ventilation as required by the possible range of ambient temperatures. Except in spaces of restricted height and where their use is specially appropriate, detection systems using only thermal detectors are to not be permitted. The detection system is 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. When the navigating bridge is unmanned the alarm is to sound in a place where a responsible member of the crew is on duty.

5.1.3 Fixed Fire Detection and Fire Alarm System

1 A fixed fire detection and fire alarm system is to be provided in accordance with the following provisions of this Chapter.

2 A fixed fire detection and alarm system required in this Part is to comply with **Chapter 29, Part R of the Rules for the Survey and Construction of Steel Ships** or be deemed as appropriate by the Society.

3 Where a fixed fire detection and fire alarm system is required for the protection of spaces other than those specified in **5.1.1**, at least one detector complying with **Chapter 29, Part R of the Rules for the Survey and Construction of Steel Ships** or deemed as appropriate by the Society is to be installed in each such space.

5.1.4 Initial and Periodical Test

1 The function of fixed fire detection and fire alarm systems required by the relevant provisions of this Part are to be tested under varying conditions of ventilation after installation.

2 The function of fixed fire detection and fire alarm systems is to be periodically tested to the satisfaction of the Society by means of equipment producing hot air at the appropriate temperature, or smoke or aerosol particles having the appropriate range of density or particle size, or other phenomena associated with incipient fires to which the detector is designed to respond.

Chapter 6 CONTROL OF SMOKE SPREAD

6.1 Release of Smoke

6.1.1 Release of Smoke from Machinery Spaces

1 The provisions of **6.1.1** are to apply to machinery spaces of category *A* and, in principle, to other machinery spaces.

2 Suitable arrangements are to be made to permit the release of smoke, in the event of fire, from the space to be protected, subject to the provisions of **7.1.2-1**. The normal ventilation systems may be acceptable for this purpose.

3 Means of control are to be provided for permitting the release of smoke and the controls are to be located outside the space concerned so that they will not be cut off in the event of fire in the space they serve.

4 The controls required by **-3** above are to be situated at one control position or grouped in as few positions as possible to the satisfaction of the Society. Such positions are to have a safe access from the open deck.

Chapter 7 CONTAINMENT OF FIRE AND STRUCTURAL INTEGRITY

7.1 Protection of Openings in Machinery Spaces Boundaries

7.1.1 Application

The provision of **7.1** is to apply to machinery spaces of category *A* and, in principle, to other machinery spaces.

7.1.2 Protection of Openings in Machinery Space Boundaries

1 The number of skylights, doors, ventilators, openings in funnels to permit exhaust ventilation and other openings to machinery spaces is to be reduced to a minimum consistent with the needs of ventilation and the proper and safe working of the ship.

2 Skylights are to be of steel and are not to contain glass panels.

3 Means of control are to be provided for closing power-operated doors or actuating release mechanism on doors other than power-operated watertight doors. The control is to be located outside the space concerned, where they will not be cut off in the event of fire in the space it serves.

4 Boundary walls of machinery spaces of category *A* (including doors) and the floor plating of normal passageways in such machinery spaces are to be of steel or other equivalent material. The doors in such boundary walls are to be of self-closing type.

5 Windows are not to be fitted in machinery space boundaries. However, this does not preclude the use of glass in control rooms within the machinery spaces.

6 When access to any machinery spaces of category *A* from an adjacent shaft tunnel is provided at a low level, a light steel fire-screen door operable from each side is to be provided in the shaft tunnel, near the watertight door.

7.2 Overboard Fittings

7.2.1 Materials of Overboard Fittings

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 material in the event of fire would give rise to danger of flooding.

7.3 Special Requirements for Tank Barges

7.3.1 Protection of Cargo Space Boundaries

In tank barges, 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 are 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.

7.3.2 Protection of Cargo Tank Structure against Pressure or Vacuum

1 General

The venting arrangements are to be so designed and operated as to ensure that neither pressure nor vacuum in cargo tanks is not to exceed design parameters and 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 tank in all cases through pressure/vacuum valves (hereinafter *PV* valves) of a type approved by the Society in accordance with the procedure deemed appropriate by the Society; and

(2) the passage of large volumes of vapour, air or inert gas mixtures during cargo loading and ballasting, or during discharging.

2 Openings for Small Flow by Thermal Variations

Openings for pressure release required by **-1(1)** above are to:

(1) have as great a height as is practicable above the cargo tank deck to obtain maximum dispersal of flammable

vapours but in no case less than 2 *m* above the cargo tank deck; and

(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. Anchor windlass and chain locker openings constitute an ignition hazard.

3 Safety Measures in Cargo Tanks

(1) Preventive measures against liquid rising in the venting system

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 tanks. This is to be accomplished by high-level alarms or overflow control systems approved by the Society in accordance with the procedure deemed appropriate by the Society or other equivalent means, together with independent gauging devices required by **15.6.9, Part 7** and cargo tank filling procedures. For the purposes of this paragraph, spill valves are not considered equivalent to an overflow system.

(2) Bypasses in vent mains

PV valves required by **-1(1)** above may be provided with a bypass arrangement when they are located in a vent main or masthead riser. Where such an arrangement is provided there are to be suitable indicators to show whether the bypass is open or closed.

(3) Pressure/vacuum breaking devices

One or more pressure/vacuum breaking devices are to be provided to prevent the cargo tanks from being subject to **(a)** and **(b)** below. Such devices are to be installed on the inert gas main unless they are installed in the venting system required by **3.5.4-2** or on individual cargo tanks. The location and design of the devices are to be in accordance with **3.5.4** and **7.3.2**.

(a) a positive pressure in excess of the test pressure of the cargo tank if the cargo were to be loaded at the maximum rated capacity and all other outlets are left shut; and

(b) a negative pressure in excess of 700 *mm* water gauge if cargo were to be discharged at the maximum rated capacity of the cargo pumps and the inert gas blowers were to fail.

4 Size of Vent Outlets

Vent outlets for cargo loading, discharging and ballasting required by **-1(2)** above are to 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 tank from exceeding the design pressure. Ships are to be provided with information regarding the maximum permissible loading rate for each cargo tank and in the case of combined venting systems, for each group of cargo tanks.

Chapter 8 FIRE FIGHTING

8.1 General

Ships are to be provided with fire pumps, fire mains, hydrants and hoses complying with the applicable requirements of this Chapter.

8.2 Water Supply Systems

8.2.1 Fire Mains and Hydrants

1 General

Fire mains and hydrants are to have sufficient strength for expected pressure in operation. Materials readily rendered ineffective by heat are not to be used for fire mains and hydrants unless adequately protected. The pipes and hydrants are to be so placed that the fire hoses may be easily coupled to them. The arrangement of pipes and hydrants is to be such as to avoid the possibility of freezing. Suitable drainage provisions are to be provided for all fire main piping. Isolation valves are to be installed for all open deck fire main branches used for purposes other than fire fighting. However, for ships of less than 300 *gross tonnage*, the fire mains and hydrants are to be to the satisfaction of the Society.

2 Ready availability of water supply

The fire pump starting arrangement in the machinery space is to be located in an easily accessible position in the event of fire.

3 Diameter of fire mains

The diameter of the fire main and water service pipes is to be sufficient for the effective distribution of the maximum required discharge from the fire pump.

4 Isolating valves and relief valves

(1) A valve is to be fitted to serve each fire hydrant so that any fire hose may be removed while the fire pumps are in operation. However, for ships of less than 300 *gross tonnage*, isolating valves are to be to the satisfaction of the Society.

(2) For ships of 300 *gross tonnage* and upwards, relief valves are to be provided in conjunction with all fire pumps if the pumps are capable of developing a pressure exceeding the design pressure of the water service pipes, hydrants and hoses. These valves are to be so placed and adjusted as to prevent excessive pressure in any part of the fire main system.

5 Number and position of hydrants

The number and position of hydrants are to be such that at least one jet of water not emanating from the same hydrant, one of which is to be from a single length of hose, may reach any part of the ship normally accessible to the passengers or crew while the ship is being navigated and any part of any cargo space when empty, each from a single length of hose. However, for ships of less than 300 *gross tonnage*, the number and position of hydrants are to be to the satisfaction of the Society.

6 Pressure at hydrants

(1) With the pump delivering water through the nozzles specified in **8.2.3-3**, with the quantity of water specified in **8.2.1-3**, through any hydrant, the minimum pressure of 0.25 N/mm^2 is to be maintained at all hydrants:

(2) the maximum pressure at any hydrant is not to exceed that at which the effective control of a fire hose can be demonstrated.

8.2.2 Fire Pumps

1 Pumps accepted as fire pumps

For ships of 300 *gross tonnage* and upwards, sanitary, ballast, bilge or general service pumps may be accepted as fire pumps, provided that they are not normally used for pumping oil and that if they are subject to occasional duty for the transfer or pumping of oil fuel, suitable change-over arrangements are fitted.

2 Number of fire pumps

Ships are to be provided with at least one independently power driven fire pump. However, for ships of less than 300 *gross tonnage*, fire pumps are to be to the satisfaction of the Society.

3 Arrangement of fire pumps and fire mains

In ships of 300 *gross tonnage* and upwards navigating in ice, fire pumps are to be arranged to the satisfaction of the Society.

4 Capacity of fire pumps

The fire pump required by **8.2.2** is to have a capacity at least 10 m^3/h, and such pump is to in any event be capable of delivering at least one jet of water required by **8.2.1-5**. The fire pump is to be capable of supplying the fire main system under the conditions required by **8.2.1-6**. Where more pumps than the minimum of pump required by **-2** above are installed, such additional pumps are to have a capacity of at least 10 m^3/h and are to be capable of delivering at least the one jet of water required by **8.2.1-5**. However, for ships of less than 300 *gross tonnage*, capacity of fire pumps is to be to the satisfaction of the Society.

8.2.3 Fire Hoses and Nozzles

1 General specifications

(1) Fire hoses are to be of non-perishable material approved by the Society, are to have sufficient strength for expected pressure in operation and are to be sufficient in length to project a jet of water to any of the spaces in which they may be required to be used. Each hose is to be provided with a nozzle and the necessary couplings. Fire hoses are, together with any necessary fittings and tools, to be kept ready for use in conspicuous positions near the water service hydrants or connections. Fire hoses are to have a length of at least 10 *m*, but not more than the following length. However, for ships of less than 300 *gross tonnage*, fire hoses are to be to the satisfaction of the Society.
  - (a) 15 *m* in machinery spaces;
  - (b) 20 *m* in other spaces and open decks; and
  - (c) 25 *m* for open decks on ships with a maximum breadth in excess of 30 *m*.

(2) Unless one hose and nozzle is provided for each hydrant in the ship, there is to be complete interchangeability of hose couplings and nozzles. However, for ships of less than 300 *gross tonnage*, nozzles are to be to the satisfaction of the Society.

2 Number and diameter of fire hoses

Ships are to be provided with fire hoses in accordance with the following **(1)** and **(2)**. However, for ships of less than 300 *gross tonnage*, the number and diameter of fire hoses are to be to the satisfaction of the Society.

(1) The number of fire hoses to be provided is to be one for each 30 *m* length of the ship and one spare but in no case less than three in all. This number does not include any hoses required in any machinery spaces of category *A*. The Society may increase the number of hoses required so as to ensure that hoses in sufficient number are available and accessible at all times, having regard to the type of ship and the nature of trade in which the ship is employed.

(2) All hydrants in machinery spaces of category *A* are to be fitted with hoses having nozzles.

3 Size and types of nozzles

(1) For the purposes of this chapter, standard nozzle sizes are to be 12 *mm*, 16 *mm* and 19 *mm* or as near thereto as possible. Larger diameter nozzles may be permitted at the discretion of the Society.

(2) For accommodation and service spaces, a nozzle size greater than 12 *mm* need not be used.

(3) For machinery spaces and exterior locations, the nozzle size is to be such as to obtain the maximum discharge possible from one jet at the pressure mentioned in **8.2.1-6** from the smallest pump, provided that a nozzle size greater than 19 *mm* need not be used.

(4) Nozzles are to be of an approved dual-purpose type (*i.e.*, spray/jet type) incorporating a shutoff.

8.3 Portable Fire Extinguishers

8.3.1 Type and Design

Portable fire extinguishers are to comply with the requirements of **Chapter 24, Part R of the Rules for the Survey and Construction of Steel Ships** or be ones deemed appropriate by the Society.

8.3.2 Arrangement of Fire Extinguishers

1 Accommodation spaces and service spaces are to be suitably provided with portable fire extinguishers. Ships of 100 *gross tonnage* and upwards are to carry at least three portable fire extinguishers. Ships of less than 100 *gross tonnage* but 50 *gross tonnage* and upwards are to carry at least two portable fire extinguishers. Ships of less than 50 *gross tonnage* are to carry at least one portable fire extinguisher.

2 One of the portable fire extinguishers intended for use in any space is to be stowed near the entrance to that space.

3 Carbon dioxide fire extinguishers are not to be placed in accommodation spaces. In control stations and other spaces containing electrical or electronic equipment or appliances necessary for the safety of the ship, fire extinguishers are to be provided whose extinguishing media are neither electrically conductive nor harmful to the equipment and appliances.

4 Required fire extinguishers are to be situated ready for use at easily visible places, which can be reached quickly and easily at any time in the event of a fire, and in such a way that their serviceability is not impaired by the weather, vibration or other external factors. Portable fire extinguishers are to be indicated whether they have been used or not used.

8.3.3 Spare Charges

1 Spare charges of capacity or mass which can recharge at least 10% of the total fire extinguishers required in this Part are to be provided.

2 For fire extinguishers which cannot be recharged onboard, additional portable fire extinguishers of the same quantity, type, capacity and number as determined in **-1** above are to be provided in lieu of spare charges.

8.4 Fixed Fire-extinguishing Systems

8.4.1 General

1 Unless otherwise specified, the requirements of **8.4** apply to fixed fire-extinguishing systems required by the provisions of **8.5**.

2 Where a fixed fire-extinguishing system not required by this chapter is installed, it is to meet the relevant requirements of this Chapter and the requirements of **Chapters 22** to **36, Part R of the Rules for the Survey and Construction of Steel Ships**, as appropriate or to be one deemed appropriate by the Society.

3 Fire-extinguishing systems using Halon 1211, 1301 and 2402 and perfluorocarbons are to be prohibited.

4 In general, the use of steam as a fire-extinguishing medium in fixed fire-extinguishing systems is not permitted. Where the use of steam is permitted by the Society, it is to be used only in restricted areas as an addition to the required fire-extinguishing system and is to comply with the requirements of **Chapter 25, Part R of the Rules for the Survey and Construction of Steel Ships** or be one deemed appropriate by the Society.

5 When a pump system is commonly served for fixed water-based fire-extinguishing systems for the protection of different areas, appropriate measures are to be taken for a system consisting of fire-extinguishing systems, pump systems, etc., to prevent that a damage or a failure of any one fire-extinguishing system will result in a failure of function of other fire-extinguishing systems.

8.4.2 Closing Appliances for Fixed Gas Fire-extinguishing Systems

Where a fixed gas fire-extinguishing system is used, openings which may admit air to, or allow gas to escape from, a protected space is to be capable of being closed from outside the protected space.

8.4.3 Storage Rooms of Fire-extinguishing Medium

When the fire-extinguishing medium is stored outside a protected space, it is to be in accordance with the following requirements:

(1) It is to be stored in a room which is located behind the forward collision bulkhead.

(2) Such a storage room is used for no other purposes.

(3) Any entrance to such a storage room is to preferably be from the open deck and is to be independent of the protected space.

(4) If the storage space is located below deck, it is to be located no more than one deck below the open deck and is to be directly accessible by a stairway or ladder from the open deck.

(5) Spaces which are located below deck or spaces where access from the open deck is not provided are to be fitted with a mechanical ventilation system designed to take exhaust air from the bottom of the space and are to be sized to provide at least 6 air changes per hour.
(6) Access doors are to open outwards, and bulkheads and decks including doors and other means of closing any opening therein, which form the boundaries between such rooms and adjacent enclosed spaces are to be gas tight.

8.4.4 Water Pumps for Other Fire-extinguishing Systems

Pumps, other than those serving the fire main, required for the provision of water for fire-extinguishing systems required by this chapter, their sources of power and their controls are to be installed outside the space or spaces protected by such systems and are to be so arranged that a fire in the space or spaces protected will not put any such system out of action.

8.5 Fire-extinguishing Arrangements in Machinery Spaces

8.5.1 Machinery Spaces containing Oil-fired Boilers or Oil Fuel Units

1 Fixed fire-extinguishing systems

Machinery spaces of category *A* containing oil-fired boilers are to be provided with any one of the following fixed fire-extinguishing systems or a foam fire-extinguishing systems deemed appropriate by the Society. In each case if the engine and boiler rooms are not entirely separate, or if fuel oil can drain from the boiler room into the engine-room, the combined engine and boiler rooms are to be considered as one compartment.

(1) A fixed gas fire-extinguishing system complying with the provision of **Chapter 25, Part R of the Rules for the Survey and Construction of Steel Ships** or deemed appropriate by the Society;
(2) A fixed high-expansion foam fire-extinguishing system complying with the provision of **Chapter 26, Part R of the Rules for the Survey and Construction of Steel Ships** or deemed appropriate by the Society; and
(3) A fixed pressure water-spraying fire-extinguishing system complying with the provision of **Chapter 27, Part R of the Rules for the Survey and Construction of Steel Ships** or deemed appropriate by the Society.

2 Additional fire-extinguishing arrangements

There is to be at least one portable foam extinguisher or equivalent in each firing space in each boiler room and in each space in which a part of the oil fuel installation is situated. These extinguishers are to be provided with hoses on reels suitable for reaching any part of the boiler room.

8.5.2 Machinery Spaces containing Internal Combustion Machinery

Machinery spaces of category *A* containing internal combustion machinery are to be provided with a sufficient number of portable foam extinguishers or equivalent which are to be so located that no point in the space is more than 10 *m* walking distance from an extinguisher and that there are at least two such extinguishers in each such space. For smaller spaces of ships the Society may consider relaxing this requirement.

8.5.3 Machinery Spaces containing Steam Turbines or Enclosed Steam Engines

1 Fixed fire-extinguishing systems

In spaces containing steam turbines or enclosed steam engines used either for main propulsion or other purposes having in the aggregate a total output of not less than 375 *kW*, one of the fire-extinguishing systems specified in **8.5.1-1(1)** to **(3)** is to be provided if such spaces are periodically unattended.

2 Additional fire-extinguishing arrangements

(1) There are to be approved foam fire extinguishers each of at least 45 *l* capacity or equivalent sufficient in number to enable foam or its equivalent to be directed on to any part of the pressure lubrication system, on to any part of the casings enclosing pressure lubricated parts of the turbines, engines or associated gearing, and any other fire hazards. These foam fire extinguishers are to comply with the requirements of **Chapter 24, Part R of Rules for the Survey and Construction of Steel Ships** or be ones deemed appropriate by the Society. However, such extinguishers are not required if protection at least equivalent to that required by this subparagraph is provided in such spaces by a fixed fire-extinguishing system fitted in compliance with **8.4.1**.
(2) There are to be a sufficient number of portable foam extinguishers or equivalent which are to be so located that no point in the space is more than 10 *m* walking distance from an extinguisher and that there are at least two

such extinguishers in each such space, except that such extinguishers are not required in addition to any provided in compliance with **8.5.1-2**.

8.6 Fire-extinguishing Arrangements in Control Stations, Accommodation and Service Spaces

8.6.1 Spaces containing Flammable Liquid

1 Paint lockers are to be protected by the fire-extinguishing system specified in **(1)** to **(4)** below. In any case, the system is to be operable from outside the protected space.

(1) A carbon dioxide system, designed to give a minimum volume of free gas equal to 40% of the gross volume of the protected space;

(2) A dry powder system, designed for at least 0.5 kg/m^3;

(3) A water spraying or sprinkler system, designed for 5 l/m^2 *per minute* (Water spraying systems may be connected to the fire main of the ship.); or

(4) A system providing equivalent protection, as determined by the Society.

2 Flammable liquid lockers other than paint lockers are to be protected by an appropriate fire-extinguishing arrangement approved by the Society.

3 For paint lockers of a deck area of less than 4 m^2, which do not give access to accommodation spaces, a carbon dioxide portable fire extinguisher sized to provide a minimum volume of free gas equal to 40% of the gross volume of the space may be accepted in lieu of a fixed system. A discharge port is to be arranged in the locker to allow the discharge of the extinguisher without having to enter into the protected space. The required portable fire extinguisher is to be stowed adjacent to the port. Alternatively, a port or hose connection may be provided to facilitate the use of fire main water.

Chapter 9 MEANS OF ESCAPE

9.1 General

9.1.1 Application

Unless expressly provided otherwise in this Chapter, at least two widely separated and ready means of escape are to be provided from all spaces or group of spaces.

9.1.2 General

Unless expressly provided otherwise in this Chapter, sizes of means of escape are, in principle, to be in accordance with the following requirements as a minimum:

(1) width of stairways and corridors: 600 *mm*;

(2) manholes including windows for means of escape: 600 × 400 *mm*; and

(3) small hatches: 600 *mm* × 600 *mm* for a rectangular shape, 600 *mm* in diameter for a round shape

9.1.3 Lifts

Lifts are not considered as forming one of the required means of escape as required by this Chapter.

9.2 Means of Escape from Control Stations, Accommodation and Service Spaces

9.2.1 General Requirements

1 Stairways and ladders are to be so arranged as to provide ready means of escape to the open deck from all passenger and crew accommodation spaces and from spaces in which the crew is normally employed, other than machinery spaces.

2 Unless expressly provided otherwise in this Chapter, a corridor, lobby, or part of a corridor from which there is only one route of escape is to be prohibited. Dead-end corridors used in service areas which are necessary for the practical utility of the ship, such as fuel oil stations and athwartship supply corridors, may be permitted, provided such dead-end corridors are separated from crew accommodation areas and are inaccessible from passenger accommodation areas. Also, a part of a corridor that has a depth not exceeding its width is considered a recess or local extension and is permitted.

3 All stairways in accommodation and service spaces and control stations are to be of steel frame construction except where the Society sanctions the use of other equivalent material.

4 If a radiotelegraph station has no direct access to the open deck, two means of escape from or access to, the station are to be provided, one of which may, for the purpose of being provided as emergency escape, be a porthole or window of sufficient size or other means to the satisfaction of the Society.

5 Doors in escape routes are, in general, to open in-way of the direction of escape, except that:

(1) individual cabin doors may open into the cabins in order to avoid injury to persons in the corridor when the door is opened; and

(2) doors in vertical emergency escape trunks or shelters may open out of the trunk in order to permit the trunk to be used both for escape and for access.

9.2.2 Details of Means of Escape

1 General

At all levels of accommodation there are to be provided at least two widely separated means of escape from each restricted space or group of spaces.

2 Escape from spaces below the lowest open deck

Below the lowest open deck the main means of escape is to be a stairway and the second escape may be a trunk or a stairway.

3 Escape from spaces above the lowest open deck

Above the lowest open deck the means of escape are to be stairways or doors to an open deck or a combination thereof.

4 Dead-end corridors

No dead-end corridors having a length of more than 7 *m* is to be accepted.

5 Width and continuity of escape routes

The width, number and continuity of escape routes are to be in accordance with the following requirements **(1)** to **(3)**:

(1) stairways and corridors used as means of escape from control stations, accommodation and service spaces are to be not less than 600 *mm* in clear width and are to have a handrail on one side. Stairways and corridors with a clear width of 1,800 *mm* and over are to have handrails on both sides. “Clear width” is considered the distance between the handrail and the bulkhead on the other side or between the handrails;

(2) the angle of inclination of stairways is to be, in general, 45 *degrees* but not greater than 50 *degrees*, and in machinery spaces and small spaces not more than 60 *degrees*; and

(3) doorways which give access to a stairway are to be of the same size as the stairway.

6 Dispensation from two means of escape

Exceptionally the Society may dispense with one of the means of escape, for crew spaces that are entered only occasionally, if the required escape route is independent of watertight doors.

9.3 Means of Escape from Machinery Spaces

9.3.1 Escape from Machinery Spaces of Category *A*

Except as provided in **9.3.2**, two means of escape are to be provided from each machinery space of category *A*. In cases where enclosures are provided as means of escape, the enclosure is to have minimum internal dimensions of at least 600 *mm* × 600 *mm*.

9.3.2 Dispensation from Two Means of Escape

The Society may dispense with one of the means of escape required by **9.3.1**, due regard being paid to the dimension and disposition of the upper part of the space.

9.3.3 Escape from Machinery Spaces other than Those of Category *A*

1 From machinery spaces other than those of category *A*, two escape routes are to be provided except that a single escape route may be accepted for spaces that are entered only occasionally, and for spaces where the maximum travel distance to the door is 5 *m* or less.

2 In the steering gear space, a second means of escape is to be provided when the emergency steering position is located in that space unless there is direct access to the open deck.

Part 10 LOAD LINES

Chapter 1 LOAD LINES

1.1 General

1.1.1 Application

This Part applies to ships which are required to be assigned freeboards and on which load line marks are required to be marked.

Chapter 2 ASSIGNMENT OF FREEBOARD AND MARKING OF LOAD LINES

2.1 Assignment of Freeboard and Marking of Load Lines

2.1.1 Assignment of Freeboard

Freeboard is to be assigned in accordance with "*International Convention on Load Lines, 1966*", "*Protocol of 1988 relating to the International Convention on Load Lines, 1966*", national regulations of flag-government of ships, national regulations of the government of sovereign nation in which ships navigate or regional regulations contracted among sovereign nations around inland waterways in which ships navigate, etc.

2.1.2 Marking of Load Lines

Marking of load lines are to be in accordance with "*International Convention on Load Lines, 1966*", "*Protocol of 1988 relating to the International Convention on Load Lines, 1966*", national regulations of flag-government of ships, national regulations of the government of sovereign nation in which ships navigate or regional regulations contracted among sovereign nations around inland waterways in which ships navigate, etc.

GUIDANCE FOR THE SURVEY AND CONSTRUCTION OF INLAND WATERWAY SHIPS

ESTABLISHMENT

Notice No.51 17th September 2014
Resolved by Technical Committee on 29th July 2014

Notice No.51 17th September 2014
“Guidance for the survey and construction of inland waterway ships” has been established as follows:

GUIDANCE FOR THE SURVEY AND CONSTRUCTION OF INLAND WATERWAY SHIPS

(See attached)

EFFECTIVE DATE AND APPLICATION

1. The effective date of the establishment is 17 September 2014.

GUIDANCE FOR THE SURVEY AND CONSTRUCTION OF INLAND WATERWAY SHIPS

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GUIDANCE FOR THE SURVEY AND CONSTRUCTION OF INLAND WATERWAY SHIPS

Part 1 GENERAL RULES

Chapter 1 GENERAL

1.1 General

1.1.1 Application

1 With respect to the provisions of these Rules, unless explicitly specified otherwise in the relevant requirements, distances regarding ship length, breadth, depth, and tank length, breadth, height, etc. are to be measured by using moulded dimensions. However, where the effects of plate thickness are not negligible, this requirement is not applicable. For the distance between an independent cargo tank and the hull construction, such distance is to be measured from the external face of the tank.

2 Barges which navigate as the unity type pusher tugs defined in **2.1.3** are to comply with the relevant requirements as individual barges and also comply with relevant requirements as units which a pusher tug and a barge are connected.

1.2 Class Notations

1.2.4 Application of Special Survey Scheme

For ships for which surveys are to be carried out in accordance with "***HIDROVIA Parana - Paraguay***" as the "standards deemed appropriate by the Society" specified in **1.2.4, Part 2 of the Rules**, the notation of "*HIDROVIA*" is affixed to the Classification Characters.

Chapter 2 DEFINITIONS

2.1 Application and Definitions

2.1.1 Application

L, B, D, D_s, d and other principal dimensions are to be rounded to two decimal places, except that D and d are to be rounded to three decimal places in the freeboard calculations.

2.1.3 Pushers

Pushers defined in **2.1.3, Part 1 of the Rules** are categorized into the following **(1)** or **(2)** according to the way they are connected to barges

(1) Easy separation type pushers:
Connected by a pin and can be separated quickly and easily during an emergency.

(2) Unity type pusher barge:
Pushers which are tightly connected to barges so that a single structure is formed. More specifically,
  (a) Connection by a bolt and so on
  (b) Has a special structure so that they complement each other in the connecting part, and can be secured by wire ropes and so on after connection is made.

2.1.4 Length of Ship

1 Where the requirements of **2.1.4-1, Part 1 of the Rules** apply to ships with rudder posts which do not reach the shoe piece, the ships are treated as ships without rudder posts.

2 In cases where L is determined by 96% of the extreme length on the designed maximum load line, the aft end of L is to be the point situated at a distance L from the fore side of the stem parallel to the base line.

3 For ships having neither rudder post nor rudder stock (for example, a ships equipped with a Voith-Schneider Propeller), L is to be 96% of the extreme length on the designed maximum load line.

4 If the difference between the scantling draught (d_s) and the designed maximum load draught does not exceed 300*mm*, the length of ship and the extreme length on load line are to be those measured according to the designed maximum load draught. If the difference exceeds 300*mm*, they are to be those measured according to d_s.

2.1.5 Length for Freeboard

1 The fore end of the length for freeboard is to be as specified in the following:

(1) In ships with a stem which has no hollowed part above the waterline at 85% of the least moulded depth measured from the top of keel
The fore end of L_f is the perpendicular at the intersection of the waterline at 85% of the least moulded depth with the fore side of the stem. (*See* **Fig. 1.2.1.5-1**)

(2) In ships with a stem which has a hollowed part above the waterline at 85% of the least moulded depth measured from the top of keel (*See* **Fig. 1.2.1.5-2**)

2 In ships designed with a rake of keel, the waterline on which this length is measured is to be parallel to the designed waterline at 85% of the least moulded depth $D_{\min}$, found by drawing a line parallel to the keel line of the vessel (including skeg) tangent to the moulded sheer line of the freeboard deck. The least moulded depth is the vertical distance measured from the top of the keel to the top of the freeboard deck beam at side at the point of tangency. (*See* **Fig. 1.2.1.5-3**)

Fig. 1.2.1.5-1

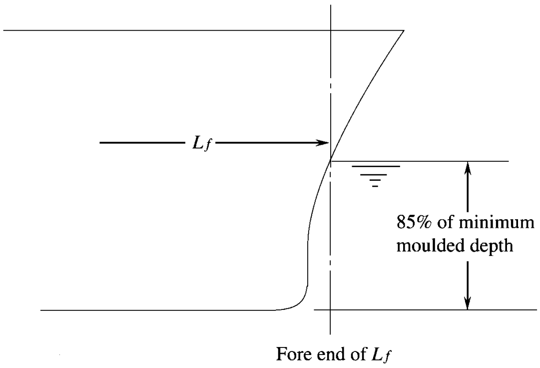


Fig. 1.2.1.5-2

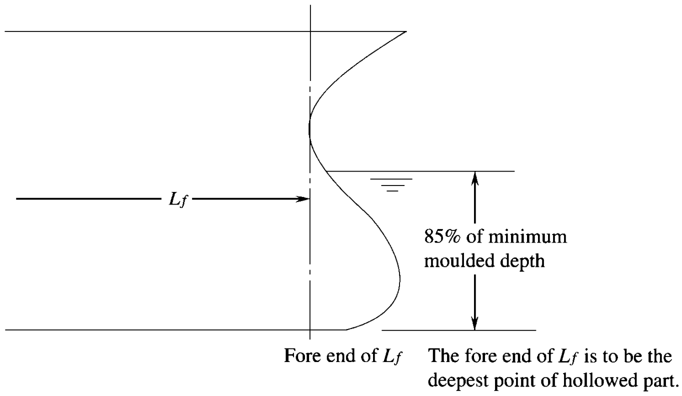
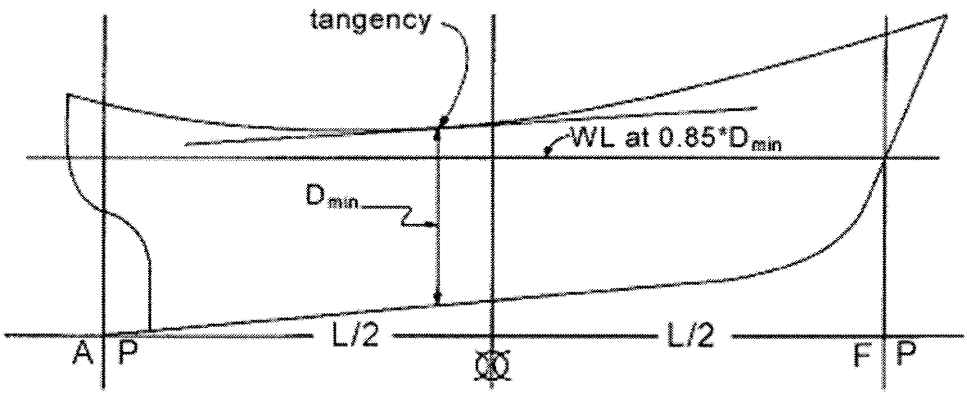


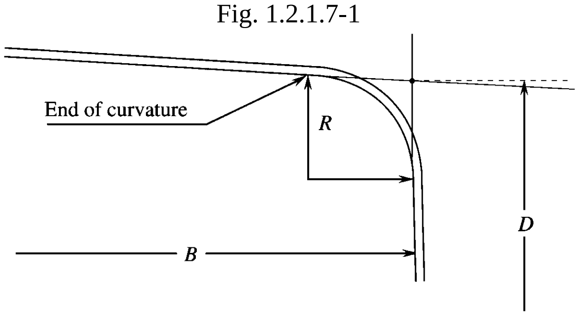
Fig. 1.2.1.5-3



2.1.7 Depth of Ship

The depth of ship D for ships having rounded gunwales is to be the depth measured up to the intersection of the extension of the lower surface of deck plating at the end of curvature and the extension of the inner surface of side shell plating. (*See* **Fig. 1.2.1.7-1**)

Fig. 1.2.1.7-1



2.1.8 Depth for Strength Computation

Where the lowest point of sheer of the strength deck at side is not situated amidships, the depth for strength computation D_s is to be the minimum depth up to the strength deck in the range of 0.4L amidships.

2.1.32 Machinery Space of Category A

"Incinerators" referred to in **2.1.32(3), Part 1 of the Rules** mean those with a maximum combustion capacity over 34.5kW.

2.1.42 Important System

System necessary for safety of life and ship are as follows:

(1) Bilge discharge system;
(2) Anchoring system;
(3) Mooring system;
(4) Ballast system for tank barge and barge designed to load and unload by submerging or inclining itself;
(5) Lighting System (except for unmanned barge); and
(6) Electric power source supplying electric power to any one of the systems listed above **(1)** to **(5)** or navigation light or signal light.

Part 2 CLASS SURVEYS

Chapter 1 GENERAL

1.1 Surveys

1.1.2 Class Maintenance Surveys

1 Modifications and changes that are subject to Occasional Surveys referred to in **1.1.2-2(3), Part 2 of the Rules** are as specified in **(1)** through **(4)** below:

(1) Change in the purpose of combined deep water tank/oil tank/cargo hold
When such dual-purpose holds are intended to be used for cargoes exclusively, the Owner is to submit an application for the change of purpose to the Society. A part of the oil/ballast suction line is to be removed and blank flanges are to be fitted at the end of the line. Hydrostatic tests for the holds need not be carried out after the change.

(2) Change in the loading conditions
When ships are loaded in an extremely different way from the conditions specified in the approved plans, the longitudinal strength, shearing force and local strength are to be verified and approved by the Society.

(3) Change in the loading manuals, the stability information and other similar documents
When a modification is intended that alters the principal data of the ship, a new loading manual, stability information and other similar documents are to be prepared based on the new data and approved by the Society. When differences of light weight and lightship longitudinal centre of gravity from the original values to values calculated for after conversion exceed either of the following limits, an inclining test is to be carried out.
  (a) Light weight: 2% of the original value or 2 *tonnes*, whichever is greater
  (b) Lightship longitudinal centre of gravity: 1% of length of ship (L)

(4) Other changes and modifications
As changes and modifications may require approval by the Society, the Owner is to notify the Society in such a case. In general, modifications to the main hull structure require approval by the Society. Reference is made to the provisions of **2.4.1, Part 2 of the Rules**.

2 Where a change needs to be made to the documents listed in **2.1.6** and **2.2.3, Part 2 of the Rules** as a result of modifications and changes specified in **-1** above, relevant documents are to be renewed and then confirmed/approved by the Surveyor. However, small changes to the contents of such documents due to repair work based on the principle of restoration or localized reinforcement (*e.g.* changes of welding lines due to the replacement of plate structure, addition of local stiffeners for carrying short-term deck cargoes) need not require such renewal and confirmation/approval.

1.1.3 Intervals of Class Maintenance Surveys

1 In applying the requirements specified in **1.1.3-1(3)(b), Part 2 of the Rules**, where Annual Surveys or Intermediate Surveys have been carried out in advance in accordance with **1.1.4-2, Part 2 of the Rules**, the Special Survey may be carried as specified in **(1)** or **(2)** below:

(1) The Special Survey may commence up to 15 *months* before the date of expiry of the *Certificate of Classification* and be completed within 3 *months* before the date of expiry of the *Certificate of Classification*.

(2) The Special Survey may be carried out during the period specified in accordance with **1.1.3-1(3)(c), Part 2 of the Rules**.

2 The main parts of machinery specified in **1.1.3-3(1), Part 2 of the Rules** generally refer to the parts subject to examination at the Classification Survey.

3 Ordinary Surveys of propeller shafts Kind 1 and stern tube shafts Kind 1 specified in **1.1.3-1(6)(a), Part 2 of the Rules** may be postponed until the date of the next Docking Survey only for the purpose of merging the two dates. However, an Occasional Survey is to be carried out on the following requirements, and the examined parts are to be in good condition. Also, this postponement is not to exceed 6 *months* for shafts Kind 1*A*, and 12 *months* for shafts Kind 1*B*.

(1) Propeller shafts exposed in the engine room are to be visually examined.

(2) The records of the weardown/clearance at the after end of the stern tube bearing (or the after end of the shaft bracket bearing, if any) are to be examined.

(3) Confirmation is to be made that the stern tube sealing devices are in good condition through the examination of maintenance records.

(4) Confirmation is to be made that the main engines have been operated outside the barred speed range for torsional vibration.

(5) Examinations specified in items 8, 9 and 10 of **Table 2.8.1**, **Part 2 of the Rules** are to be carried out.

4 The "periodical analysis for lubricating oil" referred to in **1.1.3-1(6)(b), Part 2 of the Rules** is to be carried out regularly at intervals not exceeding 1 year and the items to be analyzed in each analysis are to include water content, chloride content, shaft metal content, bearing metal particle content, and oil oxidation degree.

5 The postponement of the Ordinary Surveys of propeller shafts Kind 1 and stern tube shafts Kind 1 facilitated by the Occasional Survey specified in **-3** above or the Partial Survey specified in **1.1.3-1(6)(b), Part 2 of the Rules**, are not to be beyond the following longest terms:

(1) 6 *years* and 6 *months* for shafts Kind 1*A*

(2) 12 *years* for shafts Kind 1*B*

6 In applying the requirements specified in **1.1.3-1, Part 2 of the Rules**, the ship's owner/operator is to submit the statement of "the ship's operating period in salt water" to the Society.

7 For ships navigating in the Parana River Basin and the Paraguay River Basin, etc., "***HIDROVIA Parana - Paraguay***" may be applied as the "standards deemed appropriate by the Society". Intervals of Periodical Survey may, in principal, be treated as follows where such standards are applied mutatis mutandis. However, the extent and contents of Periodical Surveys and Planned Machinery Surveys are to comply with this Rules in accordance with the age of the ship.

(1) Annual Surveys

Annual Surveys are not required to be carried out.

(2) Intermediate Surveys

Intermediate Surveys are to be carried out in accordance with ship's type at the intervals specified in **(a)** through **(c)** below:

(a) For Tanker Convoy Pushers, Intermediate Surveys are to be carried out within 3 *months* before or after every second anniversary date after the Classification Survey during Construction or a Special Survey;

(b) For self-propelled ships which are not specified in **(a)** above and non-propelled ships carrying flammable liquid cargos, liquefied gases or dangerous chemicals in bulk, or dangerous goods, Intermediate Surveys are to be carried out within 3 *months* before or after every third anniversary date after the Classification Survey during Construction or a Special Survey;

(c) For non-propelled ships which are not specified in **(b)** above, Intermediate Surveys are to be carried out within 3 *months* before or after every fourth anniversary date after the Classification Survey during Construction or a Special Survey.

(3) Special Surveys

Special Surveys are to be carried out as specified in **(a)** through **(c)** below.

(a) For self-propelled ships and manned non-propelled ships, Special Surveys are to be carried out within 3 *months* before the date not exceeding 6 *years* from the date of completion of the Classification Survey or the previous Special Survey. However, when the previous Special Survey was completed within 3 *months* before the expiry date of the previous certificate, Special Surveys are to be carried out within 3 *months* before the date not exceeding 6 *years* from the expiry date of the previous certificate.

(b) For unmanned ships, Special Surveys are to be carried out within 3 *months* before the date not exceeding 8 *years* from the date of completion of the Classification Survey or the previous Special Survey. However, when the previous Special Survey was completed within 3 *months* before the expiry date of the previous certificate, Special Surveys are to be carried out within 3 *months* before the date not exceeding 8 *years* from the expiry date of the previous certificate.

(c) Notwithstanding the requirement in **(b)** above, for unmanned ships other than ships carrying flammable liquid cargos, liquefied gases or dangerous chemicals in bulk, the first Special Survey is to be carried out within 3 *months* before the date not exceeding 10 *years* from the date of completion of the Classification Survey.

(4) Docking Surveys

Docking Surveys are to be carried out concurrently with Special Surveys.

(5) Boiler Surveys

Boiler Surveys are to be carried out in accordance with **1.1.3-1(5), Part 2 of the Rules**.

(6) Propeller Shaft and Stern Tube Shaft Surveys

Ordinary Surveys of propeller shafts and stern tube shafts are to be carried out in accordance with **1.1.3-1(6), Part 2 of the Rules**.

(7) Planned Machinery Surveys

(a) For self-propelled ships and manned non-propelled ships, survey items are to be examined at intervals not exceeding 6 *years* in the Continuous Machinery Survey.

(b) For unmanned ships, survey items are to be examined at intervals not exceeding the intervals between special surveys.

(c) In the Planned Machinery Maintenance Scheme, survey items are to be examined according to the survey schedule table specified in **9.1.3, Part 2 of the Rules** and at the general examination (including review of maintenance records) which is to be carried out every year.

1.1.4 Periodical Surveys Carried out in Advance

1 Where an Annual Survey or Intermediate Survey was carried out in advance in accordance with **1.1.4-2, Part 2 of the Rules**, the anniversary date is to be amended to a new date 3 *months* after the date on which the Annual Survey or Intermediate Survey was completed. Subsequent Annual Surveys and Intermediate Surveys specified in **1.1.3-1(1)** and **1.1.3-1(2), Part 2 of the Rules** are to be carried out at the intervals using the new anniversary date. However, where the third Periodical Survey (determined using the intervals corresponding to the new anniversary date) after the previous Intermediate Survey is due before the expiry date of the Classification Certificate of the ship, the Intermediate Survey is to be carried out in lieu of the Annual Survey.

2 In cases where Special Surveys are carried out in advance of the due dates of Intermediate Surveys and such Intermediate Surveys are dispensed with in accordance with **1.1.4-3, Part 2 of the Rules**, then such Special Surveys are to be completed up to and including the due date of the third Annual Surveys.

1.1.5 Postponement of Surveys

The procedure and approval of the postponement of Periodical Surveys specified in **1.1.5, Part 2 of the Rules** are to be handled in accordance with **(1)** and **(2)** below;

(1) Procedure for postponement of Surveys

The ship's Owner or Captain is to submit the documents listed below for approval to the Society before the due time of the Survey intended to be postponed. The documents are to be submitted at any one of our offices at the applicant's convenience. However, where the report file of the Class Survey is not part of the submission, then the documents must be submitted to the head office.

(a) Application for postponement of Survey: 3 copies (or 2 copies in case where the application is to be submitted to the head office of the Society.)

(b) Report file of Class Surveys

(2) Approval of postponement of Surveys

The Society will verify the items specified in **(a)** and **(b)** below, and upon approval, will return one copy of the application to the applicant as proof of approval. The applicant is to take suitable action, such as to keep the approval letter on board the ship, in order to show the Surveyor that the ship is accepted to extend the Survey by the Society.

(a) The ship is maintained in good order. Verification may be made by reviewing the description of the current condition of the ship on the application and the report file of the Class Surveys.

(b) There are no outstanding recommendations in the survey reports. Outstanding recommendations (used hereafter in this Part) refer to matters that affect or may affect the seaworthiness of the ship.

(c) Postponement of the Boiler surveys specified in **1.1.5-2, Part 2 of the Rules** is to be approved by the Society after the following is satisfactorily carried out.

i) External examination
ii) Operation test of the relieving gear of the safety valve or the relief valve
iii) Operation tests of safety devices, alarm devices and pressure indicators
iv) Review of the following records since the last Boiler Survey
    1) Operation
    2) Maintenance
    3) Repair history
    4) Quality control of the feed water or thermal oil

1.1.6 Modification of the Requirements

1 "In cases where considered appropriate by the Society" specified in **1.1.6-1, Part 2 of the Rules** means only those cases where any of the modifications specified in **Table 2.1.1.6-1** are carried out during Periodical Surveys and Planned Machinery Surveys. However, this regulation is not to be applied to surveys required by the requirements of flag states.

2 Conditions that "the Surveyor considers … necessary" as used in **1.1.6-2, Part 2 of the Rules** means where there are tanks or cargo holds similar in structure to tanks, cargo holds or ships that have experienced defects.

1.1.7 Laid-up Ships

For the commencement of lay-up, the Owner is required to submit the three copies of the Application for Lay-up of Ship (**Form 1-1**) to the Society's local office.

Table 2.1.1.6-1 Modification of Requirements

Survey	Extent and contents of survey
1 General	The Surveyor may increase or decrease the contents of an examination based on the survey history and actual condition, etc. of the ship.
2 Surveys for similar ships or similar tanks	In cases where damage has occurred in similar ships or similar tanks, the scope of examinations may be expanded.
3 Examination of auxiliary machinery and pressure vessels	With the exception of general examinations, auxiliary machinery and pressure vessels subject to examinations in accordance with the Rules are as follows: (1) Essential auxiliary machinery as specified in **1.1.5, Part 7 of the Rules**. (2) Pressure vessels (Group I and II) and pressure vessels (Group III) for essential uses as specified in **8.1.3, Part 7 of the Rules**.
4 Examination of machinery and equipment of small capacity or infrequent use	Examinations of the following machinery and equipment in working condition and general examinations are to be carried out during Special Surveys. An open-up examination is required based on the results of the examination. (1) Air compressors for emergency use and their motors (2) Starting devices of boilers in cold conditions (3) Forced draft fans, pumps, and related parts attached to small packaged boilers (4) Electrical heaters with a capacity of not more than 10 kW (5) Oil tanks with a capacity of not more than 1 m^3 (6) Lubricating oil tanks (7) Hand pumps (for bilge, transfer of fuel oil, etc.)
5 Boiler Surveys	The examinations of boilers other than those of water tube type subject to Classification Surveys may be modified at the first Boiler Survey after the Classification Survey at the discretion of the Surveyor based on present conditions.
6 Others	With respect to other surveys in cases where specially approved by the Society, examinations are to be carried out in accordance with approved measures.

1.3 Definitions

1.3.1 Terms

"Critical structural areas" as specified in **1.3.1(3), Part 2 of the Rules** means locations which have been identified from calculations to require monitoring or from the service history of the subject ship or from similar or sister ships to be sensitive to cracking, buckling or corrosion which would impair the structural integrity of the ship.

1.4 Preparation for Surveys and Miscellaneous

1.4.2 Preparation for Surveys

1 The preparation for surveys specified in **1.4.2, Part 2 of the Rules** includes taking measures against present dangers. "Present dangers" used here includes improper arrangement of scaffolding, lack of lighting, fire, explosion, electric shock, falling objects, harmful gases and oxygen shortage.

2 The applicant is to make the necessary preparations so that tests and examinations to reveal corrosion, deformation, fractures, damage, or other structural deterioration can be conducted smoothly. This includes cleaning compartments; freeing water, scale, dirt, oil residues and gas; and providing means of access, sufficient lighting, non-destructive testing equipment and other necessary items. Furthermore, casings, ceilings or linings, and loose insulation, where fitted, are to be removed as required by the Surveyor. However, the areas of structural members already designated for renewal need only be cleaned and descaled to the extent necessary to determine the limits of renewal. The soundness of the means of access to the survey area is to be verified.

3 The applicant is to prepare the items indicated in **(1)** to **(3)** below in addition to the preparations specified in **-1** and **-2** above. Furthermore, where the preparations for the survey are made by the crew members of the ship, the applicant is to give necessary instructions to the crew members in order to assist the Surveyor.

(1) A communication system between the survey party in the tank and the officer in charge on the deck

(2) A portable gas detector, portable oxygen-meter, breathing apparatus, whistle, safety belts, and lifelines

(3) Adequate and safe lighting and protective clothing

4 Surveys of tanks by means of boats or rafts may only be made with the agreement of the Surveyor, who takes into account the safety arrangements provided, including weather forecasts and ship response under foreseeable conditions; and provided the expected rise of water within the tank does not exceed 0.25 *m*. In this case, in addition to preparations as specified in **-1** to **-3**, the applicant is to ensure the following.

(1) A communication system is to be arranged between the survey party on the boats or rafts in the tank and the personnel in charge of ballast pump handling.

(2) Appropriate life jackets are to be available for all participants.

(3) The tank or space is to contain clean ballast water only.

(4) The boat or raft is to be tethered to the access ladder and an additional person is to be stationed down the access ladder with a clear view of the boat or raft.

(5) The surface of the water in the tank or hold is to be calm and the water level stationary. On no account is the level of the water to be rising while the boat or raft is in use.

(6) At no time is the water level to be allowed to be within 1 *m* of the deepest under deck web face flat, so that the survey team is not isolated from a direct escape route to the tank hatch. Filling to levels above the deck transverses is only to be contemplated if a deck access manhole is fitted and open in the bay being examined, so that an escape route for the survey party is available at all times. Other effective means of escape to the deck may be considered.

(7) If the tanks are connected by a common venting system, or inert gas system, the tank in which the boat or raft is used is to be isolated to prevent a transfer of gas from other tanks.

5 Boats or rafts used in the survey specified in **-4** above are to have satisfactory residual buoyancy and stability even if one chamber is ruptured.

6 As a rule, the following preparations in **(1)** to **(4)** are to be made for Special Surveys.

(1) For the first Special Survey, the preparations specified in **(a)** to **(d)** below are to be made.

  (a) Coal and ballast, articles not permanently attached to the hull, and all limber boards are to be removed. Mud boxes are to be opened, strainers of bilge suction pipes exposed and interior of the hull cleared.

(b) For ships of single bottom construction, at least one strake of bottom ceilings is to be removed on each side of the centreline and in way of the bilge. Flooring plates are to be removed in machinery space where considered necessary.

(c) For ships of double bottom construction, the ceiling is to be removed as required by the Surveyor for examination of the condition of top plating.

(d) Water and oil residue in tanks and compartments are to be thoroughly cleaned. Gas inside fuel oil tanks and cargo tanks is to be removed to ensure safety during examinations.

(2) For the second Special Survey, in addition to the requirements in **(1)** above, the preparations specified in **(a)** and **(b)** below are to be made.

(a) In way of single bottoms, one strake of the ceilings on each side near the keelson is to be removed for the length of the entire ship.

(b) In way of double bottom and deep water or oil tanks, ceilings at the bilge (including limber), centreline parts, lower parts of pillars and bulkheads, shaft tunnels and any other parts considered necessary by the Surveyor are to be removed.

(3) For the third Special Survey, in addition to the requirements in **(1)** and **(2)** above, the preparations specified in **(a)** to **(e)** below are to be made.

(a) Most ceilings and linings in holds and coal bunkers and flooring plates in machinery spaces are to be removed. Rust on the outside and inside of the ship is to be chipped off.

(b) Throughout the ship, an extensive number of ceilings in way of single bottom, double bottom and deep water or oil tanks are to be removed.

(c) Wood sheeting and deck composition on steel decks are to be removed as required by the Surveyor and part of the cement chocks on the ship's sides at the bilges and decks are to be removed.

(d) In way of cabin accommodations, the panelling below side scuttles is to be removed. More panels are to be removed where considered necessary by the Surveyor.

(e) Lubricating oil tanks are to be thoroughly cleaned out and gas freed to ensure safety during examinations.

(4) For the fourth and subsequent Special Surveys, in addition to the requirements in **(3)** above, the preparations specified in **(a)** and **(b)** below are to be made.

(a) In way of single bottoms, one strake of ceilings on each side near the keelson is to be removed for the length of the entire ship.

(b) In way of double bottom and deep water or oil tanks, an extensive number of ceilings are to be removed.

7 With respect to **1.4.2-3, Part 2 of the Rules**, the following items are to be agreed upon between thickness measurement company representative and owner's representative during Intermediate or Special Survey meetings. And, documented records of these agreements, including where and when the meeting took place and who attended, are to be maintained.

(1) Reporting of thickness measurements on regular basis to the attending Surveyor.

(2) Prompt notification to the Surveyor in case of following findings:

(a) excessive and/or extensive corrosion or pitting/grooving of any significance;

(b) structural defects like buckling, fractures and deformed structures;

(c) detached and/or holed structure; and

(d) corrosion of welds.

1.4.4 Disposition when Repairs are Considered Necessary as a Result of Surveys

Boilers, pressure vessels categorized in Group I and II and piping categorized in Group I and II that have undergone extensive repair are to be subjected to the hydrostatic tests in accordance with **2.2.2(2), Part 2 of the Rules** (the testing pressure may be reduced to the extent that the Surveyor considers appropriate). However, the hydrostatic test may be replaced by an appropriate non-destructive test.

Form 1-1

Date:

To Nippon Kaiji Kyokai

APPLICATION FOR LAY-UP OF SHIP

We hereby request your approval for the lay-up of ship, according to **1.1.7 Part 2 of the Rules and Guidance.**

Ship's Name:
Classification Number:
Official Number :
Gross Tonnage:
Port of Registry:
Lay-up Location:
Lay-up Date:
Lay-up Period:

The necessary survey will be carried out according to **1.1.7-2, Part 2 of the Rules** regardless of whether Periodical or Planned Surveys are overdue, in cases where the lay-up will be canceled.

Name and Address of Applicant

Signature

Chapter 2 CLASSIFICATION SURVEYS

2.1 Classification Survey During Construction

2.1.2 Submission of Plans and Documents for Approval

1 The plans required to be submitted for approval in **2.1.2, Part 2 of the Rules** are to indicate the following items.

(1) Hull

(a) Hull structural drawings are, in general, to include scantling details, material details, location of butts and seams, cross section details as necessary, details of welding such as sizes and proportions applicable to the ship, etc.

(b) Midship Section

i) d_s and L, V, W and C_b corresponding to d_s, where the scantling draught (d_s) is larger than d

ii) The kind of freeboard assigned by the requirements of **Part 10 of the Rules**

iii) The position of the freeboard deck in ships with multiple decks

(c) Construction Profile
The forward end of L specified in **2.1.4, Part 1** and the point $0.25L$ aft of it

(d) Shell Expansion

i) In cases where "*International Convention on Load Lines, 1966*", "*Protocol of 1988 relating to the International Convention on Load Lines, 1966*", or National Regulation based on them is applied, comparative table between the standard sheer specified in **Part V of the Rules for the Survey and Construction of Steel Ships** and actual sheer on the exposed deck, where the exposed freeboard or superstructure deck has a well formed by bulwarks and end bulkheads of superstructure.

ii) In cases where other Load Line regulations are applied, it is to be to the satisfaction of the Society.

(e) Arrangements of Means of Embarkation and Disembarkation
Plans showing locations and overall arrangements of the means of embarkation and disembarkation

(f) Arrangements of Scupper Pipes (from the plans stipulated in **11.1.2(1), Part 7 of the Rules**)

i) In cases where "*International Convention on Load Lines, 1966*", "*Protocol of 1988 relating to the International Convention on Load Lines, 1966*", or National Regulation based on them is applied, the Summer Load Line and Lines 600 *mm*, $0.01L_f$ and $0.02L_f$ above it and 450 *mm* below the freeboard deck. Instead of the Summer Load Line the maximum designed load line above it may be acceptable.

ii) In cases where other Load Line regulations are applied, it is to be to the satisfaction of the Society.

2 A stability information booklet (referred to as "the booklet" in this Part) specified in **2.1.2-3, Part 2 of the Rules**, is to be submitted to the Society taking into consideration the timing of stability experiments and delivery. It is recommended that the booklet on the basis of assumed values be, in general, submitted as earlier as possible before stability experiments for preliminary examination.

3 The requirements referred to as "the requirements stipulated otherwise by the Society" in **2.1.2-6, Part 2 of the Rules**, are specified below.

(1) Where a ship is built at the same place of manufacture based on plans and documents which have already been approved, the "Application for exemption from submission of plans and documents of sister ship" and 3 copies of each of the following plans are to be submitted for approval by the Society.

(a) General Arrangement

(b) Midship Section

(c) Construction Profile & Deck Plan

(d) Shell Expansion

(e) Machinery Arrangement of Machinery Space

(f) Shafting Arrangement

(g) Piping Arrangement in Machinery Space

(2) Where machinery is built at the same place of manufacture based on plans and documents which have already been approved, 3 copies of the “Application for exemption from submission of plans and documents of a sister ship” which includes the following information are to be submitted for approval by the Society.
   (a) Specification of Machinery
   (b) Drawing Number and approved date
   (c) Classification Number and Name of sister ship or Name of Shipyard and Ship Number of sister ship
   (d) Approval Number of the Machinery approved as of Standardized Design or Mass Production, if any
(3) Where alterations to the design approved for a sister ship is made or rules that have been amended are applied, drawings and documents including relevant alterations are to be submitted for approval by the Society prior to commencement of work.

4 The wording “as stipulated otherwise by the Society” in **2.1.2-1, Part 2 of the Rules** refers to the following.

Where the applicant (stipulated in **2.3, Regulations for the Classification and Registry of Ships**) intends to get approval on plans and documents prior to submission of an application for alterations (stipulated in **2.4, Part 2 of the Rules**) or classification and surveys of the ship in order to facilitate preparation of alternations, an application for prior approval of plans and documents is to be submitted to the Society. In cases where an application for Classification Survey is submitted, an application for prior approval of plans and documents are to be transferred to the application for Classification Survey.

2.1.4 Presence of Surveyor

1 At the surveys for fire extinguishing systems referred to in **2.1.4-1(8), Part 2 of the Rules**, the following examinations are to be carried out. Where it is impractical to carry out the examinations on board the ship, the examinations may be replaced with examinations carried out at the place of manufacture under the presence of the Surveyor.

(1) Confirmation that the fire extinguishing system is installed according to the approved plans
(2) Confirmation that a fire control plan is provided
(3) For fire extinguishing systems, fire detecting systems and manually operated call points:
   (a) Fire main line including associated pumps
   Confirmation that each fire main pump can be operated so that one jet of water (at least 12 *m*) is produced from the highest positioned hydrant and a hydrant which imposes the most strict condition taking into account the distance from the fire pump, etc.
   (b) Fixed carbon dioxide fire extinguishing system
      i) For high pressure carbon dioxide fire-extinguishing systems:
         1) Airtight tests of piping at the following pressures:
         For starting line and lines between manifolds and selection valves: 3.5 *MPa*
         For lines between selection valves and open ends: 1.0 *MPa*
         2) Testing piping by delivering air
         3) Performance tests of alarm system
      ii) Test for vessels and their associated equipment are to be in accordance with the relevant requirements of **Part 7 of the Rules**, and additionally to comply with the following requirements:
         1) Shop test
         The vessels are to be subjected to magnetic particle inspections for welded joints after completion of hydraulic tests, and then subjected to tightness tests at a pressure equal to the designed pressure together with their fitting.
         2) On board test
            a) The pipes from the release valves on the distribution manifold to the nozzles are to be tested for tightness and the free flow of carbon dioxide gas (or air), after having been assembled on board. Test pressure is 1.0 *MPa*.
            b) The vessels are, after having been installed on board, to be subjected to operational tests with the charged condition of liquefied carbon dioxide gas to ensure no leakage of carbon dioxide gas and operations of the alarms, pressure gauges and liquid level indicators.
            c) The refrigerating plants are, after having been installed on board, to be subjected to an operational test with the charged condition of liquefied carbon dioxide gas including the

pressure control function test.

(c) Fixed high-expansion foam fire extinguishing systems
 i) Testing piping by delivering water
 ii) Performance tests of the system by delivering foam (the tests may be replaced with other equivalent tests at the discretion of the Surveyor)
 iii) Tests specified in **26.3.5, Part R of the Rules for the Survey and Construction of Steel Ships**, where deemed necessary by the Society.

(d) Fixed pressure water-spraying fire extinguishing system
 i) A pressure test for ordinarily pressurized parts of the system with a pressure 1.5 *times* the working pressure
 ii) A performance test by spraying water
 iii) Operation tests of relevant pumps

(e) Fixed water spray system
 Confirmation of the water delivered by the remotest spray nozzle by way of performance test

(f) Fire detecting system
 i) Performance tests for one detector of each group (for on-board function tests of fixed fire detection and alarm systems installed in machinery spaces specified in **5.1.1-1, Part 9 of the Rules**, refer to the test procedures shown in **Annex B2.1.4-1(3)(h)i), Part B of the Guidance for the Survey and Construction of Steel Ships**)
 ii) A performance test of the alarm system under loss of power or fault condition

(g) Manually operated call points
 An operation test

(4) Inert gas systems
 (a) Function test of equipment and control, safety, and alarm devices
 (b) Airtight test
 The airtight test pressure for pipes and joints in the inert gas supply line is, in principle, to be 0.024 *MPa*. However, where the set pressure of the pressure/vacuum valve is 0.024 *MPa* or more, the set pressure of the pressure/vacuum valve is to be used.
 (c) Capacity test of inert gas blowers
 It is to be verified through the use of inert gas or fresh air that the capacity of the inert gas blower is equal to or greater than 1.25 *times* the maximum design discharge capacity of the ship.
 Where fresh air is used in the test, it is to be taken in from the area in proximity to the flue gas isolating valve. However, when a ship including its inert gas system is of the same design as a ship which has already been tested, this test may be omitted.

2 The presence of the Surveyor may be reduced as stipulated in **2.1.4-4, Part 2 of the Rules** provided that the place of manufacture has been surveyed and approved in accordance with **the Rules for Approval of Manufacturers and Service Suppliers**.

2.1.5 Hydrostatic Tests, Watertight Tests, and Relevant Tests

1 The standard procedures of hydrostatic tests, watertight tests, and other relevant tests required in **2.1.5(1), Part 2 of the Rules** are as specified in **(1)** through **(3)** below.

(1) Hydrostatic tests may be carried out after application of the shop primer. However, the tests may be carried out after the protective coating has been applied, provided that the following two conditions are satisfied:
 (a) All welds are completed and carefully examined visually to the satisfaction of the Surveyor prior to the application of the protective coating.
 (b) An airtight test is carried out prior to the application of the protective coating.

(2) An airtight test is to be carried out in accordance with **(a)** through **(f)** below:
 (a) An air pressure of 0.015 *MPa* is to be applied during the test.
 (b) Prior to examination, air pressure in the tank is to be raised to 0.02 *MPa* and kept at this level for about 1 hour to reach a stabilized state and then lowered to the test pressure. The test may be conducted without lowering the pressure, provided the Society is 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 verify the test pressure. The U-tube is to have a cross section larger than that of the pipe supplying the air. In addition, the test pressure is also verified by means of one master pressure gauge or other equivalent means.

(e) The Airtight test is to be carried out prior to the application of a protective coating, on all fillet welds, penetration welds and erection welds on tank boundaries. Regarding other welds on tank boundaries, an airtight test after coating is acceptable, provided that visual inspection on the welds was carefully done before coating to the satisfaction of the Surveyor.

However, airtight tests before coating may also be required on selected locations of pre-erection manual or automatic welds, at the discretion of the Surveyor, taking account of the quality control operations in the shipyard.

(f) Any other recognized method may be accepted when deemed so by the Surveyor.

(3) Hose tests are to be carried out with a pressure in the hose of not less than 0.2 *MPa* at a maximum distance of 1.5 *m*. The nozzle diameter is not to be less than 12 *mm*.

2.1.6 Documents to be Maintained on Board

The certificates specified in **2.1.6-3, Part 2 of the Rules** are those such as the ones issued for each piece of equipment, device, etc., type approval certificates valid at the time of the Classification Survey. With regard to fire pumps, hose test records after installation on board may be accepted. In addition, unless equipment or devices on board are renewed after the ship has entered service, these certificates need not be updated.

2.1.7 Finished Plans

1 Items to be indicated in hull structural drawings specified in **2.1.7-1(2), Part 2 of the Rules** are to be in accordance with **2.1.2-1(1)**.

2 Scantling plans specified in **2.1.7-1(2), Part 2 of the Rules** mean drawings containing construction arrangements and scantlings of hull structural members including fore and aft end structures unless specified otherwise. When the necessary information is available in other drawings submitted under the provisions of **2.1.7-1(2), Part 2 of the Rules**, scantling plans need not be submitted separately.

2.2 Classification Survey of Ships not Built Under Survey

2.2.1 General

1 Submission of Plans and Documents for Examination

The following plans and documents are to be submitted to the Society well in advance for the examinations necessary for the classification survey of ships not built under survey of the Society.

(1) Hull:
- (a) General Arrangement
- (b) Midship Section
- (c) Construction Profile
- (d) Shell Expansion
- (e) Piping Arrangement
- (f) Rudder
- (g) Stern Frame
- (h) Piping Arrangement for Cargo (for Tank Barges)
- (i) Lines (Where Freeboard Assignment is required)
- (j) Hydrostatic Curves (Where Freeboard Assignment is required)

(2) Machinery:
- (a) Particulars of Machinery
- (b) Machinery Arrangement of Machinery Space
- (c) Boiler and its fittings
- (d) Piping Arrangement in Machinery Space
- (e) Crankshaft and Thrust Shaft of Main engine(s), Power Transmission systems (Reduction Gear, etc.), Intermediate Shafts, Propeller Shaft, Stern Tube Bearings, Stern Tube Sealing Device and Propeller
- (f) Calculation sheets or Measurement Data for Torsional Vibration of Propeller Shaftings (for Reciprocating

Engine)
  (g) Steering Gears
  (h) Wiring Diagram
(3) Copies of Survey Reports
(4) Record of Official River Trial (where no record of official river-trial is available, river-trial is to be carried out)
(5) Stability Information (where no stability information is available, inclining experiment is to be carried out)
(6) Copies of Classification Certificate, Statutory Certificate and Certificate of Registry
(7) Other documents which show the ship's history and particulars (as far as is available)

2 Notice of the Results of Examination of Plans and Documents

Where examination of the plans and documents specified in **-1** above is made by the Society, the results will be notified to the applicant. Where sufficient examination cannot be done on the submitted plans and documents due to lack of information, the Society may require an on-board inspection.

3 Preliminary investigation for aged ships

For ships which appear to have some drawback regarding classification with the Society, a preliminary investigation may be made by the Society.

4 Modification of survey requirements

(1) Where the owner wishes to postpone a part of the survey and the Society deems it appropriate, postponement may be approved based on examinations of the present condition of the ship. The postponed examinations are to be completed within one year.
(2) Depending on the situation, special consideration may be given to the requirements of the Classification Survey of ships built under government survey provided that a year has not passed since the ship was completed and the next Special Survey is made to coincide with the due date of the next government Special Survey.

2.3 River Trials and Stability Experiments

2.3.1 River Trials

1 The Astern test required by **2.3.1-1(1), Part 2 of the Rules** is to be carried out in accordance with the following **(1)** and **(2)** below.

(1) While the ship is running ahead at maximum speed, an order for full astern is issued and the reversing operation from ahead run to full astern run is carried out as quickly as possible. The elapsed time for the ship to stop after the full astern order, heading angle of the ship and stopping distance are to be measured. For ships that are unable to perform the test at maximum speed, the ship is to run ahead at not less than the speed of at least 90% of the ship speed corresponding to not less than 95% of the maximum continuous revolutions of the main engine. However, the measurements of the items regarding stopping ability may be dispensed with, provided that sufficient data is available from an astern test of a sister ship and subject to the special approval by the Society.
(2) It is to be confirmed that the machinery is functioning normally while the ship is running astern. The main engine is to be kept at a rate of more than 70% of the maximum continuous revolutions. The ship is to be kept running astern for a period of 10 *minutes* or until the astern speed (rotational speed in rpm) stabilizes, whichever is the greater and the performance is to be confirmed in accordance with **1.3.2, Part 7 of the Rules**.

2 The Steering test and change-over test from main to auxiliary steering gears required by **2.3.1-1(2), Part 2 of the Rules** are to be carried out in accordance with the following **(1)** through **(9)**. However, the tests required in **(5)**, **(6)**, **(7)**, **(8)** and **(9)** may be dispensed with where such tests have been carried out either at dockside or in dry dock.

(1) Tests of the steering capabilities specified in **12.2.2** and **12.2.3, Part 7 of the Rules.** Where the ship cannot be tested in the full load condition, the ship is to be tested in accordance with any of the following except in cases where specially provided for by the flag state. In such cases, the ship speed at maximum continuous revolutions of the main engine is to be used instead of the speed specified in **2.1.9, Part 1 of the Rules**. If the ship is fitted with a controllable pitch propeller, the main steering gear test is to be carried out at the maximum design pitch approved by the Society for the number of maximum continuous revolutions.
  (a) Tests are to be carried out on the condition that the rudder is fully submerged (at zero speed waterline) and the vessel is in an acceptable trim condition.
  (b) Tests are to be carried out on the condition that rudder load and torque at the trial loading condition have been reliably predicted and extrapolated to the full load condition.

(2) Running tests of the power units, including transfer between power units
(3) Tests of the emergency power supply required by **12.2.6, Part 7 of the Rules**
(4) Operation tests of controls, including change-over between two control systems, change-over between the control system and the controller provided in the steering gear compartment, and change-over between automatic steering and manual steering
(5) Tests of the means of communication between the navigating bridge and the engine room, and between the engine room and the steering gear compartment
(6) Function tests of indicators for alarms, rudder angle indicator and power units required by **Chapter 12, Part 7 of the Rules**
(7) Function tests of indicators for operating condition of electric motor and relief valves for preventing overpressure
(8) Function tests of the rudder stoppers
(9) Where the steering gear is designed to avoid hydraulic locking, a demonstration of this feature

3 The performance tests of machinery installations required by **2.3.1-1(3), Part 2 of the Rules** are to include the following **(1)** to **(6)** in order to verify that the machinery installations have sufficient normal functions and reliability and are free from detrimental vibration within the numbers of revolutions used. However, these tests may be dispensed with where such tests have been conducted while the ship was anchored or at dockside. The details of these tests may be found in *JIS F* 0801 “Test Code of Propelling Machinery at Sea Trials” or other documents considered equivalent thereto.

(1) For diesel engines, the output test shown in **Table 2.2.3.1-5**, is to be used as the standard. For diesel engines driving generators or auxiliary machinery (excluding auxiliary machinery for specific uses), operating tests may be carried out at the appropriate time after installation on board.
(2) Operating tests for starting devices
It is to be confirmed that the diesel engines start continuously for the number required by **2.5.3-2, Part 7 of the Rules**.
(3) Function tests of the alarms and safety devices
Function tests of the alarms and safety devices required by **2.4, Part 7 of the Rules** are to be carried out.
(4) Fuel suitability
The suitability of residual and other special fuels for use in the engine is to be confirmed. However, this test may be dispensed with where the suitability has already been demonstrated at the shop trial.
(5) Function tests of the safety devices and alarms of boilers
(6) Function tests of the safety devices and alarms of exhaust gas economizers

Table 2.2.3.1-5 Trials of Diesel Engines

Test items	Use of engines		
	Main engines of diesel ships(1)	Main engines of electric propulsion ships(2)	Engines driving generators or auxiliaries (excluding auxiliary machinery for specific use etc.)(2)
110% power run(3)	30 *minutes* at engine speed in accordance with nominal propeller curve	30 *minutes* at n_0 (n_0 is the rated engine speed.)	Capability of supplying 110% power is to be demonstrated
100% power (rated power) run(4)	4 *hours* at engine speed in accordance with nominal propeller curve	4 *hours* at n_0	4 *hours* at n_0(4) (5) (100% power run is to be included.)
Normal continuous cruise power run(4)	2 *hours* at engine speed in accordance with nominal propeller curve	2 *hours* at n_0	
Minimum revolution test of main engine	To be carried out(6)	-	-

Notes:

(1) In the case of controllable pitch propellers, the tests with various propeller pitches are to be included.

(2) The tests are to be performed at a rated speed with a constant governor setting and to be based on the rated electrical powers of the driven generators.

(3) The tests may be dispensed with where deemed appropriate by the Society in consideration of the test results of shop tests specified in **2.6.1, Part 7**.

(4) The duration of the tests may be shortened (however, the tests at 100% power run for main engines are to be conducted for not less than one hour.) where deemed appropriate by the Society in consideration of the test results of shop tests specified in **2.6.1, Part 7**.

(5) The test loads may be decreased if the engine is unable to handle the specified loads.

(6) The test is to be carried out to identify the minimum working revolution of the main engine when the ship is steered to the maximum rudder angle.

4 Function tests of windlasses required by **2.3.1-1(4), Part 2 of the Rules** are to be carried out in accordance with **(1)** and **(2)** below, and confirmation that their construction and associated equipment are in good condition is to be made.

(1) Loading Test
One length of anchor chain on each side is to be hoisted up separately and after that one length of chain on both sides is too be hoisted up simultaneously. The hoisting speed is to be measured.

(2) Cable Lifter Braking Tests
The pay out and holding ability of the cable lifter brake is to be confirmed by dropping the anchor and applying the brake.

5 Function tests of the control systems for main propulsion machinery or controllable pitch propellers, boilers and electric generating sets required by **2.3.1-1(5), Part 2 of the Rules** are to be carried out in accordance with the following **(1)** to **(3)**. However, where these tests have been carried out when the ship was anchored or at dockside, some of these tests may be dispensed with at the river trial.

(1) The control systems for main propulsion machinery and controllable pitch propellers are to be subjected to the following **(a)** to **(d)**.

(a) The main propulsion machinery or the controllable pitch propellers 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 in the main control station or the main control station on the bridge.

(b) In addition to output increase and decrease tests, the operation tests of the main propulsion machinery or the controllable pitch propellers using the bridge control devices are to be carried out. Where operation tests were carried out for the entire output range by the bridge control devices, consideration may be given to reduction of the test items with the exception of the starting test.

(c) Where there are two or more control stations for main propulsion machinery or controllable pitch propellers, the test on transfer of control is to be carried out while the ship is running ahead and when it is running astern. Where the remote devices for main propulsion machinery or controllable pitch propellers is in accordance with **14.3.2-2(3)(b), Part 7 of the Rules**, the above-mentioned test may be carried out while the main propulsion machinery is stopped.

(d) After completion of the test on transfer of control specified in **(c)**, a demonstration that the main propulsion machinery or the controllable pitch propellers can be smoothly operated from the respective control stations is to be conducted.

(2) Function tests of the control systems for boilers are to be carried out in accordance with the following **(a)** and **(b)**.

(a) With respect to essential boilers, it is to be confirmed that they can supply steam stably to auxiliary machinery essential for main propulsion of the ship without manual operation.

(b) Where an exhaust gas economizer is used as a source of steam for driving a generator and the boiler supplies extra steam automatically during power loss, operation tests of the automatic control devices for this system are to be carried out.

(3) Where generators supply electrical power to the loads necessary for propulsion of the ship, their motive power is relying upon the propulsion systems, tests of functioning of the systems of automatic or remote control of electric generating sets are to be carried out.

6 The accumulation tests of boilers required by **2.3.1-1(6), Part 2 of the Rules**, are to be carried out in accordance with the following **(1)** to **(3)**.

(1) The accumulation test is to be conducted as specified in **(a)** and **(b)** below while the boiler is under the maximum firing condition. However, where data on the evaporation of the boiler submitted to the Society has been approved, the accumulation test specified in **(a)** may be dispensed with.

(a) When the safety valve of the boilers blows with all the stop valves closed except for the valves for steam supply to machinery necessary to operate the boiler, the accumulation of pressure in the boiler drum is not to exceed 110% of the approved working pressure. However, the feed water necessary to maintain a safe water level may be supplied.

(b) For boilers with a superheater, where the accumulation test might overheat the superheater, the operation test of the means specified in **9.9.3-8, Part D of the Rules for the Survey and Construction of Steel Ships** may be carried out as an alternative after shutting off the main steam supply. In this case, the lift of each safety valve is to be checked beforehand.

(2) The accumulation test specified in **(1)** may be carried out at an appropriate time when the ship is anchored or at dockside.

(3) For boilers which are capable of refiring while using an exhaust gas economizer, in principle, the accumulation test is to be carried out in accordance with the methods specified in **(1)(a)** and **(b)** under the maximum firing condition and at the maximum continuous output of the main engine.

7 The measurements of the torsional vibration for shafting systems required by **2.3.1-1(7), Part 2 of the Rules** are to be carried out in accordance with the requirement of **6.1.3, Part 7 of the Rules**.

8 "Tests where deemed necessary by the Society" in **2.3.1-1(8), Part 2 of the Rules**, refers to the tests and examinations mentioned in the following **(1)** to **(6)**.

(1) For ships having multiple propellers or multiple main engines, sea trials are to be carried out under the assumption that one propeller or engine is inoperable due to failure to confirm that the ship can manoeuvred properly in that condition.

(2) For propulsion gears where the total face width (in case of double helical gears, the central gap is included) exceed 300 *mm* or where the ratio of the total face width to pitch circle diameter of the pinion exceeds 2, the contact marking of the teeth is to be verified by coating thinly and uniformly with suitable paint on the tooth flank.

(3) When the ship is provided with supplementary means for manoeuvring or stopping, performance tests of such means are to be carried out.

(4) Open-up inspection of cylinders may be required after sea trials when considered necessary by the Society.

(5) Sea trials for ships with electrical propulsion plants are to be carried out in accordance with the test procedures deemed appropriate by the Society.

(6) In addition to the tests specified in **2.3.1-4**, the Society may require other tests found in *JIS F* 0801 "Test Code

of Propelling Machinery at Sea Trials" or other documents considered equivalent thereto.

2.3.2 Stability Experiments

1 Stability experiments stated in **2.3.2-1, Part 2 of the Rules** refer to inclining tests and oscillation tests.

2 **Annex B2.3.2-2, Part B of the Guidance for the Survey and Construction of Steel Ships** gives the standard method for inclining tests stipulated in **-1** above.

3 Among the particulars of stability stated in **2.3.2-1, Part 2 of the Rules**, the rolling period is to be determined by the oscillation test. However, upon special approval by the Society, the oscillation test may be dispensed with and the rolling period may be determined by an approximate calculation stipulated in **2.3.1-1(2), Part U of the Guidance for the Survey and Construction of Steel Ships**.

4 The booklet required in **2.3.2-1, Part 2 of the Rules** is to provide enough information for stability as deemed appropriate by the Society according to the specifics of the ship.

5 Where the stability experiment is dispensed with in accordance with **2.3.2-3, Part 2 of the Rules**, a light weight measurement is to be carried out, and it is to be confirmed that the deviation of light weight between **(1)** and **(2)** below does not exceed a value specified in **Table 2.2.3.2-1**, and the deviation of lightship longitudinal centre of gravity between **(1)** and **(2)** does not exceed 0.5% of length of ship (L). For the purpose of this requirement, a sister ship is a ship built by the same yard from the same plan.

(1) Light weight and lightship longitudinal centre of gravity determined by a light weight check of the ship intended

(2) Light weight and lightship longitudinal centre of gravity of a lead sister ship or those values which are determined by detailed calculation regarding differences, where the ship is modified from a lead sister ship

Table 2.2.3.2-1 Acceptable deviation of light weight regarding exemption from inclining test

Length for ship (L)	$L < 50\ m$	$50\ m \leq L \leq 160\ m$	$160\ m < L$
Acceptable deviation, as given by a ratio of deviation to the lightship displacement of the lead ship subjected to the inclining test	2%	Obtained by linear interpolation	1%

6 Where the stability experiment was dispensed with in accordance with the provisions of **2.3.2-3, Part 2 of the Rules** and **-5** above, light weight and lightship centre of gravity are to be determined as follows.

(1) Light weight and lightship longitudinal centre of gravity are to be derived from **-5(1)** above.

(2) Lightship vertical centre of gravity is to be the higher of either the lead sister ship's value or the calculated value for the considered ship.

7 "A computer for stability calculation is on board the ship as a supplement to the stability information booklet," stipulated in **2.3.2-4, Part 2 of the Rules**, refers to a computer for stability calculation or a computer in which software for stability calculation is installed that can be used at locations such as the navigation bridge and cargo control room.

2.4 Alterations

2.4.1 Examinations of Altered Parts

1 In applying the requirements specified in **2.4.1, Part 2 of the Rules**, in the case of the "application of modification, etc. which affects a main particular of a ship" (hereinafter referred to as "application of major conversion"), the following are to apply, except in cases where specified by the Society or Administration:

(1) A "Major Conversion", for example, refers to (but is not limited to) the following cases:

 (a) Alteration of the dimensions of a ship; for example, the lengthening of a ship by adding a new midbody.

 (b) Change of ship type.

(2) In cases where a major conversion is performed, unless otherwise specified in the requirements, the hull structure, machinery and equipment are to comply with all requirements in force at time of alteration. For example, in the case of the lengthening of a ship, the new midbody is to comply with all relevant requirements (for example, longitudinal strength and equipment numbers, etc.) which are affected by such alteration.

(3) "Requirements in force at the time of alteration" are those requirements, unless otherwise specified, for a conversion constructed after either of the following dates:

(a) the date on which the contract is placed for the conversion; or

(b) in the absence of a contract, the date on which the work identifiable with the specific conversion begins.

2 In applying the requirements specified in **2.4.1, Part 2 of the Rules**, "permitted by the Society" refers to those cases where the Society agrees that it is difficult to apply a new requirement, and the Administration agrees to waive the concerned requirement.

3 The stability experiment may be dispensed with in accordance with **2.3.2-5**, where sufficient reliable stability data can be obtained from the stability experiments conducted before the alterations were made or from other adequate means and a special approval is given by the Society.

Chapter 3 ANNUAL SURVEYS

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

3.2.2 General Examination

1 For item 6 of **Table 2.3.2, Part 2 of the Rules**, particular attention is to be paid to the condition of the weld connections between air pipes and deck plating.

2 The examination stipulated in item 12 of **Table 2.3.2, Part 2 of the Rules** includes checking whether movable fire extinguishers and portable fire extinguishers remain effective.

3.2.3 Performance Tests

1 Appliances stipulated in item 2 of **Table 2.3.3, Part 2 of the Rules** refer to those specified in **4.1.2**, **6.1.1-3** and **7.1.2-2, Part 9 of the Rules**.

2 For details on the examinations stipulated in items 3 and 4 of **Table 2.3.3, Part 2 of the Rules**, refer to **2.1.4-1(3)**.

3 "Computers for stability calculation that are installed as a supplement to the stability information booklet" stipulated in item 6 of **Table 2.3.3, Part 2 of the Rules**, refers to a computer for stability calculation or a computer in which software for stability calculation is installed that can be used at locations such as the navigation bridge and cargo control room.

4 The performance test stipulated in item 6 of **Table 2.3.3, Part 2 of the Rules** is to be carried out in the presence of the Surveyor according to the procedures in **(1)** to **(4)** below, so as to ensure that the stability computer is working correctly. Where a copy of prior computer checks which were carried out in accordance with procedures **(1)** to **(3)** or **(1)** to **(4)** is available on board, and the Surveyor is able to verify that the computer is working properly, the confirmation of such results may substitute for the performance test.

(1) Retrieve at least one of the test loading conditions which were used for the accuracy check and are specified in the operation manual, carry out a stability calculation and compare stability results with those in the operation manual.

(2) Change several items of input data sufficiently to change the draught or displacement by at least 10%. The results are to be reviewed to ensure that they differ in a logical way from those of the test condition as mentioned in **(1)** above.

(3) Revise the modified load condition as mentioned in **(2)** above to restore the initial test condition as mentioned in **(1)** above and compare the results.

(4) As an alternative to the provisions of **(2)** and **(3)** above, select one or more test loading conditions which were used for the accuracy check, other than the one mentioned in **(1)** above, and perform a test calculation by entering all the deadweight data as if it were a proposed loading. The results are to be verified as identical to the results of the test conditions in the operation manual.

3.2.4 Internal Examinations of Spaces and Tanks

When internal examinations are carried out, the means of access provided for the examinations are also to be examined.

3.3 Annual Surveys for Machinery

3.3.1 General Examinations

In general examinations specified in **3.3.1-1, Part 2 of the Rules**, where rubber couplings are installed, a visual inspection and measurements of surface hardness or permanent deformation of rubber elements are to be conducted.

3.3.2 Performance Tests

Performance tests of the equipment stipulated in items 6(a) and (b) of **Table 2.3.6, Part 2 of the Rules** may be dispensed with provided the Surveyor is satisfied with the results of the general examination of that equipment.

Chapter 4 INTERMEDIATE SURVEYS

4.2 Intermediate Surveys for Hull, Equipment, Fire Extinction and Fittings

4.2.3 Performance Tests

For details on the examinations stipulated in items 4 through 8 in **Table 2.4.2, Part 2 of the Rules**, refer to **2.1.4-1(3)**.

4.2.4 Internal Examinations of Spaces and Tanks

When internal examinations are carried out, the means of access provided for the examinations are also to be examined.

Chapter 5 SPECIAL SURVEYS

5.2 Special Surveys for Hull, Equipment, Fire Extinction and Fittings

5.2.3 Performance Test

1 The performance test of computers for stability calculation is to be carried out in the presence of the Surveyor according to the procedures specified in **(1)** to **(3)** below, so as to ensure that the stability computer is working correctly.

(1) Retrieve all of the test loading conditions which were used for the accuracy check and are specified in the operation manual, carry out a stability calculation and compare stability results with those in the operation manual.

(2) Change several items of input data sufficiently to change the draught or displacement by at least 10%. The results are to be reviewed to ensure that they differ in a logical way from those of the test condition as mentioned in **(1)** above.

(3) Revise the modified load condition as mentioned in **(2)** above to restore the initial test condition as mentioned in **(1)** above and compare the results.

2 Operational tests specified in **5.2.3-2(1)** and **(3), Part 2 of the Rules** are to be carried out to the working pressure of all bilge and ballast piping systems.

5.2.4 Internal Examinations of Spaces and Tanks

1 When internal examinations are carried out, the means of access provided for the examinations are also to be examined.

2 With respect to **Table 2.5.1, Part 2 of the Rules**, if a selection of tanks is accepted to be examined, then different tanks are to be selected so as to examine all tanks on a rotational basis.

5.2.5 Thickness Measurements

1 The thickness measurement record specified in **5.2.5-1(4), Part B of the Rules** is to give the position of each measuring point, the thickness measured as well as the corresponding original thickness, the allowable diminution, and extent of use of high tensile steels, if used. Furthermore, the record is to give the date when the measurement was carried out, the type of measuring equipment used, and names of the personnel and their qualifications with their signatures. The Surveyor verifies and countersigns the thickness measurement record.

2 Transverse sections are to be chosen where the largest reductions are suspected to occur or are revealed from deck plating measurements. Where two or more transverse sections are required to be measured, one of them, at least, is to be a part of the water ballast tanks arranged just below upper deck within 0.5*L* amidships.

5.2.6 Pressure Tests

1 With respect to **5.2.6, Part 2 of the Rules**, bilge, sludge and other similar tanks are to comply with the requirements for fresh water tanks.

2 Pressure tests of air pipes, sounding pipes, and other pipes may be required where deemed necessary by the Surveyor as a result of examinations.

3 "when deemed appropriate by the Society" stipulated in **5.2.6-3, Part 2 of the Rules** means that pressure tests of certain cargo tanks are conducted in accordance with the Rules at an appropriate time under the presence of the Master or any other representative personnel of the ship before the due date of the examination and the following conditions **(1)** and **(2)** are met. In such cases, such pressure tests may be regarded as the pressure tests required for Special Surveys provided that the Surveyor will carry out an examination on the bulkhead in question based on the results given in **(2)** and test records.

(1) The cargo tank subject to the pressure test is readily accessible by crew members for examination for leakage at river such as a tank located contiguous to a cargo pump room.

(2) Records of examination for leakage are kept by the crew.

4 "In cases where deemed appropriate by the Society" stipulated in **Table 2.5.4** and **2.5.5, Part 2 of the Rules**

means that satisfactory external examinations of tank boundaries and confirmations from Masters stating that all pressure testing has been carried out according to **5.2.6, Part 2 of the Rules** with satisfactory results.

5.3 Special Surveys for Machinery

5.3.2 Performance Tests and Pressure Tests

"Where deemed necessary by the Surveyor" in item 2 of **Table 2.5.7, Part 2 of the Rules** refers to the following.

(1) For parts exposed to pressure, where wastage such as corrosion or abrasion that affect the strength of those parts is found.

(2) For boilers, pressure vessels or main steam piping, where the condition of internal wastage is impossible to be checked.

Chapter 6 DOCKING SURVEYS

6.1 Docking Surveys

6.1.1 Surveys in Dry Dock or on Slipway

"Mean diameter" as prescribed in item 7 of **Table 2.6.1**, **Part 2 of the Rules** refers to the average of the smallest diameter (the diameter measured in the direction with the most wear) found in one cross-section of the link and the diameter measured perpendicular to it in the same cross-section.

6.1.2 In-water Surveys

The approval of application for the In-water Survey specified in **6.1.2, Part 2 of the Rules** is subject to the following conditions in below.

(1) Survey Conditions

The In-water Survey is to be carried out under the following conditions in **(a)** through **(c)** to ensure that the information obtained is as reliable as that obtained by surveys in a dry dock or on slipway.

(a) The ship is at its lightest possible draught and is in sheltered waters. The in-water visibility and the cleanliness of the hull below the waterline are to be good enough to permit a meaningful examination which allows the Surveyor and diver to determine the condition of the plating, appendages and welding, and the Surveyor is present.

(b) Diving and in-water survey operations are to be carried out by a company approved by the Society under the **Rules for Approval of Manufacturers and Service Suppliers** which is separately specified. The services of a diver well-experienced in using underwater cameras (still and live) in in-water surveying operations are to be available.

(c) The Surveyor is to have access to a video display unit for viewing live footage and a means to keep good communication with the underwater diver. Means for taking colour photographs is to be provided.

Chapter 8 PROPELLER SHAFT AND STERN TUBE SHAFT SURVEYS

8.1 Propeller Shaft and Stern Tube Shaft Surveys

8.1.1 Ordinary Surveys

1 “An efficient crack detection method” stipulated in item 1 and 2 of **Table 2.8.1, Part 2 of the Rules** generally refers to the magnetic particle method.

2 When the clearance and/or wear down at the aft end of the stern tube or the shaft bracket bearing exceed the value given below, the bearing is to be replaced or repaired.

(1) Clearance for water lubricated bearings:

Propeller shaft diameter, *d* (*mm*): Clearance (*mm*)

$d \leq 230$:	6.0
$230 < d \leq 305$:	8.0
$305 < d$:	9.5

(2) Wear down for oil lubricated bearings:

As a rule, 0.3 *mm*, but factors such as the characteristics of the lubricating oil, the temperature fluctuation history of the lubricating oil or bearing material are to be taken into account.

8.1.3 Preventive Maintenance System

1 Appropriate stern tube sealing devices approved by the Society and devices for properly monitoring the bearing temperature specified in **8.1.3, Part 2 of the Rules**, are specified respectively as follows.

(1) Stern tube sealing devices capable of being repaired and replaced without drawing the shaft

(2) Either of the following devices to measure the temperature at the aft end bottom of the stern tube metal and a device to record the temperature:

(a) Two or more temperature sensors embedded in the metal

(b) An embedded temperature sensor replaceable from inboard the ship and a spare temperature sensor.
In this case, replacement with the spare sensor is to be demonstrated according to the procedures submitted beforehand.

2 The preventive maintenance system specified in **8.1.3, Part 2 of the Rules**, is to be approved in accordance with the procedures specified in **Table 2.8.1.3-1**.

3 The wording “where deemed appropriate by the Society” in **8.1.3, Part 2 of the Rules** means those cases where it is difficult to sufficiently draw out the propeller from the propeller shaft for those ships in which the distance between the propeller and the rudder plate is short and where no sign of slippage between the shaft and propeller has been confirmed. However, even in such cases, the propeller is to be drawn out from its shaft as far as possible and the condition of the propeller boss bore is to be checked by the Surveyor.

Table 2.8.1.3-1 Approval procedure of preventive maintenance system for oil lubricated propeller shafts

Item	Procedures
1. General	These Procedures will apply to ships intended for the preventative maintenance of propeller shafts as specified in **8.1.3, Part 2 of the Rules**. This system permits the shipowners to maintain the shafts using preventive measures such as by carrying out lubricating oil analysis regularly and diagnosing the lubricating condition of the shaft based on the results.
2. Application	-1 The executive management (hereinafter referred to as a "management") responsible for adopting the preventive maintenance system according to the Procedures is to submit to the Society three copies of the maintenance manual specifying at least the following items. (1) Management's policy for implementing the preventive maintenance system (2) Procedures and personnel responsible for sampling oil, monitoring parameters such as oil analysis results and recording the necessary data (3) Procedures and personnel responsible for selecting and controlling the analytical testing machines (or testing laboratory) and the measuring devices for monitoring parameters (4) Procedures and personnel responsible for review of each parameter monitored and diagnosing the lubricating condition thereby (5) Procedures and personnel responsible for handling any abnormalities found (including those for reporting to the Society) (6) Procedures and personnel responsible for ensuring that proper maintenance is carried out according to the maintenance manual -2 The Society returns two copies of the documents to the applicant after review and approval. The management is to keep one copy of the approved documents on board the ship and the other copy of the approved documents either on hand or at the shipowner's office. -3 The application is to be submitted within 6 *months* from the date of completion of the Classification Survey or the previous Ordinary Survey of the propeller shaft. However, this 6 *month* period may be waived in cases where supplementary documentation confirming the soundness of the propeller shafting system is submitted.
3. Approval and Notation	The Society examines the documents submitted and bases its approval on items such as the management system, the maintenance procedures and the criteria for parameters (including the criteria for alarm and abnormal conditions) of oil analysis results. The Society assigns approved ships with the notation (PSCM) as classification characters.
4. Approval Conditions	-1 Management system (1) The management is to state clearly that it will take responsibility for proper implementation of the preventive maintenance of the related parts according to the manual and familiarize the crew concerned with the procedures. (2) The management is to verify that parameters such as oil analysis results are all within their limits and to take suitable measures as necessary. The management is to report to the Society immediately where any abnormality is found. (3) The management is to verify that suitable maintenance is carried out according to the manual. (4) The items monitored or reviewed according to the manual are to be recorded. -2 Maintenance procedures (1) Oil sampling for analytical testing Oil sampling for analytical testing is to be carried out regularly at the intervals of at least 6 *months* and the procedures are in accordance with the following. (a) Sampling is to be carried out at sea as much as possible. The sampling oil quantity is about 200 *ml* and it is to be always from a fixed place after fully draining. For example, the air purge pipe at the pump exit or oil sample cock; places where the sampled oil can be representative of the system. (b) Where the sampling can only be conducted at port, the sampling is to be carried out after sufficient circulation of the oil with an oil pump if one is available, and according to the method in **(a)** above. Otherwise, the oil is to be sampled from a few points at different levels and all the samples are mixed together as the testing sample.

4.Approval Conditions

(2) Monitoring and recording of parameters

Monitoring and recording of each parameter is to be properly carried out and the following data is to be recorded at each sampling.

(a) Temperature of the circulation oil

(b) Temperature of the aft stern tube bearing

(c) Sampling date, service oil name, service hours, total oil quantity and oil consumption rate (*l*/*day*)

(3) Testing machines and measuring devices for monitoring parameters

The testing machines and measuring devices for monitoring the parameters specified in **8.1.3, Part 2 of the Rules** are to have their accuracy confirmed and calibrated properly.

-3 Criteria for parameters

The management is to determine the criteria for each parameter for the ship based on the reference standards below and by taking into account its experience and knowledge.

(1) Oil analysis

(a) Analytical items and methods:

Refer to **Table 1** as a standard. However, alternative analytical items and methods can be adopted instead where deemed appropriate by the Society.

Table 1 Standard criteria (Reference)

analytical items	max. values	analytical methods
Fe (*ppm*)	50	ICP (SOAP)
Sn (*ppm*)	20	ICP (SOAP)
Pb (*ppm*)	20	ICP (SOAP)
Na (*ppm*)	80	ICP (SOAP)
IR Oxidation @ 5.85 μm (Abs. *unit/cm*)	10	FT-IR
Separated Water (%)	1	Visual(24 settling hrs)

(b) Standard criteria:

To be within the max. values specified in **Table 1** counting from the values of the new oil

(c) Alarm values:

To be less than double the standard criteria (where any parameter exceeds the alarm value, the testing oil is to be re-sampled and re-analysis for all the items is to be carried out immediately)

(2) Lubricating oil consumption rate:

2 *l/day* or less

(3) Temperature at aft. stern tube bearing:

55°*C* or less

(4) Wear down for oil lubricated bearing:

0.3 *mm* or less

<table>
<tr><td>5. After Approval</td><td>-1 The parameters are to be monitored and recorded onboard the ship in accordance with the approved manual, and the lubricating condition of the propeller shafts is to be diagnosed thereby. Where any abnormality is found, the management is to report it to the Society as soon as possible and withdraw the shaft for a thorough examination or carry out maintenance to the shaft as necessary.
-2 The management is to submit the analysis records with the data specified in 4.-2(2) after every analysis of the sample oil. In the documents, the management's opinion, such as on the necessity for withdrawing the propeller shaft, is to be included.
-3 The Society will carry out general examinations on the related propeller shafting parts and review each record of parameters monitored at the ship's periodical surveys to verify that appropriate maintenance is carried out in compliance with the approved manual, and notify the ship's management of any necessary maintenance. Where any abnormality or improper maintenance is found out through the examination, the management is required to apply for an Open-up Survey of the propeller shaft.
-4 The ship is to undergo the examinations specified in Table 2.8.1, Part 2 of the Rules (excluding survey items 2, 3 and 5 for parts covered by the preventive maintenance system) at the propeller shaft surveys in accordance with 1.1.3-1(6), Part 2 of the Rules. However, for propeller shafts with keyless propeller attachments or having coupling flanges at the aft end, survey items 1, 6 and 7 in Table 2.8.1, Part 2 of the Rules may be extended until the earlier date of the following (1) or (2);
(1) The date when the propeller shaft is withdrawn for an examination due to some reason such as an abnormality being found by the analysis of monitoring parameters
(2) The date six years after the propeller shaft survey (excluding survey items 1, 6 and 7 in Table 2.8.1, Part 2 of the Rules) was completed</td></tr>
<tr><td>6. Cancellation of Approval</td><td>Where the following -1 to -3 is applicable, the Society may cancel the ship's approval to adopt the preventive maintenance system for the propeller shaft. In this case, the Society notifies the ship's management of the cancellation, and the ship is to undergo the propeller shaft survey immediately in accordance with the requirements of 8.1.1, Part 2 of the Rules.
-1 Where any improper conduct is found regarding entries in the records such as for oil analysis results.
-2 Where it is regarded by the Society that proper maintenance is not carried out according to the approved manual.
-3 Where the shipowner or ship management company has changed, or cancellation of the approval to adopt the preventive maintenance system has been requested by the ship's management.</td></tr>
</table>

Chapter 9 PLANNED MACHINERY SURVEYS

9.1 Planned Machinery Surveys

9.1.1 Application

The Planned Machinery Survey generally applies to surveys of machinery and equipment that have had much use. However, it does not apply to the following machinery, equipment and survey items.

(1) Propellers and propeller shafts
(2) Valves fitted with hull below the designed maximum load line
(3) Boilers
(4) Machinery and equipment (cargo handling appliances, refrigerating installations, bilge separators, pumps for bilge separators, etc.) that comply with rules other than the Rules, and that are required to have open-up surveys
(5) Measurement of crankshaft deflections of main diesel engines and clearances of stern tubes or shaft bracket bearings at their aft ends
(6) Machinery and equipment (electrical installations, spare parts, etc.) for which open-up surveys are not required (also performance tests, pressure tests, etc.)
(7) In addition to the above, machinery, equipment, and survey items which are considered by the Society to be outside the application of the Planned Machinery Survey for the following reasons:
    (a) Newly developed machinery and equipment that are not considered appropriate for application of the Planned Machinery Survey
    (b) Machinery and equipment to which the Planned Machinery Survey applies, but are not considered to be appropriate for further application of the Planned Machinery Survey due to frequent occurrences of damage

9.1.2 Continuous Machinery Survey

1 Application of CMS

(1) The survey items covered by the CMS are the open-up surveys of the equipment and machinery specified in **Table 2.9.1, Part 2 of the Rules**.
(2) Auxiliaries prescribed in item 4 of **Table 2.9.1, Part 2 of the Rules** are as follows:
    (a) Air compressors and blowers
    Main and auxiliary starting air compressors (excluding those for emergency use), air compressors for the control system, and forced draught fans for boilers (excluding those with a maximum evaporation rate of 3 tons/hr or less)
    (b) Cooling pumps
    Piston cooling fresh water / oil pumps, cylinder jacket cooling fresh water / river water pumps, turbocharger cooling fresh water / river water pumps, fuel valve cooling fresh water / oil pumps, cooling river water pumps for L.O. cooler, cooling river water pumps for fresh water cooler, and cooling fresh water /river water pumps for generator engine
    (c) Fuel oil pumps
    F.O. supply pumps, F.O. service pumps, boiler burning pumps (excluding those with a maximum evaporation rate of 3 tons/hr or less), and F.O. transfer pumps
    (d) Lubricating oil pumps
    L.O. pumps for main engine, L.O. pumps for camshaft, L.O. pumps for reduction gear, L.O. pumps for controllable pitch propeller (C.P.P.), stern tube L.O. pumps (excluding those where the lubricating oil can be supplied and circulated under the gravity tank system), thermal oil circulating pumps, and system oil pumps (pumps for feeding oil to hydraulic systems for control and adjustment of essential auxiliaries for propulsion)
    (e) Feed water pumps, condensing pumps, drain pumps
    Feed water pumps, boiler water circulating pumps, and drain pumps
    (f) Bilge pumps, ballast pumps, and fire pumps

Bilge pumps, ballast pumps, general service pumps, and fire pumps (excluding those for emergency use)

(g) Condensers and feed water heaters

Auxiliary condensers, gland condensers, atmospheric condensers, dirty steam condensers, vent condensers, drain cooler feed water heaters, and deaerators

(h) Coolers

Main fresh water coolers (for cylinder jackets and pistons), F.O. valve cooling fresh water / oil coolers, fresh water coolers for turbochargers, cooling fresh water coolers for generator engines, F.O. coolers, main L.O. coolers, turbocharger L.O. coolers, camshaft L.O. coolers, reduction gear L.O. coolers, hydraulic oil coolers, coolers for C.P.P., stern tube L.O. coolers, and coolers for generator turbines

(i) Oil heaters

F.O. heaters, L.O. heaters (excluding electric heaters with a capacity of 10 *kW* or less)

(j) F.O. tanks (having a capacity of more than 1 m^3 which do not form part of the hull structure)

F.O. settling tanks and service tanks (for main and auxiliary machinery), and F.O. tanks for boilers

(k) Air reservoirs (including those for main, auxiliary, control, general service and emergency use)

Air reservoirs and their essential valves

(l) Deck machinery

Steering gears, windlasses and mooring winches (including their hydraulic pumps)

(m) Other machinery and equipment which the Society considers to be covered by the Planned Machinery Survey

2 Application for CMS

(1) To apply for CMS, the shipowner or agent is to submit three copies of the following documents in the prescribed format (one for the Society's files, the ship and the shipowner) to the Society before the first survey after the Classification Survey or the previous Special Survey.

(a) Application for CMS

(b) CMS Program

(2) For existing ships (such as those subject to Classification Survey of ships not built under the Society's Survey), the survey items applicable to Planned Machinery Surveys are selected from among those surveyed by the previous Classification Society at the Classification Survey of ships not built under the Society's Survey. The procedures to be adopted after the Classification Survey are to be the same as in **(1)** above.

3 CMS Program

The CMS Program is to be prepared referring to the following **(1)** to **(3)**. Each survey interval for items covered by the Planned Machinery Survey is not to exceed 6 *years*, and the Program is to be retained on board the ship so that it can be presented to the Surveyor whenever so requested.

(1) All the items applicable for the CMS are to be included.

(2) The interval between open-up examinations of identical items is not to exceed 6 *years*.

(3) Preferably, the survey schedule for machinery and equipment is to be planned in such a way that the conditions of one set of machinery and equipment can be deduced from the results of an open-up examination of another set of machinery and equipment. Accordingly, when there are identical sets of machinery or equipment, the examinations should be conducted on an alternate set each time as far as practicable.

4 Procedures for CMS

(1) Surveys under CMS are to be carried out in accordance with the CMS Program prescribed in **-3** above. However, where partial changes are made to the maintenance plan of machinery and equipment while executing the CMS Program, the Program retained on board may be corrected upon approval by the Surveyor and the subsequent surveys may be carried out according to the corrected Program.

(2) When defects or failures are found in areas surveyed, a thorough examination may be required on similar parts despite the CMS Program prescribed in **-3** above.

5 Substitution for open-up examinations

The machinery and equipment listed below may be exempt from open-up examinations if they are found to be in satisfactory condition by carrying out the examinations listed and examining records such as the logbooks. However, when defects are found during the examinations, or if the maintenance condition is judged to be questionable as a result of examining the logbooks or other records, open-up examinations may be required.

(1) Oil pumps (excluding cargo pumps) and hydraulic deck machinery

Visual examinations of general conditions by checking items such as the amount of fouling of oil strainers or the state of the oil

Examination of the operating condition of the pumps

(2) Oil tanks, F.O. coolers and oil heaters

Visual examinations of general conditions

(3) Cooling fresh water pumps and blowers

Visual examinations under their operating conditions

(4) Auxiliary diesel engines that are not normally used at sea and those that have a total running time of less than 7,000 hrs counting from the last open-up examination

Visual examinations under their operating conditions (However, an open-up examination is required when the total running time reaches 7,000 hrs counting from the last open-up examination)

6 Confirmatory Survey

In ships deemed by the Society as maintaining their machinery and equipment well, overhaul inspections according to the CMS Program specified in **-3** by the shipowner (or the ship management company) may forgo the open-up examination performed in the presence of Surveyors by conducting the following confirmatory surveys, provided that the machinery and equipment are overhauled as part of the ship's maintenance practices and the records from such overhauls are kept in good order. In this case, the date of the next open-up examination is to be within a 6-*year* period from the date of its last overhaul and inspection.

(1) Procedure of the confirmatory survey

(a) In the case of any machinery and equipment specified in **(2)** below overhauled and inspected by the Chief Engineer as routine maintenance work, one copy of the inspection report including the items mentioned below is to be submitted to, and reviewed by the attending Surveyor. Also, the Chief Engineer's profile is to be confirmed by the attending Surveyor.

i) Signature of the Chief Engineer and license number

ii) Date and place of the inspection

iii) Inspection items and their results

iv) Operating conditions before and after the inspection

(b) Parts replaced with spares or repaired are to be verified by visual examinations on by photographs.

(c) Visual examinations are to be carried out for main propulsion machinery, and examinations under operating conditions, as well as visual examinations are to be carried out for other machinery and auxiliary machinery, etc.

(d) Visual examinations of lubricating oil conditions are to be carried out through open-up inspections, etc. of the lubricating oil filters of crankshafts, main bearings, crankpin bearings, crankpin bolts, main diesel engine camshafts and main diesel engine camshaft driving devices.

(e) Visual examinations to confirm the current conditions and the lubricating oil maintenance conditions of intermediate shafts, thrust shafts and bearings are to be carried out as far as possible.

(f) Confirmation of the open-up inspection and adjustment records of safety valves (excluding fusible plugs) is to be carried out for air reservoirs.

(g) As a result of the confirmatory survey stipulated in **(a)** to **(f)** above, open-up examinations and/or re-examinations may be required when deemed necessary by the Surveyor.

(2) Items applicable to the confirmatory survey

Items of machinery and equipment applicable to the confirmatory surveys are as follows.

(a) Main diesel engines

(b) Diesel engines used for driving generators, auxiliary machinery essential for main propulsion or auxiliary machinery for manoeuvring and safety of the ship

(c) Intermediate shafts, thrust shafts and bearings

(d) Auxiliary machinery (air compressors, pumps, heat exchangers, air reservoirs, deck machinery and distilling plants)

(3) Timing of the confirmatory survey

A confirmatory survey is to be carried out by the completion date of the first periodical survey after the day the item of machinery and equipment intended for the confirmatory survey was overhauled and inspected.

7 Cancellation of CMS

(1) Where the shipowner or representative requests termination of the CMS, the machinery and equipment are to be subjected to all the surveys required for the CMS at Special Surveys henceforth. If there are any items of machinery or equipment that will not be covered by a Special Survey within 6 *years* of the previous survey, they are to be examined within those 6 *years*.
(2) When non-compliance with this Guidance is found for machinery or equipment to which the CMS is applied, application of the CMS may be cancelled by the Society. The procedures to be taken henceforth are to be in accordance with the requirements in **(1)** above.
(3) When the shipowner changes, the CMS is generally discontinued. Where the new shipowner wishes to continue CMS, a new application as prescribed in **-3** above is to be made by the new shipowner.

9.1.3 Planned Machinery Maintenance Scheme

1 Application of PMS
(1) PMS generally applies to machinery and equipment installed in the following ships.
  (a) Ships with machinery and equipment less than 15 *years* old at the time of application.
  (b) Ships operated by a shipowner or ship management company that has an established maintenance system and organization.
(2) PMS applies to the open-up examinations of machinery and equipment prescribed in **9.1.2-1**.
2 Terms
The definitions of terms which appear in **9.1.3** are as specified in the following **(1)** and **(2)**.
(1) Maintenance management system
A computer system for managing the maintenance and inspection plans of machinery and its components that are subject to the Planned Machinery Maintenance Scheme
(2) Condition monitoring system
A system which is composed of displays for diagnosing the deterioration trend of the machinery and its components from data continuously or periodically measured by sensors and computers for saving and maintaining this data
3 Application Procedure for PMS
To apply for PMS, the shipowner or ship management company or representative is to submit an Application for PMS accompanying the following documents to the Society.
(1) Documents for approval (3 sets: one each for the ship's file, shipowner's file and Society's file)
  (a) Machinery maintenance scheme
  (b) Survey schedule table
  (c) Function descriptions for maintenance management system
  (d) The following documents in addition to **(a)** through **(c)** above, when applying for the condition monitoring maintenance method
    i) Function description for condition monitoring system
    ii) Condition monitoring procedures and sensor lists
    iii) Kinds and contents of output information
(2) Documents for reference (1 set)
  (a) Sample form of machinery maintenance records
  (b) Organization chart identifying the section and the personnel responsibility for the machinery maintenance
4 Approval of PMS
Conditions for approval of PMS are as follows:
(1) Planned maintenance method
The machinery maintenance scheme for PMS made based on the planned maintenance system is to cover the maintenance plans not only for survey items but for all machinery. It is to specify maintenance works such as overhaul inspection, replacement of parts and general inspection with their time schedule and/or running hours for each item of machinery and equipment including their parts. The scheme is to be prepared based on the inspection and maintenance intervals recommended by the manufacturers of the machinery and equipment with input from the experience and knowledge of the shipowner and ship management company. The inspection intervals for all items covered by PMS are generally planned not to exceed 6 *years*. However, for the items whose overhaul intervals are specified on the basis of their running hours, longer intervals may be accepted as

long as the intervals are based on the manufacturer's recommendations. When the machinery maintenance scheme is changed, the amended scheme is to be submitted to the Society for approval.

(2) Condition monitoring maintenance method

The machinery maintenance scheme is to cover the maintenance plan for all the machinery as **(1)** above. For machinery, equipment and parts with a condition monitoring system which complies with the following requirements, the inspection intervals may be prolonged until an abnormal condition is observed. In this case, the machinery maintenance scheme for PMS is also to cover all condition monitoring functions, criteria for judgment and procedures for monitoring, analysis and handling (including reporting observed abnormal conditions to the Society) of the system.

(a) Condition monitoring systems are to be suited to diagnosing any deterioration of equipment or its components on the basis of the data from sensors or centralized machinery monitoring and control systems. The sensors are to be subject to the tests specified in **14.7.1, Part 7 of the Rules**.

(b) Condition monitoring systems are to be suited to diagnosing the condition of equipment or its components on the basis of independent or coalesced data or their trends.

(c) Back-ups of the data can be made.

(3) Survey Schedule Table

Survey intervals of the survey items are not to exceed those specified in the machinery maintenance scheme. The following items are to be generally opened and examined in the presence of the Surveyor. Where the condition monitoring maintenance method is applied, the items are to be opened and examined only when an abnormal condition is observed.

(a) Reduction gears for main propulsion

(b) Flexible couplings for main propulsion

(c) Other items deemed necessary by the Society.

When this survey schedule table is amended, the amended survey schedule table is to be submitted to the Society for approval.

(4) Machinery Maintenance Records

Machinery maintenance records are to include at least the following items. These records are to be retained on board the ship at all times.

(a) Date of maintenance work

(b) Signature by the Chief Engineer

(c) Details of maintenance work and results

(d) Total running hours (parts replacement intervals and overhaul intervals)

(e) Names of parts replaced

(f) Measuring data (including original design dimensions and allowable tolerance)

(g) The condition of damage and repair method

(h) Results of visual examinations of lubricating oil conditions carried out through open-up examinations of the lubricating oil filters, etc. of crankpins, crank journals, thrust shafts and bearings of main diesel engines (in cases where the principle components of such engines were inspected through independent open-up surveys conducted by chief engineers)

(5) Condition monitoring records

Condition monitoring records are to include at least the following items.

(a) Date of condition monitoring and relevant content of survey

(b) Signature of the Chief Engineer at the condition monitoring

(c) Contents and results of condition monitoring (including criteria for judgment)

(6) Chief Engineer

The Chief Engineer in charge of PMS is to be a person designated by the shipowner or ship management company.

(7) Computer

Computers used for condition monitoring and diagnosis systems are to satisfy the following requirements specified in **(a)** through **(f)**:

(a) Computers are to be configured so that the effects of a system failure in part of the circuits or devices can be limited to a certain range as far as possible.

(b) Each system component is to be protected against overvoltages (electrical noise) likely to enter through input/output terminals.
(c) Central processing units and important peripheral devices are to have a self-monitoring function.
(d) Important programmes and data are not to be deleted in the event of a temporary failure of the external source of power supply.
(e) Spare parts for important system components that require specialist services for repairs are to be supplied in readily replaceable part units.
(f) It is recommended that the software is approved in accordance with **Annex B9.1.3-4 "PROCEDURES FOR APPROVAL OF PMS MANAGEMENT SOFTWARE", Part B of the Guidance for the Survey and Construction of Steel Ships**.

5 Surveys for PMS

(1) Initial Survey

The initial survey is to be carried out by the Surveyor within 1 *year* from the date of approval for application of PMS, and it is to be verified that planned machinery maintenance is being carried out in accordance with the approval scheme.

(2) Annual Survey

General examinations (including review of maintenance records) are to be carried out yearly to confirm that the planned machinery maintenance is being carried out by the designated Chief Engineer in accordance with the approved scheme on relevant machinery, equipment, and parts, and that these items are in good condition. Where the condition monitoring maintenance method is applied, it is to be verified that condition monitoring has been properly carried out and as a result of which, machinery, equipment and parts are in good order. Confirmation that the condition monitoring system and maintenance management system are being operated effectively and are also in good order is to be made. Condition monitoring data and the results of the diagnosis are to be evaluated before the survey and are to be retained on board at all times.

(3) Special Survey

Where the condition monitoring maintenance method is applied, confirmation that the condition monitoring system and maintenance management system are being operated effectively and are also in good order is to be made. Condition monitoring data and the results of the diagnosis are to be evaluated before the survey and are to be retained on board at all times.

(4) Open-up Survey

The items prescribed in **-4(3)** above are to be opened and examined in the presence of the Surveyor in accordance with the survey schedule table.

(5) Occasional Survey

Any damage to items covered by PMS or any abnormal conditions observed by the condition monitoring system specified in **-4(2)** are to be reported to the Society immediately. Upon review of the reports, the Society may request an occasional survey when considered necessary.

6 Cancellation of PMS

The Society may cancel approval for PMS when it is considered difficult to continue PMS for any of the following reasons.

(1) It is found that PMS is not operated in accordance with the approved scheme
(2) Damage or deficiencies found on items covered by PMS have not been rectified by the date recommended
(3) When the shipowner or ship management company has changed
(4) When the class of the ship has been transferred

Part 4 HULL CONSTRUCTION AND EQUIPMENT OF TUGS AND PUSHERS

Chapter 2 RUDDERS AND STERN FRAMES

2.1 Rudders

2.1.1 Application

1 For Mariner-type rudders (*See* **Fig. 4.2.1.1-1**), the scantling of rudders is to be determined in accordance with the requirements in **Chapter 3, Part C of the Rules for the Survey and Construction of Steel Ships**.

2 The scantling of each member of rudders having three or more pintles is to be determined in accordance with the requirements in **Chapter 2, Part 4 of the Rules**. However, the moment and force acting on each member are to be determined by the direct calculation method, in accordance with the requirements in **2.1.7**.

3 Rudders having a special shape or sectional form (*e.g.* rudders with flaps, fish tail rudders and nozzle rudders) are to be as specified in **(1)** and **(2)** below, unless the rudder force and rudder torque are required to be determined by tests or detailed theoretical calculation. In other rudders, the scantling of each member is to be determined by obtaining the rudder force and rudder torque through tests or detailed theoretical calculations, and correspondingly applying the requirements in **Chapter 2, Part 4 of the Rules**. Results of tests or theoretical calculations are to be submitted to the Society.

(1) Rudders with flaps and fish tail rudders

The scantling of each member of rudders with flaps or fish tail rudders is to be determined in accordance with the requirements in **Chapter 2, Part 4 of the Rules**. However, in applying the Rules, values of factor K_2 in **2.1.4** and values of factor α in **2.1.5, Part 4 of the Rules** are to be as specified in **Table 4.2.1.1-1**. K_2 and α in astern condition are to be to the discretion of the Society.

(2) Nozzle rudders

The scantling of each member of nozzle rudders is to be determined in accordance with the requirements in **Chapter 2, Part 4 of the Rules**. In applying the Rules, the total rudder area and the rudder area ahead of the centreline of the rudder stock are to be calculated as follows:

Total rudder area A:

$$2h(b_1 + b_2) + h'(a_1 + a_2) \quad (m^2)$$

Rudder area ahead of the centreline of the rudder stock A_f :

$$2hb_2 \quad (m^2)$$

Where:

a_1, a_2, b_1, b_2, h and h' : Refer to **Fig. 4.2.1.1-2**

4 The scantling of each member of rudders designed for helm angles exceeding 35° is to be determined in accordance with the requirements in **Chapter 2, Part 4 of the Rules**, on the basis of the rudder force and rudder torque obtained through tests or detailed theoretical calculations. The results of tests or theoretical calculations are to be submitted to the Society.

Fig. 4.2.1.1-1 Mariner-type Rudders

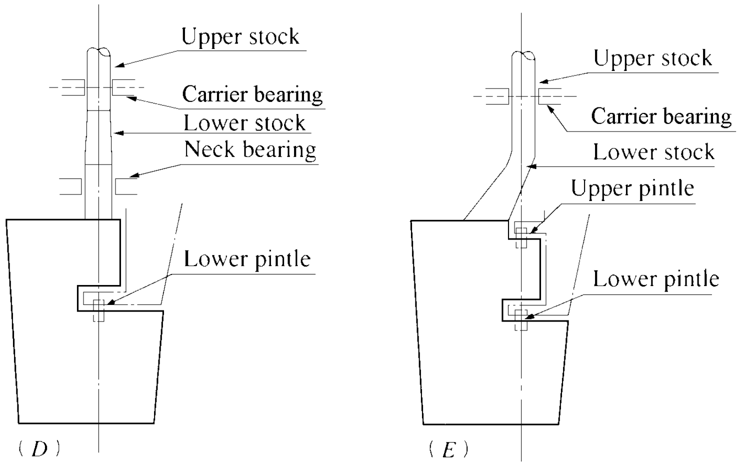


Table 4.2.1.1-1 Factor K_2 and α

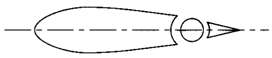
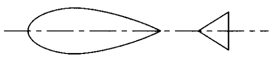
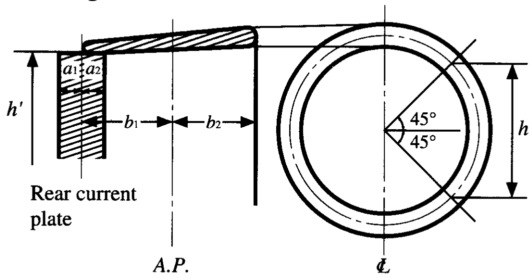
Profile type	K_2 Ahead Condition	α Ahead Condition
Rudders with flaps 	1.7	0.45
Fish tail rudders 	1.4	0.45

Fig. 4.2.1.1-2 Area of Nozzle Rudder



2.1.2 Materials

If the diameter of the rudder stock is small, cast carbon steel is not to be used.

2.1.4 Rudder Force

For single plate rudders, factor K_2 is to be 1.0 for both the ahead and astern conditions.

2.1.6 Rudder Strength Calculation

1 General

The bending moment, shear force, and supporting force acting on the rudder and rudder stock may be evaluated using the basic rudder models shown in **Fig. 4.2.1.6-1** to **Fig. 4.2.1.6-5**.

2 Moments and forces to be evaluated

The bending moment M_R and the shear force Q_1 acting on the rudder body, the bending moment M_b acting on the bearing, and the bending moment M_s acting on the coupling between the rudder stock and the rudder main piece and the supporting forces B_1, B_2, B_3 are to be obtained. These moments and forces are to be used for analyzing the stresses in accordance with the requirements in **Chapter 2, Part 4 of the Rules**.

3 Method of evaluating moments and forces

(1) General data

Data on the basic rudder models shown in **Fig. 4.2.1.6-1** to **Fig. 4.2.1.6-5** is as follows:

$l_{10} \sim l_{50}$: Lengths (m) of individual girders of the system

$I_{10} \sim I_{50}$: Moments (cm^4) of inertia of these girders

For rudders supported by a shoe piece, the length l_{20} is the distance between the lower edge of the rudder body and the centre of the shoe piece and I_{20} is the moment of inertia of the pintle in the shoe piece.

h_c is the vertical distance (m) from the mid-point of the length of that pintle to the centroid of the rudder area.

(2) Direct calculation

The standard data to be used for direct calculation are as follows:

Load acting on rudder body (Type B and C rudders)

$$P_R = \frac{F_R}{1000 l_{10}} \quad (kN/m)$$

Load acting on rudder body (Type A rudder)

$$P_{R10} = \frac{F_{R2}}{1000 l_{10}} \quad (kN/m)$$

$$P_{R20} = \frac{F_{R1}}{1000 l_{30}} \quad (kN/m)$$

Load acting on rudder body (Type D and E rudders)

$$P_{R10} = \frac{F_{R2}}{1000 l_{10}} \quad (kN/m)$$

$$P_{R20} = \frac{F_{R1}}{1000 l_{20}} \quad (kN/m)$$

Where:

F_R : As specified in **2.1.4, Part 4 of the Rules**

F_{R1}, F_{R2} : As specified in **2.1.5, Part 4 of the Rules**

k : Spring constant of the supporting point of the shoe piece or rudder horn respectively, as shown below

For the supporting point of the shoe piece:

$$k = \frac{6.18 I_{50}}{l_{50}{}^3} \quad (kN/m)$$

(*See* **Fig. 4.2.1.6-1** and **Fig. 4.2.1.6-2**)

Where:

I_{50} : The moment (cm^4) of inertia of shoe piece around the Z-axis

l_{50} : Effective length (m) of shoe piece

For the supporting point of rudder horn:

$$k = \frac{1}{f_b + f_t} \quad (kN/m)$$

(*See* **Fig. 4.2.1.6-1**, **Fig. 4.2.1.6-4** and **Fig. 4.2.1.6-5**)

Where:

f_b : Unit displacement of rudder horn due to a unit force of 1 kN acting in the centre of support as shown below.

$$f_b = 1.3 \frac{d^3}{6.18 I_n} \quad (m/kN)$$

Where:

I_n : The moment of inertia (cm^4) of rudder horn around the X-axis

f_t : Unit displacement due to torsion, as shown below.

$$f_t = \frac{d c^2 \Sigma u_i / t_i}{3.14 F_T{}^2} \times 10^{-8} \quad (m/kN)$$

F_T : Mean sectional area (m^2) of the rudder horn

u_i : Breadth (mm) of the individual plates forming the mean sectional area of the rudder horn

t_i : Plate thickness (mm) within the individual breadth u_i

For c and d, *see* **Fig. 4.2.1.6-4** and **Fig. 4.2.1.6-5**. (For the rudder horn of Type *A* rudders, the same values are to be also applied.)

(3) Simplified method

The moments and forces for rudders of each type may be obtained from the following formulae.

(a) Type *A* rudders

$$M_R = \frac{B_1^2(l_{10}+l_{30})}{2F_R} \quad (N\text{-}m)$$

$$M_b = \frac{B_3(l_{30}+l_{40})(l_{10}+l_{30})^2}{l_{10}^2} \quad (N\text{-}m)$$

$$M_s = B_3 l_{40} \quad (N\text{-}m)$$

$$B_1 = \frac{F_R h_c}{l_{10}} \quad (N)$$

$$B_2 = F_R - 0.8B_1 + B_3 \quad (N)$$

$$B_3 = \frac{F_R {l_{10}}^2}{8l_{40}(l_{10}+l_{30}+l_{40})} \quad (N)$$

(b) Type *B* rudders

$$M_R = \frac{B_1^2 l_{10}}{2F_R} \quad (N\text{-}m)$$

$$M_b = B_3 l_{40} \quad (N\text{-}m)$$

$$M_s = \frac{3M_R l_{30}}{l_{10}+l_{30}} \quad (N\text{-}m)$$

$$B_1 = \frac{F_R h_c}{l_{10}+l_{30}} \quad (N)$$

$$B_2 = F_R - 0.8B_1 + B_3 \quad (N)$$

$$B_3 = \frac{F_R(l_{10}+l_{30})^2}{8l_{40}(l_{10}+l_{30}+l_{40})} \quad (N)$$

(c) Type *C* rudders

$$M_b = F_R h_c \quad (N\text{-}m)$$

$$B_2 = F_R + B_3 \quad (N)$$

$$B_3 = \frac{M_b}{l_{40}} \quad (N)$$

(d) Type *D* rudders

$$M_R = \frac{F_{R2} l_{10}}{2} \quad (N\text{-}m)$$

$$M_b = \frac{F_R {l_{10}}^2}{10(l_{20}+l_{30})} \quad (N\text{-}m)$$

$$M_s = \frac{2M_R l_{10} l_{30}}{(l_{20}+l_{30})^2} \quad (N\text{-}m)$$

$$B_1 = \frac{F_R h_c}{l_{20}+l_{30}} \quad (N)$$

$$B_2 = F_R - B_1,\ \min B_2 = F_R/4 \quad (N)$$

$$B_3 = \frac{M_b}{l_{40}} \quad (N)$$

$$Q_1 = F_{R2} \quad (N)$$

(e) Type *E* rudders

$$M_R = \frac{F_{R2} l_{10}}{2} \quad (N\text{-}m)$$

$$M_b = \frac{F_R {l_{10}}^2}{10 l_{20}} \quad (N\text{-}m)$$

$$B_1 = \frac{F_R h_c}{l_{20}} \quad (N)$$

$$B_2 = F_R - B_1,\ \min B_2 = F_R / 4 \quad (N)$$

$$B_3 = \frac{M_b}{l_{40}} \quad (N)$$

$$Q_1 = F_{R2} \quad (N)$$

Fig. 4.2.1.6-1 Type *A* Rudder

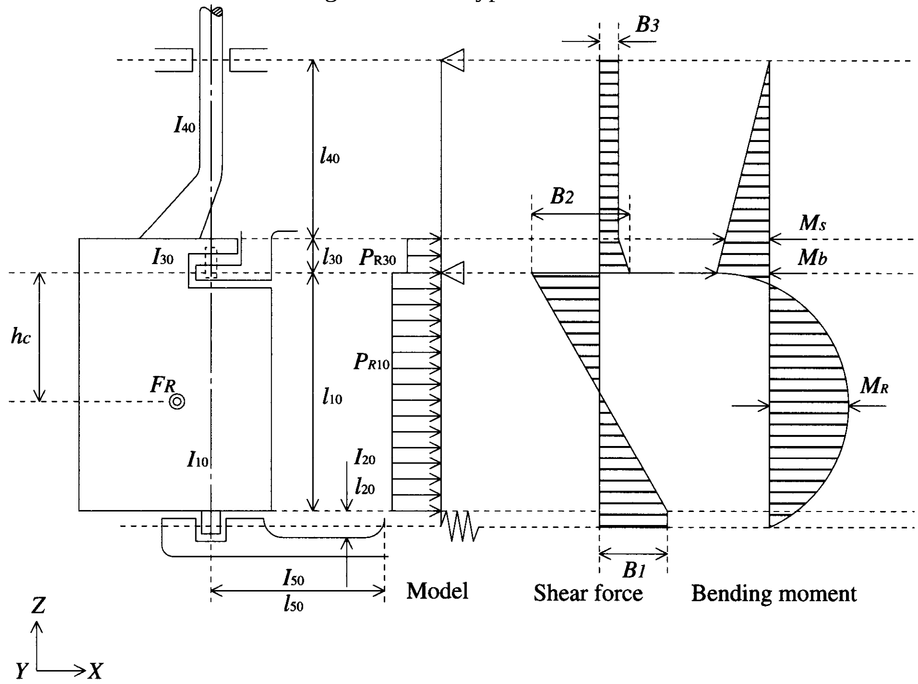


Fig. 4.2.1.6-2 Type *B* Rudder

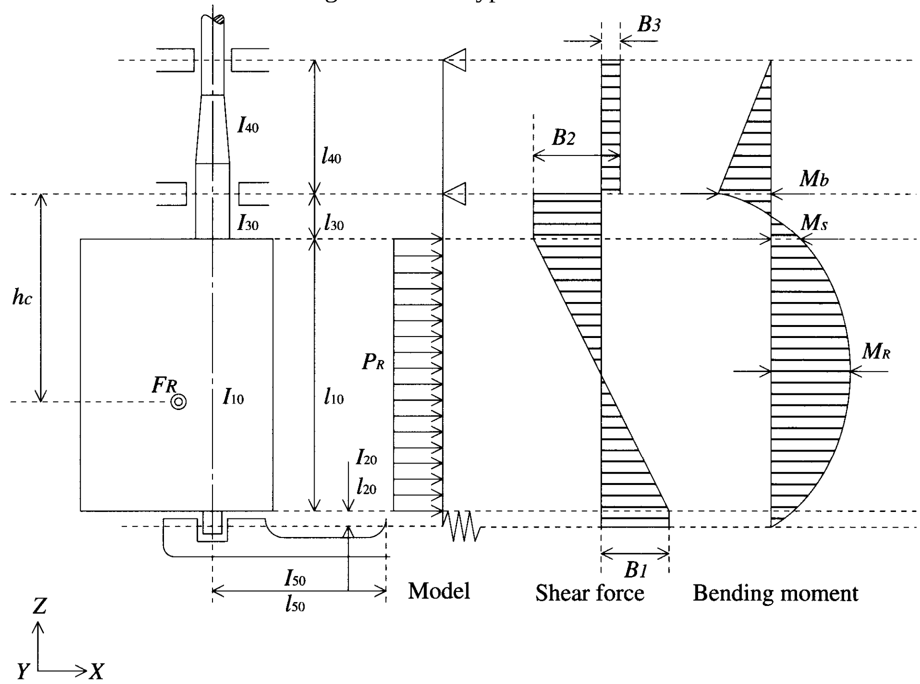


Fig. 4.2.1.6-3 Type *C* Rudder

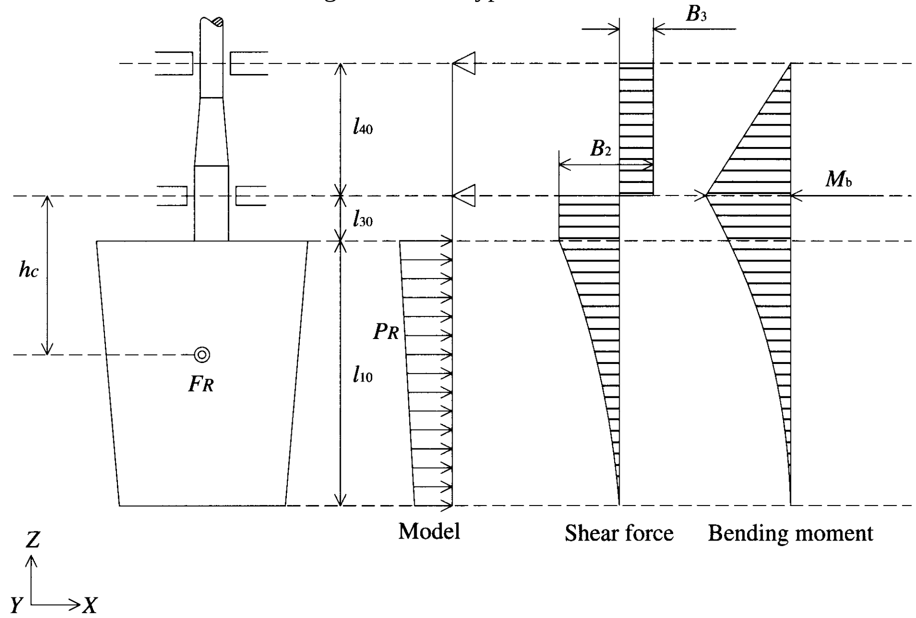


Fig. 4.2.1.6-4 Type *D* Rudder

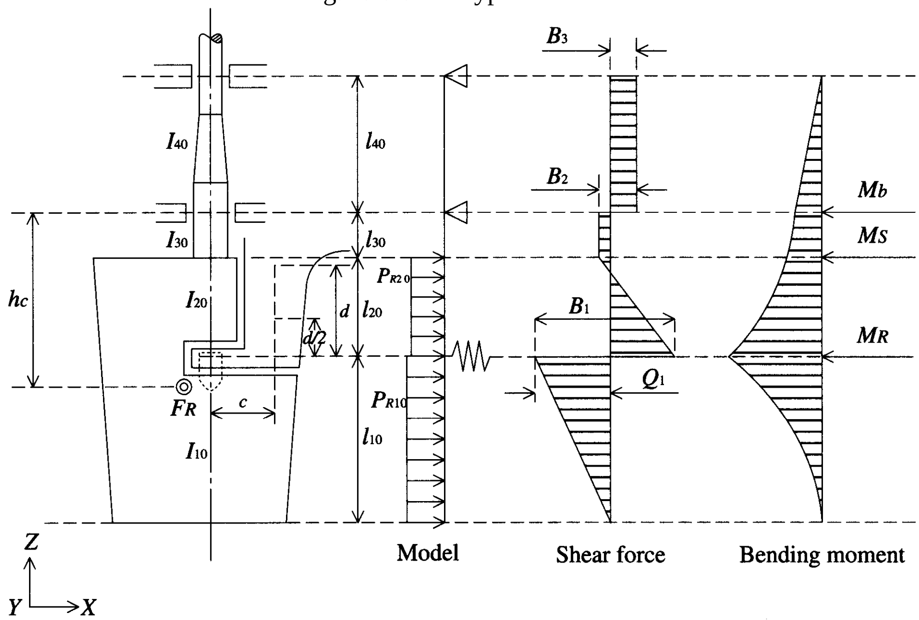
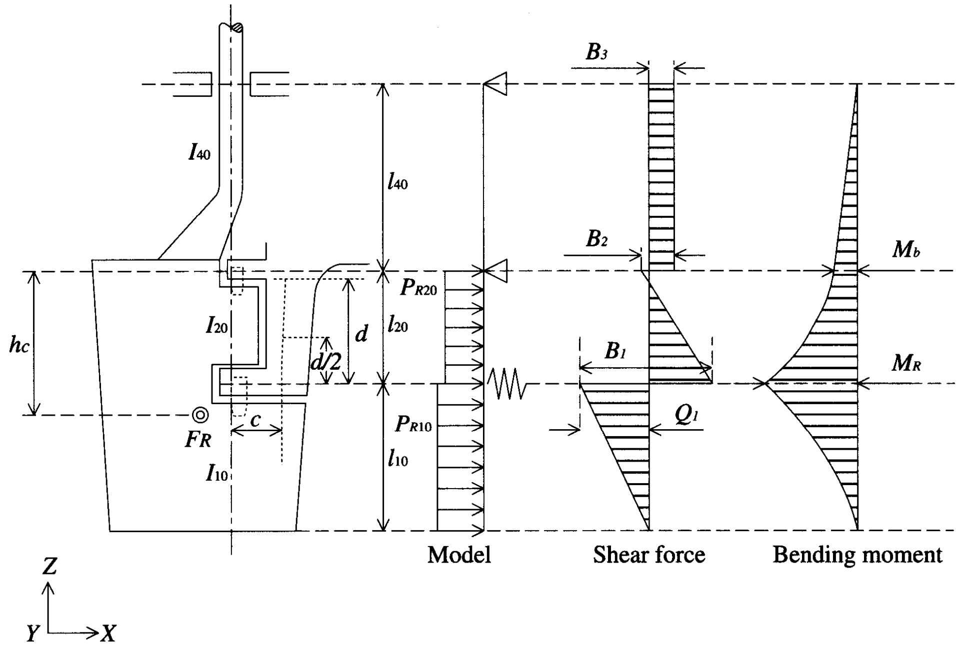


Fig. 4.2.1.6-5 Type *E* Rudder



2.1.7 Upper Stocks

1 Taper of upper stock at joint with tiller

Where the upper stocks are tapered for fitting the tiller, the taper is not to exceed 1/25 of the radius or 1/12.5 of the diameter.

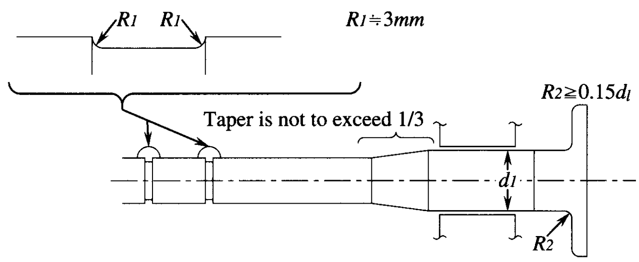
2 Keyways

(1) The depth of the keyway may be neglected in determining the diameter of the rudder stock.

(2) All corners of keyways are to be properly rounded.

3 Each part of the rudder stocks of Type *B*, *C* and *D* rudders is to be so constructed as shown in **Fig. 4.2.1.7-1**.

Fig. 4.2.1.7-1 Rudder Stock of Type *B*, *C* and *D* Rudder



2.1.9 Rudder Plates, Rudder Frames and Rudder Main Pieces of Double Plate Rudders

1 In Type *D* and Type *E* rudders, the effective breadth of the rudder plate B_e to be included in the section modulus of the main piece is to be as shown in **Fig. 4.2.1.9-1**. However, the cover plate which is removed to lift up the rudder is not to be included in the section modulus. These requirements also apply to Type *A* rudders.

2 The rudder plate is to be connected to rudder frames by spot welding as far as is practicable. **Fig. 4.2.1.9-2** is to be referred to as the standard for spot welding.

3 In principle, edge bars are to be fitted to the aft end of the rudder. However, considering the size and form of the rudder, weldability, etc., edge bars and/or chill plates may be omitted. (*See* **Fig. 4.2.1.9-3**)

Fig. 4.2.1.9-1 Effective Breadth of Rudder Plate

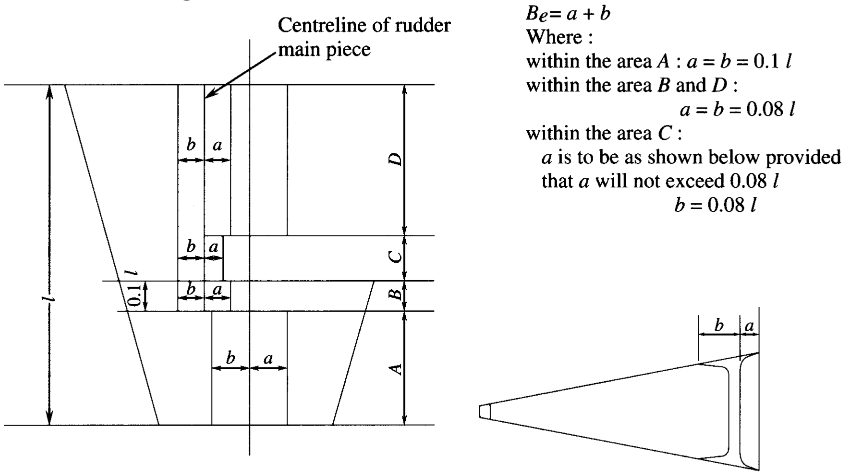


Fig. 4.2.1.9-2 Slot Welding

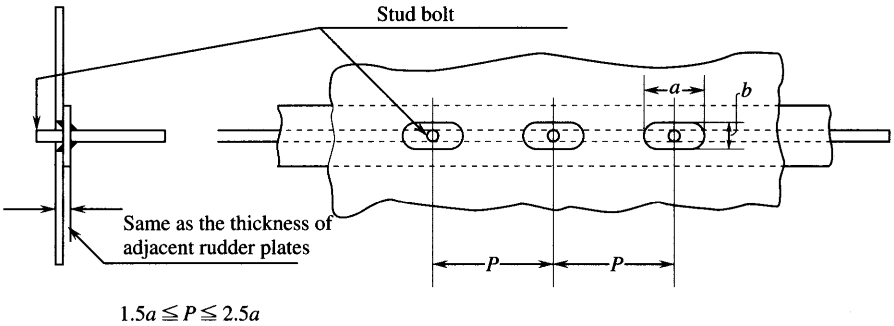
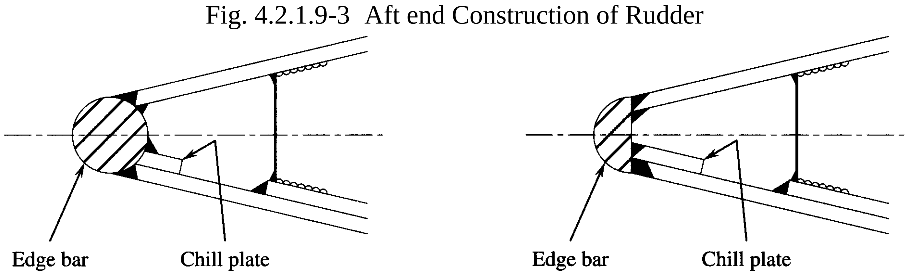


Plate thickness (*mm*)	Dimensions (*mm*)		Kind of fillet weld
	a	*b*	
Up to 6	65	35	*F*1
7~18	75	40	
19 or more	85	45	

Fig. 4.2.1.9-3 Aft end Construction of Rudder



2.1.11 Couplings between Rudder Stocks and Main Pieces

1 In principle, rudder stock and flange are to be of monoblock construction. However, for ships less than 60 *m* in length, the rudder stock may be of a welded type where the stock is inserted into the flange and welded with edge preparation.

2 In the application of **2.1.11-1, Part 4** of the Rules, the following requirements are also to be complied with.

(1) The diameter of the coupling bolt d_l in Type *A* and Type *E* rudders is to be determined in accordance with the requirements in **2.1.8, Part 4 of the Rules**, assuming that the lower stock is cylindrical.

(2) The nuts of coupling bolts are to have locking devices. They may be split pins.

3 In the application of **2.1.11-2, Part 4 of the Rules**, the following requirements are also to be complied with.

(1) The lower stock is to be securely connected to the rudder body with slugging nuts or hydraulic arrangements. Shipbuilders are to submit data on this connection to the Society.
(2) Special attention is to be paid to corrosion of the lower stock.
(3) The thickness t_B of the cast steel part of the rudder body (*See* **Fig. 4.2.1.11-1**) is not to be less than 0.25 *times* the required diameter of the lower stock.
(4) In the application of **2.1.11-2(1)** and **(2), Part 4 of the Rules**, actual values are to be used for d_0, d_g and d_e.
(5) The shear area A_k of keys provided on the cone coupling for rudder stocks fitted into the rudder body and secured by a nut (hereinafter referred to as "keys") is not to be less than:

$$A_k = \frac{30 T_R K_K}{d_k} \quad (mm^2)$$

Where:

d_k : Rudder stock diameter (*mm*) at the mid-point of length of the key

T_R : Rudder torque obtained from **2.1.5, Part 4 of the Rules**

K_K : Material factor for the key as given in **2.1.2, Part 4 of the Rules**

(6) The abutting surface area A_c between the key and rudder stock or between the key and rudder body, respectively, is not to be less than:

$$A_c = \frac{10 T_R K_{max}}{d_k} \quad (mm^2)$$

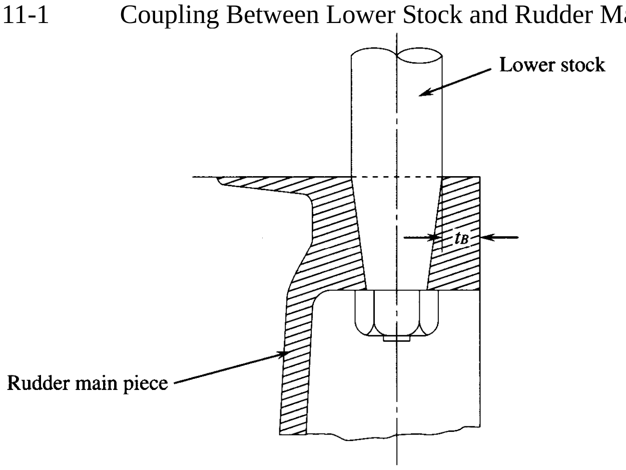
Where:

d_k and T_R : As specified in **(5)**

K_{max} : The greater of the material factors (given in **2.1.2, Part 4 of the Rules**) between the rudder stock and the key it is in contact with or the greater of the material factors between rudder body and the key it is in contact with

(7) "It is considered that rudder torque is transmitted by friction at the couplings" prescribed in **2.1.11-2(3), Part 4 of the Rules** refers to those cases in which 50% of the rudder torque is transmitted by friction at the coupling. In such cases, the value of the shear area of the key, the abutting surface area between the key and rudder stock or between the key and rudder body specified in **(5)** and **(6)** above may be reduced to half respectively.

Fig. 4.2.1.11-1 Coupling Between Lower Stock and Rudder Main Piece



4 In the application of **2.1.11-3, Part 4 of the Rules**, the following requirements are also to be complied with.
(1) The diameter of the coupling bolt d_l in Type *A* and *E* rudders is to be determined in accordance with **2.1.8, Part 4 of the Rules**, assuming that the lower stock is cylindrical.
(2) The nuts of coupling bolts are to have locking devices. They may be split pins.

2.1.12 Pintles

1 Locking device for pintle nut

Split pins are not recommendable as the locking device for pintle nuts. Locking rings or other equivalent devices are to be used, as shown in **Fig. 4.2.1.12-1**.

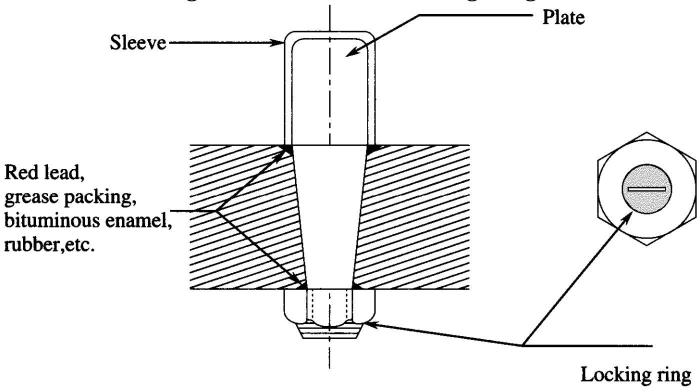
2 Preventing corrosion of pintles

To prevent corrosion of pintles, the end of the sleeve is to be filled with red lead, grease packing, bituminous enamel, rubber, etc. as shown in **Fig. 4.2.1.12-1**.

3 Combination of pintle and rudder frame in monoblock

In ships exceeding 80 *m* in length, combining the pintle and rudder frame into a monoblock is not recommended.

Fig. 4.2.1.12-1 Locking Ring



2.1.13 Bearings of Rudder Stock and Pintles

1 Where a metal bush is used, the sleeve is to be of a different material from the bush (for example, sleeve of *BC*3 and bush of *BC*2).

2 "The type as deemed appropriate by the Society" stipulated in **Table 4.2.2, Part 4 of the Rules** means that approval is to be made in accordance with the requirements of **Chapter 5, Part 4 of Guidance for the Approval and Type Approval of Materials and Equipment for Marine Use**.

3 Where a bush is non-metal, the standard bearing clearance is to be 1.5~2.0 *mm* in diameter.

2.1.14 Rudder Accessories

1 Materials of rudder carriers and intermediate bearings

Rudder carriers and intermediate bearings are to be of steel. They are not to be of cast iron.

2 Thrust bearing of rudder carrier

(1) The bearing is to be provided with a bearing disc made of *BC* or other equivalent materials.

(2) The calculated bearing pressure is not to exceed 0.98 *MPa* as a standard. In calculating the weight of the rudder, its buoyancy is to be neglected.

(3) The bearing part is to be well lubricated by dripping oil, automatic grease feeding, or a similar method.

(4) The bearing is to be designed to be structurally below the level of lubricating oil at all times. (*See* **Fig 4.2.1.14-1**)

3 Watertightness of rudder carrier part

(1) In rudder trunks which are open to the water, a seal or stuffing box is to be fitted above the deepest designed maximum load line to prevent water from entering the steering gear compartment and the lubricant from being washed away from the rudder carrier.

(2) It is recommended that the packing gland in the stuffing box have an appropriate clearance from the rudder stock corresponding to the position of the stuffing box. The standard clearance is to be 4 *mm* for the stuffing box provided at the neck or intermediate bearing, and 2 *mm* for the stuffing box at the upper stock bearing.

4 Assembly of rudder carriers

In split type rudder carriers, at least two bolts are to be used on each side of the rudder for assembly.

5 Installation of rudder carriers

(1) In ships exceeding 80 *m* in length, it is recommended that the rudder carrier is directly installed on the seat on the deck.

(2) A spigot type seat is not recommended to be installed on the deck.

(3) The hull construction in way of the rudder carrier is to be suitably reinforced.

6 Bolts securing rudder carriers and intermediate bearing

(1) At least one half of the bolts securing the rudder carrier and the intermediate bearing are to be reamer bolts. If stoppers for preventing the rudder carrier from moving are to be fitted on the deck, all bolts may be ordinary bolts. In using chocks as stoppers, they are to be carefully arranged so that they are not driven in, in the same direction. (*See* **Fig 4.2.1.14-2**)

(2) In ships provided with electrohydraulic steering gears, the total sectional area of the bolts securing the rudder carriers or the bearing just under the tiller to the deck is not to be less than that obtained from the following formula:

$0.1 d_u^2 \quad (mm^2)$

Where:

d_u : Required diameter of upper stock (mm)

(3) Where the arrangement of the steering gear is such that each of the two tiller arms is connected with an actuator and two actuators function simultaneously, or is of any other type where the rudder stock is free from horizontal force, the total sectional area of bolts securing the rudder carrier to the deck may be reduced to 60% of the area required in **(a)**.

(4) Where all the bolts securing the rudder carrier to the deck are reamer bolts, the total sectional area of bolts may be reduced to 80% of the area required by **(a)** and **(b)**.

7 A 2 *mm* clearance between the jumping stopper and the rudder carrier is deemed as standard. In ships provided with power-operated steering gears, this clearance is not to exceed 2 *mm*.

Fig. 4.2.1.14-1 Rudder Carrier

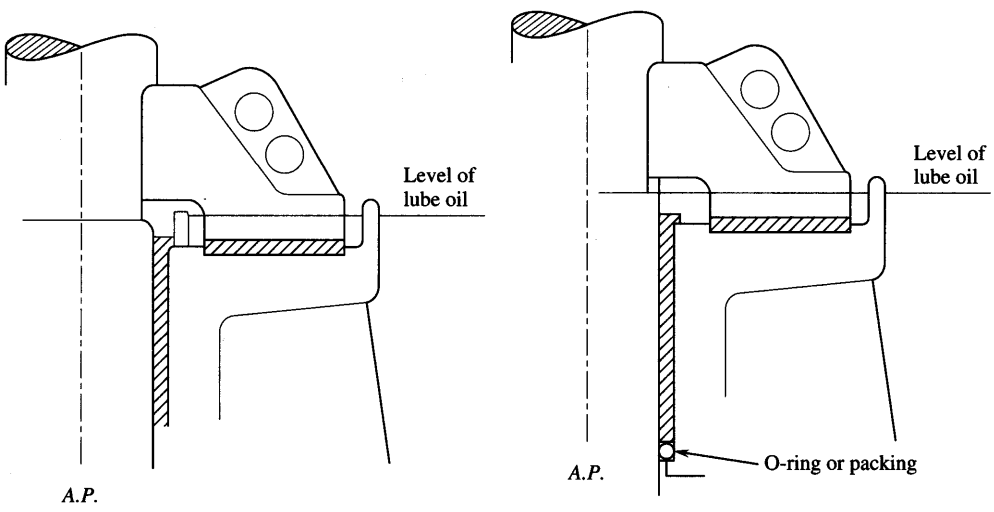
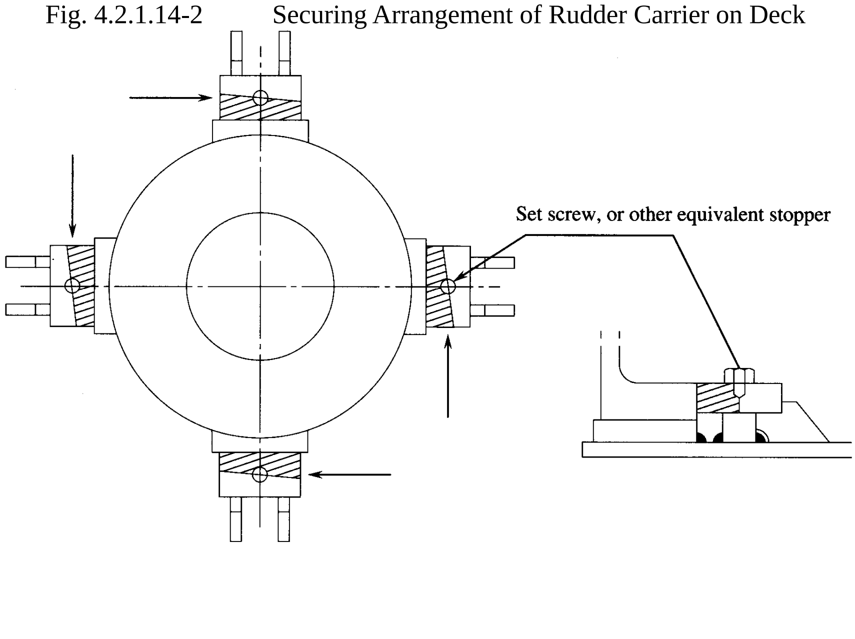


Fig. 4.2.1.14-2 Securing Arrangement of Rudder Carrier on Deck



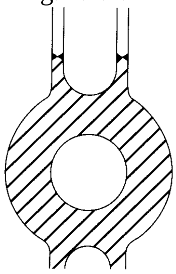
2.2 Stern Frames

2.2.2 Propeller Posts

1 Connection of cast steel boss and plate parts of built-up steel plate stern frame

The connection of a cast steel boss and built-up steel plate stern frame is to be well grooved and welded with full penetrations at the root as shown in **Fig. 4.2.2.2-1**. A cast steel boss having a shape different from that shown in **Fig. 4.2.2.2-1** may be used if enough consideration is paid to workmanship, at the discretion of the Society.

Fig. 4.2.2.2-1



2 Length of shaft hole of propeller boss

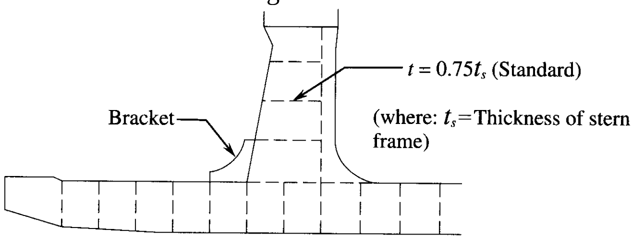
The length of the shaft hole of the propeller boss is to be greater than 1.25 *times* the inside diameter of the boss hole. Where the length of the shaft hole is less than the length of the bearing prescribed in **4.2.10, Part 7 of the Rules**, it is recommended that the length of the shaft hole be adjusted to match that of the bearing.

3 Round bars used for built-up steel plate stern frame

Where a round bar is used as the aft edge of a built-up steel plate stern frame, the standard radius of the round bar is at least 70% of $R(0.40L+16)$ prescribed in **2.2.2, Part 4 of the Rules**. At the connection of the round bar to the cast steel part or at the connection of round bars, the depth of the bevel for welding is to be at least 1/3 the diameter of the round bar.

4 The standard thickness of ribs fitted to the stern frame is 75% of the stern frame plate. (*See* **Fig. 4.2.2.3-1**)

Fig. 4.2.2.3-1



2.2.3 Shoe Pieces

1 Connection of shoe pieces and propeller posts

The top plate of the shoe piece is to be extended forward beyond the aft end of the propeller post. A bracket of the same thickness as the stern frame is to be fitted at the connection of the shoe piece and the aft end of the propeller post to keep a sufficient continuity of strength. (*See* **Fig. 4.2.2.3-1**)

2 Steel bolts for fixing zinc slabs to the shoe piece must not be directly screwed into the shoe piece. They are to be directly welded to the shoe piece or screwed into steel plates welded to the shoe piece.

3 Shoe pieces of built-up construction are to be made watertight and the inside coated with effective coating material. Where no coating is applied to the inside of the built-up shoe piece, the thickness of the shoe piece is to be increased by 1.5 *mm*.

4 Refer to **2.2.2-4** as well.

2.2.4 Heel Pieces

Determination of length of heel pieces

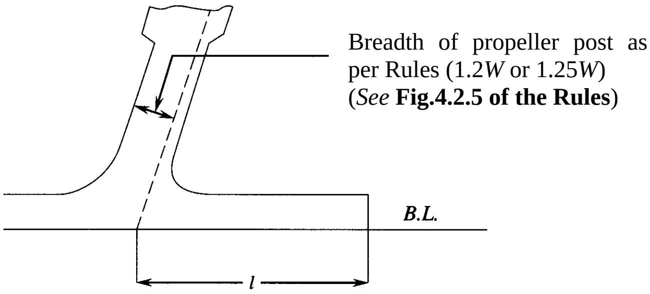
(1) In built-up steel plate stern frames, the length of heel pieces may be equal to twice the frame spacing at the

position of the heel pieces providing that the thickness of flat keels connected to the heel pieces is increased by 5 *mm*.

(2) The length of heel pieces is to be measured as shown in **Fig. 4.2.2.4-1**.

(3) Refer to **2.2.2-4** as well.

Fig. 4.2.2.4-1



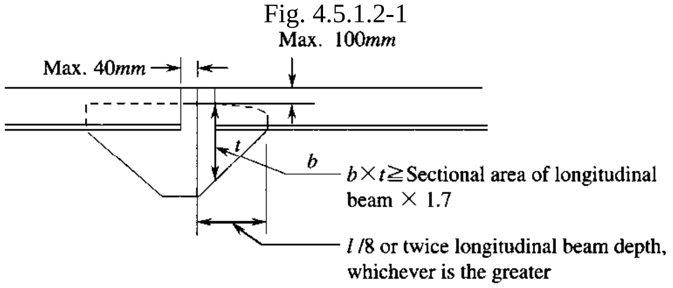
Chapter 5 BEAMS

5.1 General

5.1.2 End Connection of Beams

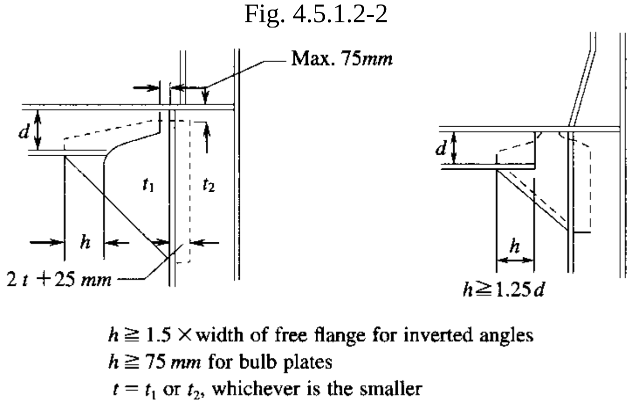
1 The standard connection method of the ends of longitudinal beams is shown in **Fig. 4.5.1.2-1**.

Fig. 4.5.1.2-1



2 The standard connection method of transverse beams by means of brackets is shown in **Fig. 4.5.1.2-2**.

Fig. 4.5.1.2-2



5.2 Longitudinal Beams

5.2.3 Section Modulus of Longitudinal Beams

The section modulus of longitudinal beams of the strength deck fore and aft of the midship part may be determined by interpolation between the requirements of **5.2.3-1** and **-2, Part 4 of the Rules**. Interpolation may be performed at the middle of each building block in the direction of the ship's length. However, where the length of the block is over 15 *metres*, the block is to be subdivided into appropriate lengths.

5.3 Transverse Beams

5.3.2 Proportion

Where the span/depth ratio of transverse beams exceeds 30 in strength decks or 40 in effective decks and superstructure decks, the section moduli of these beams are to be increased by the corresponding ratios.

Chapter 6 PILLARS

6.2 Scantlings

6.2.1 Sectional Area of Pillars

The sectional area of pillars which can be regarded as fixed at both ends may be obtained from the following formula:

$$\frac{0.223w}{2.72-\frac{0.5l}{k_0}} \quad (cm^2)$$

The expressions are stipulated in **6.2.1, Part 4 of the Rules**.

Chapter 7 DECK GIRDERS

7.1 General

7.1.3 Construction

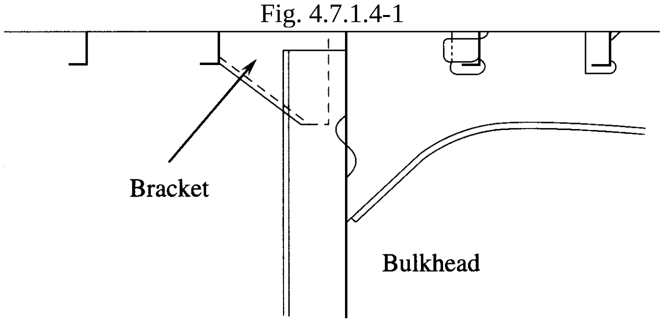
1 At the upper and lower ends of pillars and other places where concentrated loads are expected, girders are to be fitted with tripping brackets and slots in the girders are to be fitted with collars. Under the end bulkheads of superstructures, only collars are required. Collars are also to be fitted at the slots near the toes of end brackets.

2 Butt joints of girder webs are to be away from slots. Butt joints of face plates are to be away from knuckled parts. The depth of slots is not to exceed $0.4d_G$. If this limit is exceeded, collars are to be fitted. This depth is not to exceed $0.5d_G$. These requirements may be suitably modified for superstructures.

7.1.4 End Connection

1 Where a girder stops at a bulkhead, a bracket is to be fitted on the reverse side. (*See* **Fig. 4.7.1.4-1**)

Fig. 4.7.1.4-1



2 Continuity of Deck Girders

(1) The standard depth of a bracket is twice the depth of a web. If the depth of the bracket is smaller than this standard, suitable equivalent means, such as attaching a gusset plate, is to be provided. (*See* **Fig. 4.7.1.4-2**)

(2) The girder included in the calculation of the section modulus is to completely penetrate the bulkhead (including the web and face plate) or is to be connected in a way that ensures an equivalently secure bond. (*See* **Fig. 4.7.1.4-3**)

(3) Where deck girders are discontinuous, they are to be sufficiently overlapped. (*See* **Fig. 4.7.1.4-4**)

Fig. 4.7.1.4-2

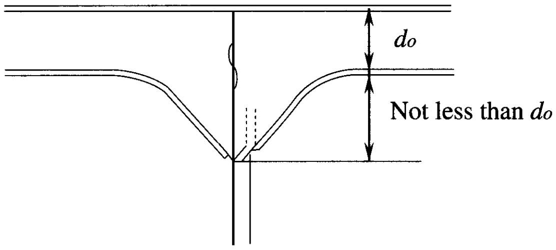


Fig. 4.7.1.4-3

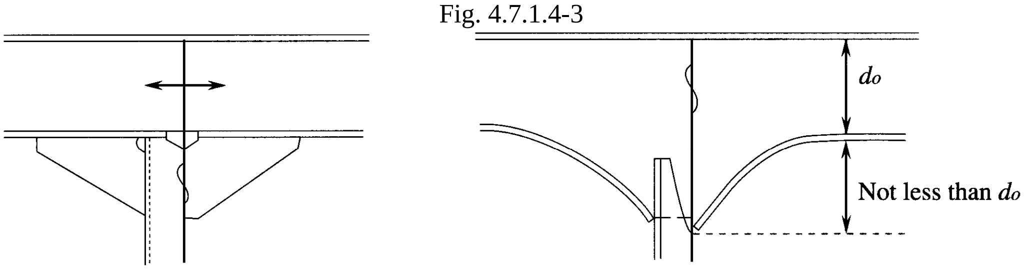
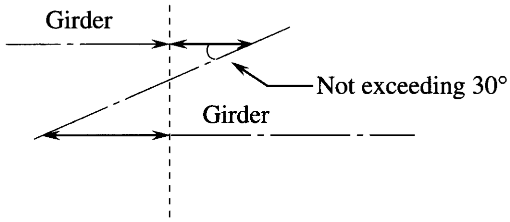


Fig. 4.7.1.4-4



7.2 Longitudinal Deck Girders

7.2.1 Section Modulus of Girders

The section modulus of longitudinal deck girders of the strength deck fore and aft of the midship part is generally determined by interpolation as stipulated in **7.2.1-1** and **7.2.1-2, Part 4 of the Rules**. Interpolation is to be performed at the centre of the girder's span. However, this may be modified when taking into consideration factors such as the length of building blocks.

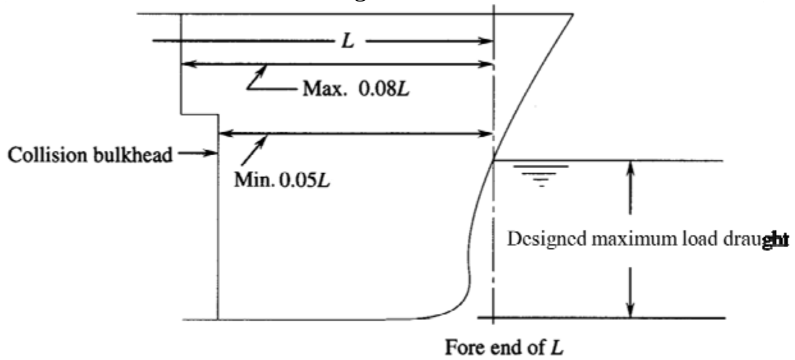
Chapter 8 WATERTIGHT BULKHEADS

8.1 Arrangement of Watertight Bulkheads

8.1.1 Collision Bulkheads

1 In case of a Collision Bulkhead with a Step or Recess (*See* **Fig. 4.8.1.1-1**), the position of the collision bulkhead is to be determined as shown below.

Fig. 4.8.1.1-1



2 "Special structural reasons which are approved by the Society" in **8.1.1-1, Part 4 of the Rules** are reasons approved on the basis that an application is submitted together with calculations verifying that no part of the bulkhead deck will be immersed even when the compartment forward of the collision bulkhead is flooded under loaded conditions (without trim) corresponding to the designed maximum load draught.

8.2 Construction of Watertight Bulkheads

8.2.2 Stiffeners

1 Scantlings of bulkhead stiffeners just under deck girders

The scantlings of bulkhead stiffeners supporting under-deck girders are to comply with the following formula:

$$C\frac{Z_0}{Z}+\frac{W}{A}\le C$$

Z_0 : Required section modulus (cm^3) of stiffener

Z : Actual section modulus (cm^3)

C : 17.7

A : Sectional area (cm^2) of stiffener (may include attached plate)

W : Axial load (kN) of stiffener obtained from the following formula:

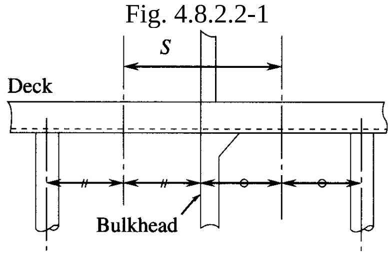
Sbh

S : Distance (m) between mid-spaces of adjacent girders supported by stiffeners (*See* **Fig. 4.8.2.2-1**)

b and h : As specified in **8.2.1, Part 4 of the Rules**

In ships having two or more decks, W for the upper tier deck need not be taken into consideration.

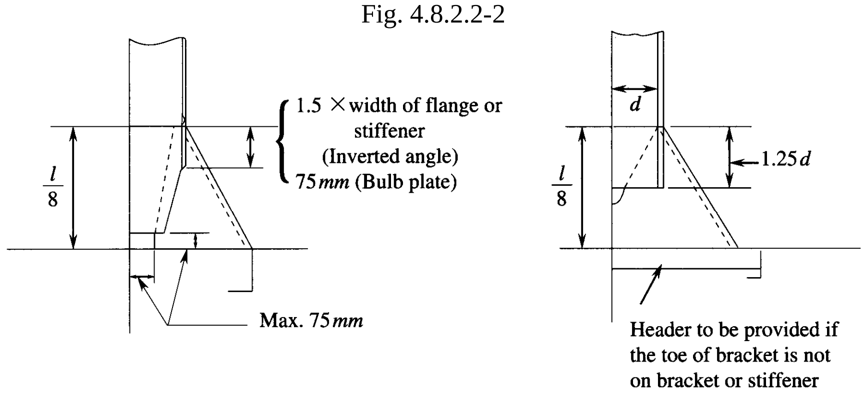
Fig. 4.8.2.2-1



2 Dimensions of brackets of bulkhead stiffeners

The dimensions of brackets of bulkhead stiffeners are to be as indicated in **Fig. 4.8.2.2-2**.

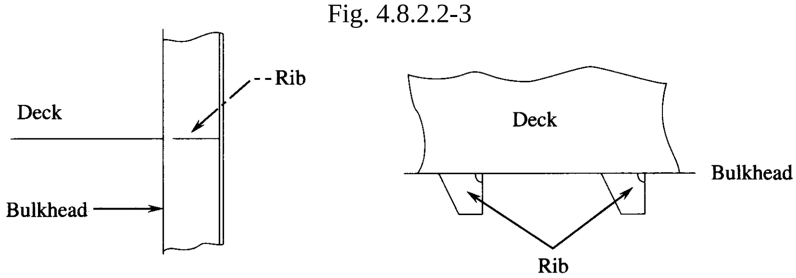
Fig. 4.8.2.2-2



3 Support of stiffeners at decks

Where a deck terminates at the bulkhead, the stiffeners are to have ribs at the level of the deck. (*See* **Fig.4.8.2.2-3**)

Fig. 4.8.2.2-3



Chapter 9 DEEP TANKS

9.1 General

9.1.2 Application

The construction of deep tanks is to comply with the requirements for the construction of watertight bulkheads stipulated in **8.2** in addition to the requirements in this Chapter.

9.2 Deep Tank Bulkheads

9.2.3 Bulkhead Stiffeners

1 Span of stiffeners

For stiffeners having "Connection Type A," the span may be taken as $4l'/3$ if the arm length of brackets exceed $l/8$. For "Connection Type A," *see* **Fig. 4.9.2.3-1**.

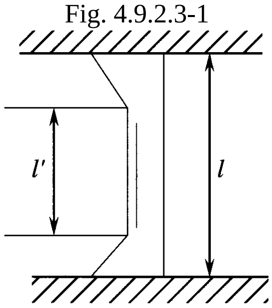
2 End connection of stiffeners at the top of deep tanks

Stiffeners of deep tank bulkheads, which are not in line with stiffeners of tween deck bulkheads at the top of the tank, are to have bracket ends.

3 Scantlings of bulkhead stiffeners supporting under-deck girders

The scantlings are to be calculated according to **8.2.2**, taking C as 9.81.

Fig. 4.9.2.3-1



Chapter 10 LONGITUDINAL STRENGTH

10.2 Bending Strength

10.2.3 Calculation of Section Modulus of Transverse Section of Hull

1 Unit of section modulus of transverse section of hull

The section modulus Z (cm^3) is to have five significant figures.

2 Members included in longitudinal strength

The ratio of inclusion of members effective for longitudinal strength is to be as follows.

(1) All intercostal plates may be included if the fillet welding complies with **Note 1** of **Table C1.5, Part C of the Rules for the Survey and Construction of Steel Ships**.

(2) All doubling plates may be included if fitted during ship construction or 90% if fitted during conversion or addition.

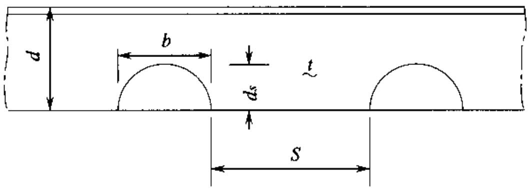
(3) For side stringers, slots for frames are to be deducted.

(4) Scallops complying with the following conditions need not be deducted from the sectional area. (*See* **Fig. 4.10.2.3-1**)

(a) d_s not exceeding d/4 nor exceeding 7t, maximum 75 *mm*

(b) S more than 5b and more than $10d_s$

Fig. 4.10.2.3-1 *S*, *b* and d_s of Scallops



(5) Where the sectional area of longitudinals, which are unable to be continued due to factors such as the arrangement of small hatch openings are compensated by adjacent ones, they may be included in the calculation of the section modulus of the transverse section.

3 Openings in strength decks

Openings in strength decks are to be reinforced by rings, thicker plate, etc. is required ,where the intervals between centres of holes *e* do not meet the conditions in **Fig. 4.10.2.3-2.** (*See* **Fig. 4.10.2.3-3** and **Fig.4.10.2.3-4**)

10.2.4 Loading Manual

For loading manuals required for ships greater than *L* 65 (*m*), the provisions of **C34.1.2**, **Part C of the Guidance** are to be applied.

Fig. 4.10.2.3-2 Intervals Between Centres of Holes

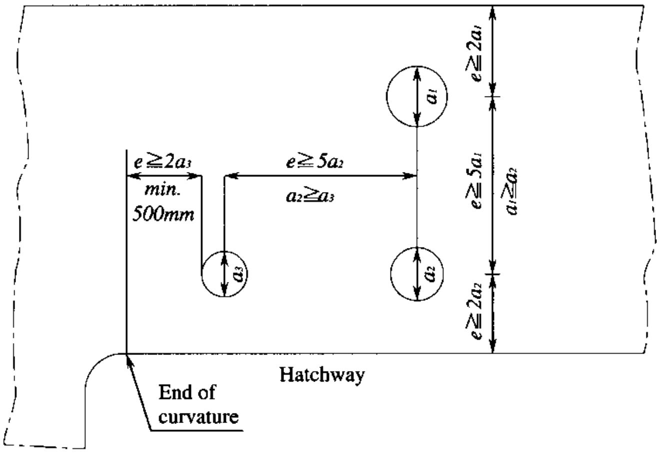


Fig. 4.10.2.3-3 Where Elliptic Hole and Circular Hole are in Same Cross-section

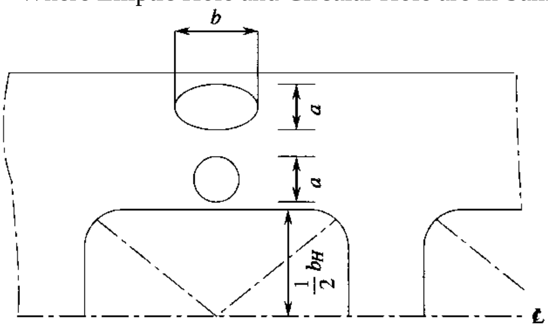
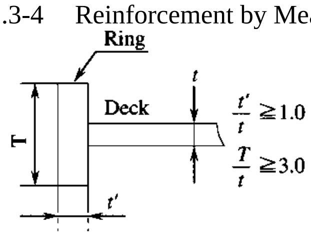


Fig. 4.10.2.3-4 Reinforcement by Means of Ring



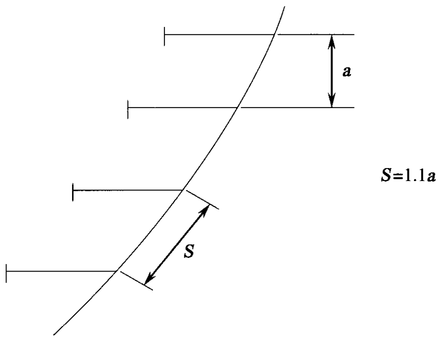
Chapter 11 SHELL PLATING

11.2 Shell Plating

11.2.2 Thickness of Side Shell Plating

The thickness of side shell plating of curved parts within 0.3*L* from the forward and aft end may be calculated with the value of *S* taken as equal to 1.1 *times* the vertical or horizontal distance between frames *a* (*See* **Fig. 4.11.2.2-1**)

Fig. 4.11.2.2-1 Relation of *S* and *a* in End Parts



11.2.3 Thickness of Bottom Shell Plating

The thickness of bottom shell plating of curved parts within 0.3*L* from the forward and aft end may be in accordance with the requirements specified in **11.2.2**

Chapter 12 DECKS

12.1 General

12.1.1 Steel Deck Plating

Decks which are not fully plated

(1) Stringer plates

Decks not fully plated are to have stringer plates of an appropriate breadth and of a thickness not less than that determined for deck plating in accordance with the requirements in **12.4, Part 4 of the Rules** for the positions concerned. The stringer plates of effective decks are to be effectively connected to the shell plating.

(2) Tie plates

Tie plates are to be provided along hatch sides, in way of pillars, on the under-deck girders and under deckhouse coamings. These tie plates are to have an appropriate breadth and a thickness not less than that determined for deck plating in accordance with the requirements in **12.4, Part 4 of the Rules** for the positions concerned.

(3) In way of transverse bulkheads and at the ends of deck openings

In way of transverse bulkheads and at the ends of deck openings, the deck is to be suitably plated with steel plates.

12.1.2 Watertightness of Decks

Where the rudder stock penetrates the deck lower than 1.5 *m* above the load line, special attention is to be given to the watertightness at the penetration.

12.1.3 Compensation for Openings

All corners of openings on decks are to be well rounded, properly smoothed and reinforced, as necessary, by thickening the deck plating or by means of doubling plates.

(1) Regions where thicker plating or doubling plates are required

Strength deck: Within 0.75*L*⊠

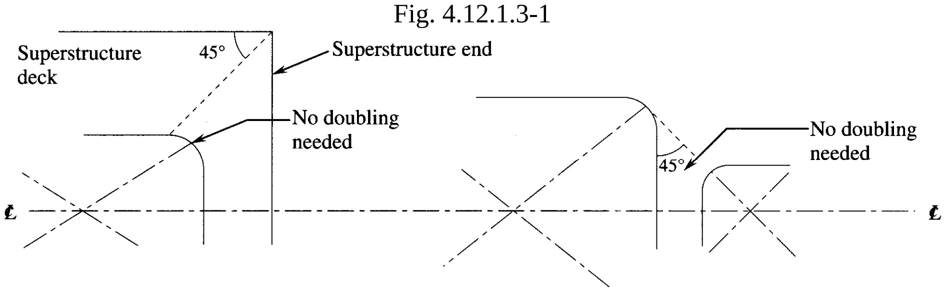
Effective 2nd deck: Within 0.6*L*⊠

3rd deck and lower decks: No doubling needed, as a rule

Superstructures and long deckhouse: Doubling within 0.6*L*⊠ for decks immediately above the strength deck

(2) Plate thickening and doubling plates may be properly reduced depending upon their locations. (*See* **Fig. 4.12.1.3-1**)

Fig. 4.12.1.3-1



(3) The dimensions and thickness of doubling plates or ranges of thickening are to be determined considering the degree of stress concentration around the openings.

(4) The minimum radii at the corners are to be as follows:

Within 0.5*L*⊠ of strength deck: 250 *mm*

Elsewhere: 200 *mm*

The radius may be suitably reduced for small openings. For companionways and similar small openings, the radius at the corners may be 150 *mm* in the strength deck.

(5) For corners of openings having a radius not less than 600 *mm* or having a parabolic or similar shape, neither

doubling plates nor thickening of the plating is required. The recommended corner shape is as shown in **Fig. 4.12.1.3-2**.

(6) No welded joints are permitted at the corners of openings in the strength deck. The welded joints are to be properly off the end of the curvature. (*See* **Fig. 4.12.1.3-3**)

Fig. 4.12.1.3-2

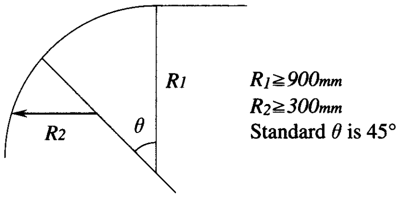
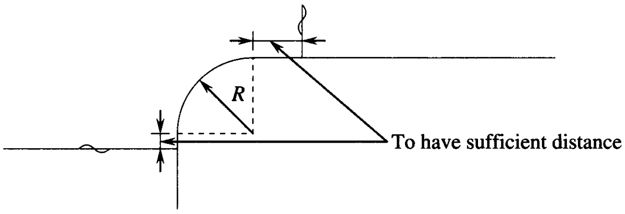


Fig. 4.12.1.3-3



12.3 Effective Sectional Area of Strength Deck

12.3.2 Effective Sectional Area of Strength Deck

1 Members to be included in the calculation of the actual sectional area of strength deck

In addition to the deck plating, members attached to the deck plating, such as stringer angles and longitudinal beams, which are included as longitudinal strength members are to be included in the calculation of the actual sectional area.

2 Where round gunwales are provided, the sectional area is to be calculated assuming that the plate of the round gunwale is horizontally extended to the ship's side.

Chapter 15 MACHINERY SPACES, BOILER ROOMS AND TUNNEL RECESSES

15.2 Main Engine Foundations

15.2.2 Ships with Double Bottoms

1 Girder plates beneath seat plates of the main engine are generally to penetrate inner bottom plates. Where they are unable to penetrate, the inner bottom plates are to be suitably thicker than required and rider plates are to be welded with edge preparation. If man holes are provided in girder plates, their number is to be minimized as far as possible.

2 Where main engines are directly installed on to inner bottom plates, the compartments beneath main engines are recommended to be cofferdams. Where they are used as deep tanks, cap nuts, packing, etc. are to be fitted to the foundation bolts in order to keep water/oil-tightness.

Chapter 16 EQUIPMENT

16.1 Anchors, Chain Cables and Ropes

16.1.1 General

1 In applying **16.1.1-5, Part 4 of the Rules**, where equipment which is less than that given in **Table 4.16.1** is provided, the request stating rational reasons taking into account environmental conditions in which the ship will operate, etc. is to be submitted to the Society.

2 In applying **16.1.1-5, Part 4 of the Rules**, where omission of equipment is requested the following are to be complied with.

(1) In case of omission of anchors, the request of omission of anchors together with such statement that the barge is intended to be moored only on quay, is to be submitted to the Society.

(2) In case of omission of mooring lines, the request of omission of mooring lines together with such statement that the mooring lines have been arranged on the shore where the barge is intended to be moored, is to be submitted to the Society.

16.1.5 Mooring Lines

1 **Table 4.16.1.5-1** indicates the equivalencies of Manila ropes and synthetic fibre ropes expressed in diameters. Special considerations will be given to a double braided rope.

2 The manner of determining the diameter of synthetic fibre rope corresponding to the equipment number is as indicated in the following example.

Example

Breaking strength of mooring line for equipment number 660 - 720 (*RD*2): 147*kN*

Diameter of Manila rope corresponding to the breaking strength

50ϕ : 144 *kN*

55ϕ : 173 *kN*

As per **Table L5.1, Part L of Rules for the Survey and Construction of Steel Ships**

$$50+(55-50)\times\frac{147-144}{173-144}=50.6$$

(Rounded up to 1*st* decimal place)

A) Where Manila ropes are used, 50.6 → 51ϕ (Rounded up to a whole number)

B) Where synthetic fibre ropes are used:

To determine the diameter of Polyester rope corresponding to 50.6ϕ of Manila rope

50ϕ : 36

55ϕ : 39

As per **Table 4.16.1.5-1**

$$36+(39-36)\times\frac{50.6-50}{55-50}=37\phi$$

(Rounded up to a whole number)

3 The correspondence of diameters determined as described above to the equipment numbers is indicated in **Table 4.16.1.5-2**.

Table 4.16.1.5-1 Comparison of Diameters of Manila Ropes and Synthetic Fibre Ropes (Unit: *mm*)

Manila rope	Vinylon rope		Polyethylene rope		Polyester rope	Polypropylene rope		Nylon rope
	Grade 1	Grade 2	Grade 1	Grade 2		Grade 1	Grade 2	
	Span, Mono-filament	Multi-filament	Ordinary yarn	Strong yarn		Span, Mono-filament	Multi, Special multi, Special monosplit	
20	18	16	18	15	14	16	15	14
22	19	18	19	17	16	18	17	16
24	21	19	21	18	17	19	18	18
26	23	21	23	20	19	21	20	19
28	24	23	24	21	20	23	21	20
30	26	24	26	23	22	24	23	22
32	28	26	28	24	23	26	24	24
35	30	28	30	26	25	28	26	26
40	35	32	35	30	29	33	30	29
45	40	36	40	34	32	37	34	32
50	44	40	44	38	36	41	38	35
55	48	45	48	41	39	45	41	39
60	53	50	53	45	42	49	45	42
65	58	55	58	49	46	53	49	45
70	62	60	62	53	49	57	53	49
75	67	65	67	56	53	61	57	53
80	71	70	71	60	57	65	60	56
85	75	74	75	64	61	69	64	60
90	80	78	80	68	65	73	68	64
95	84	82	84	72	70	78	72	67
100	89	87	89	75	75	82	75	70

Table 4.16.1.5-2 Comparison of Sizes of Mooring Ropes

∗:(6×12), ⊕:(6×24)

Equipment number		Breaking strength of Manila rope	Length (*m*)	Number	Dia. of steel wire rope (*mm*)	Dia. of Manila rope (*mm*)	Dia. of synthetic fibre ropes (*mm*)							
							Vinylon		Polyethylene		Polyester	Polypropylene		Nylon
							1	2	1	2		1	2	
Over	Up to	*kN*												
70	90	34	80	3	∗11	24	21	19	21	18	17	19	18	18
90	110	37	100	3	∗11	25	22	20	22	19	18	20	19	19
110	130	39	110	3	∗11	26	23	21	23	20	19	21	20	19
130	150	44	110	3	∗12	27	24	22	24	21	20	22	21	20
150	175	49	120	3	∗13	29	25	24	25	22	21	23	22	21
175	205	54	120	3	∗13	30	26	24	26	23	22	24	23	22
205	240	59	120	3	∗14	32	28	26	28	24	23	26	24	24
240	280	64	120	4	∗14	33	29	27	29	25	24	27	25	25
280	320	69	120	4	∗15	35	30	28	30	26	25	28	26	26
320	360	74	140	4	∗16	36	31	20	31	27	26	29	27	27
360	400	78	140	4	∗16	37	32	30	32	28	27	30	28	27
400	450	88	140	4	∗17	39	34	31	34	29	28	32	29	28
450	500	98	140	4	∗18	41	36	33	36	31	30	34	31	30
500	550	108	140	4	∗18	43	38	34	38	32	31	35	32	31
550	600	123	160	4	∗20	46	41	37	41	35	33	38	35	33
600	660	132	160	4	∗20	48	42	38	42	36	34	39	36	34
660	720	147	160	4	∗22	51	45	41	45	39	37	42	39	36
720	780	157	160	4	∗23	53	46	43	46	40	38	43	40	37
780	840	172	170	4	∗24	55	48	45	48	41	39	45	41	39
840	910	186	170	4	∗25	58	51	48	51	43	41	47	43	41
910	980	201	170	4	∗25	60	53	50	53	45	42	49	45	42
980	1060	216	170	4	∗26	62	55	52	55	47	44	51	47	43
1060	1140	230	180	4	⊕ 23	65	58	55	58	49	46	53	49	45
1140	1220	250	180	4	⊕ 24	68	60	58	60	51	48	55	51	47
1220	1300	270	180	4	⊕ 25	70	62	60	62	53	49	57	53	49
1300	1390	284	180	4	⊕ 26	72	64	62	64	54	51	59	54	51
1390	1480	309	180	4	⊕ 27	76	68	66	68	57	54	62	57	54
1480	1570	324	180	4	⊕ 27	78	69	68	69	58	55	63	58	55
1570	1670	324	190	5	⊕ 27	78	69	68	69	58	55	63	58	55

16.2 Equipment for Special Purpose

16.2.2 Tugs

With respect to the requirements of **16.2.2-2, Part 4 of the Rules**, the breaking strength of towlines is to be at least 2.5 *times* the maximum design towline force.

Part 5 HULL CONSTRUCTION AND EQUIPMENT OF BARGES

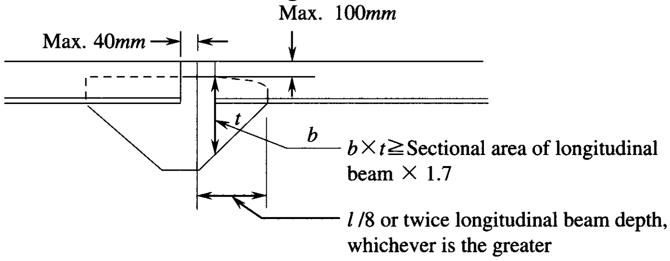
Chapter 4 BEAMS

4.1 General

4.1.2 End Connection of Beams

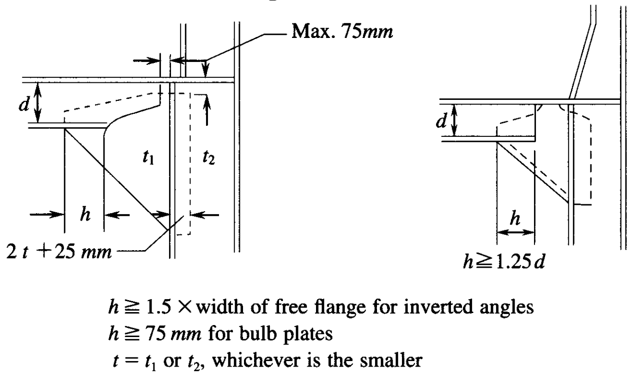
1 The standard connection method of the ends of longitudinal beams is shown in **Fig. 5.4.1.2-1**.

Fig. 5.4.1.2-1



2 The standard connection method of transverse beams by means of brackets is shown in **Fig. 5.4.1.2-2** is standard.

Fig. 5.4.1.2-2



4.3 Transverse Beams

4.3.2 Proportion

Where the span/depth ratio of transverse beams exceeds 30 in strength decks or 40 in effective decks and superstructure decks, the section moduli of these beams are to be increased by the corresponding ratios.

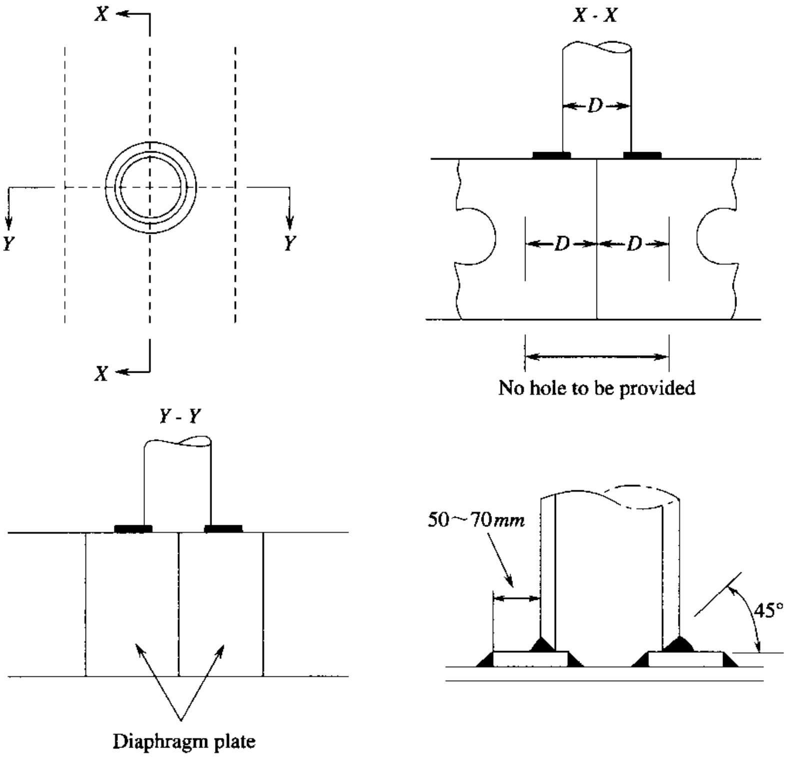
Chapter 5 PILLARS AND TRUSSES

5.1 General

5.1.1 Arrangement

The reinforcement under pillars is to be as shown in **Fig.5.5.1.1-1**.

Fig. 5.5.1.1-1



5.2 Scantlings of pillars

5.2.1 Sectional Area of Pillars

The sectional area of pillars which can be regarded as fixed at both ends may be obtained from the following formula:

$$\frac{0.223w}{2.72 - \frac{0.5l}{k_0}} \quad (cm^2)$$

The expressions are stipulated in **5.2.1**, **Part 5 of the Rules**.

Chapter 6 DECK GIRDERS

6.1 General

6.1.3 Construction

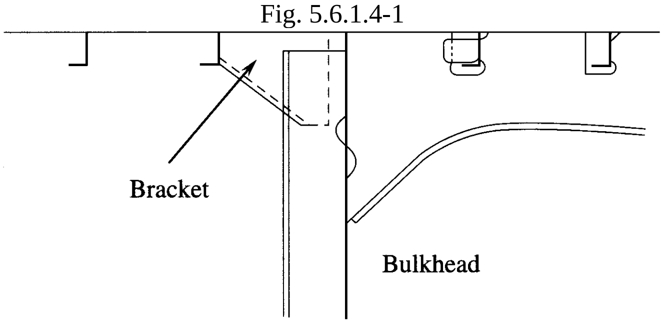
1 At the upper and lower ends of pillars and other places where concentrated loads are expected, girders are to be fitted with tripping brackets and slots in the girders are to be fitted with collars. Under the end bulkheads of superstructures, only collars are required. Collars are also to be fitted at the slots near the toes of end brackets.

2 Butt joints of girder webs are to be away from slots. Butt joints of face plates are to be away from knuckled parts. The depth of slots is not to exceed $0.4d_G$. If this limit is exceeded, collars are to be fitted. This depth is not to exceed $0.5d_G$. These requirements may be suitably modified for superstructures.

6.1.4 End Connection

1 Where a girder stops at a bulkhead, a bracket is to be fitted on the reverse side. (*See* **Fig. 5.6.1.4-1**)

Fig. 5.6.1.4-1



2 Continuity of Deck Girders

(1) The standard depth of a bracket is twice the depth of a web. If the depth of the bracket is smaller than this standard, suitable equivalent means, such as attaching a gusset plate, is to be provided. (*See* **Fig. 5.6.1.4-2**)

(2) The girder included in the calculation of the section modulus is to completely penetrate the bulkhead (including the web and face plate) or is to be connected in a way that ensures an equivalently secure bond. (*See* **Fig. 5.6.1.4-3**)

(3) Where deck girders are discontinuous, they are to be sufficiently overlapped. (*See* **Fig. 5.6.1.4-4**)

Fig. 5.6.1.4-2

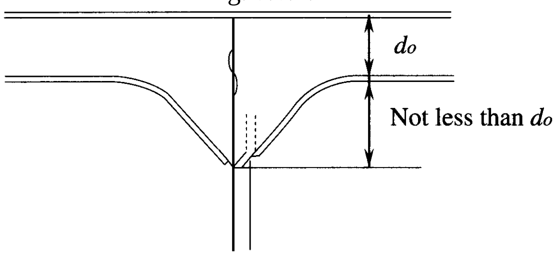


Fig. 5.6.1.4-3

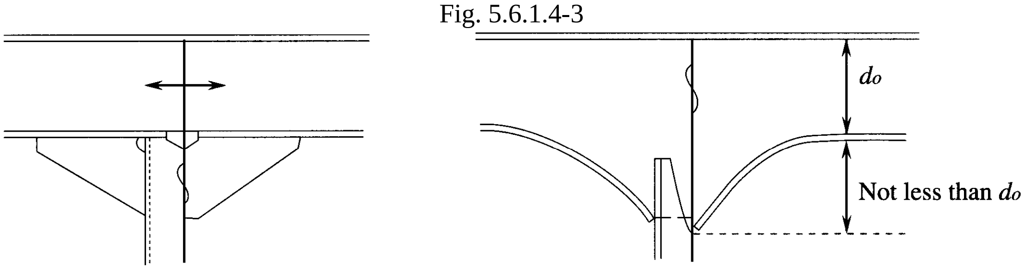
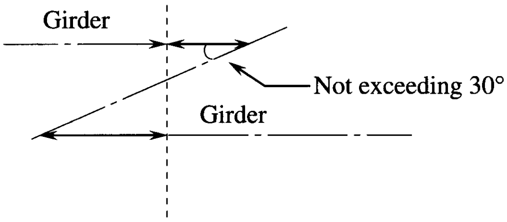


Fig. 5.6.1.4-4



6.2 Longitudinal Deck Girders

6.2.1 Section Modulus of Girders

The section modulus of longitudinal deck girders of the strength deck fore and aft of the midship part is generally determined by interpolation as stipulated in **6.2.1-1** and **6.2.1-2, Part 5 of the Rules**. Interpolation is to be performed at the centre of the girder's span. However, this may be modified when taking into consideration factors such as the length of building blocks.

Chapter 7 WATERTIGHT BULKHEADS

7.2 Construction of Watertight Bulkheads

7.2.2 Stiffeners

1 Scantlings of bulkhead stiffeners just under deck girders

The scantlings of bulkhead stiffeners supporting under-deck girders are to comply with the following formula:

$$C\frac{Z_0}{Z}+\frac{W}{A}\leq C$$

Z_0 : Required section modulus (cm^3) of stiffener

Z : Actual section modulus (cm^3)

C : 17.7

A : Sectional area (cm^2) of stiffener (may include attached plate)

W : Axial load (kN) of stiffener obtained from the following formula:

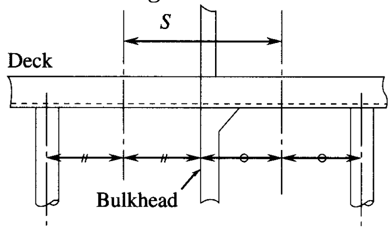
Sbh

S : Distance (m) between mid-spaces of adjacent girders supported by stiffeners (*See* **Fig. 5.7.2.2-1**)

b and h : As specified in **6.2.1, Part 5 of the Rules**

In ships having two or more decks, *W* for the upper tier deck need not be taken into consideration.

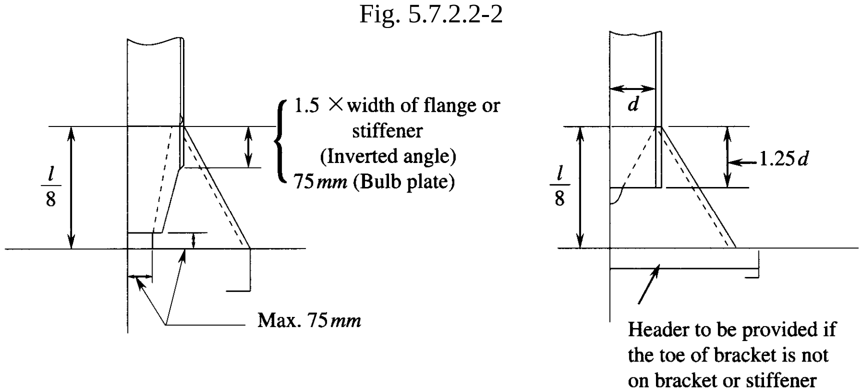
Fig. 5.7.2.2-1



2 Dimensions of brackets of bulkhead stiffeners

The dimensions of brackets of bulkhead stiffeners are to be as indicated in **Fig. 5.7.2.2-2**.

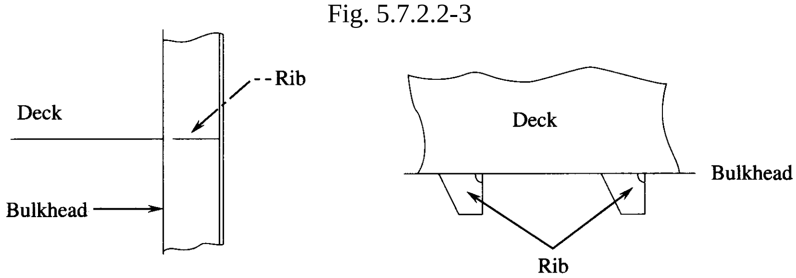
Fig. 5.7.2.2-2



3 Support of stiffeners at decks

Where a deck terminates at the bulkhead, the stiffeners are to have ribs at the level of the deck. (*See* **Fig.5.7.2.2-3**)

Fig. 5.7.2.2-3



Chapter 8 DEEP TANKS

8.1 General

8.1.3 Divisions in Tanks

1 Length of deep tanks

The length of deep tanks is not to exceed the following limits.

(1) Where no longitudinal bulkhead is provided or a longitudinal bulkhead is provided on the centreline only:

$0.15L(m)$ or $10m$, whichever is greater

(2) Where two or more longitudinal bulkheads are provided:

$0.2L(m)$ except that the limit is to be $0.15L(m)$ in the bow and stern parts of bulk carrier type ships

Further, where the breadth of the wing tank is less than $4L+500$ (mm), the inner wall cannot be regarded as a longitudinal bulkhead.

2 Divisions

(1) Except in the bow and stern parts, deep tanks extending from side to side of the ship are to have longitudinal divisions in the ship's centreline. However, when it can be confirmed by the stability data that such bulkheads will be unnecessary, they might be omitted.

(2) In fresh water tanks extending from side to side of the ship, fuel oil tanks or other tanks which may not be kept completely full during navigation, wash plates or deep girders are to be provided on the centreline as well as in positions approximately $B/4$ distant from the ship's sides, except when it can be confirmed by the data on the rolling period of the ship and the inherent period of oscillation of water or oil in the tanks, that they will be unnecessary.

8.2 Deep Tank Bulkheads

8.2.2 Bulkhead Stiffeners

1 Span of stiffeners

For stiffeners having "Connection Type A," the span may be taken as $4l'/3$ if the arm length of brackets exceed $l/8$. For "Connection Type A," *see* **Fig. 5.8.2.2-1**.

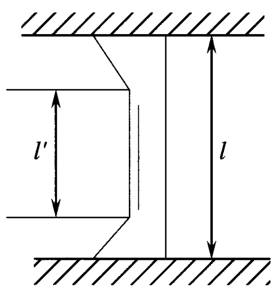
2 End connection of stiffeners at the top of deep tanks

Stiffeners of deep tank bulkheads, which are not in line with stiffeners of tween deck bulkheads at the top of the tank, are to have bracket ends.

3 Scantlings of bulkhead stiffeners supporting under-deck girders

The scantlings are to be calculated according to **7.2.2**, taking C as 9.81.

Fig. 5.8.2.2-1



Chapter 9 LONGITUDINAL STRENGTH

9.1 Longitudinal Strength

9.1.2 Calculation of Section Modulus of Transverse Section of Hull

1 Unit of section modulus of transverse section of hull

The section modulus Z (cm^3) is to have five significant figures.

2 Members included in longitudinal strength

The ratio of inclusion of members effective for longitudinal strength is to be as follows.

(1) All intercostal plates may be included if the fillet welding complies with **Note 1** of **Table C1.5, Part C of the Rules for the Survey and Construction of Steel Ships**.

(2) All doubling plates may be included if fitted during ship construction or 90% if fitted during conversion or addition.

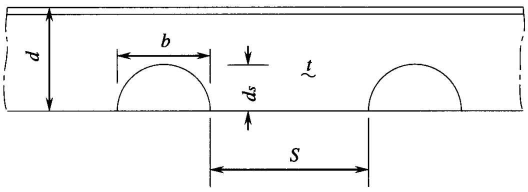
(3) For side stringers, slots for frames are to be deducted.

(4) Scallops complying with the following conditions need not be deducted from the sectional area. (*See* **Fig. 5.9.1.2-1**)

(a) d_s not exceeding d/4 nor exceeding 7t, maximum 75 *mm*

(b) S more than 5b and more than $10d_s$

Fig. 5.9.1.2-1 S, b and d_s of Scallops



(5) As for the longitudinal continuous decks between hatchways of ships having 2 or 3 rows of cargo hatches, the ratio of sectional area to be included in the calculation of the section modulus is to be obtained from **Table 5.9.1.2-1**. For intermediate values of ξ and l/L, linear interpolation is to be applied.

Table 5.9.1.2-1 Ratio of Inclusion of Sectional Area

	Hatches in 2 rows			Hatches in 3 or more rows		
ξ	l/L					
	0.10	0.20	0.30	0.10	0.15	0.20
0	0.96	0.85	0.70	0.96	0.91	0.85
0.5	0.65	0.57	0.48	0.89	0.80	0.69
1.0	0.48	0.43	0.36	0.83	0.73	0.62
2.0	0.32	0.29	0.25	0.73	0.63	0.53
3.0	0.24	0.22	0.18	0.65	0.57	0.47

Notes:

ξ = Values obtained from the following formula:

$$\frac{ab^3}{lI_c}\left\{\frac{1+2\mu}{6(2+\mu)}\times 10^4 + 2.6\frac{I_c}{a_c b^2}\right\}$$

Where:

I_c : Moment of inertia (cm^4) of deck between hatches, including hatch coamings

a_c : Effective shear area (cm^2) of deck between hatches

a : Sectional area (cm^2) of continuous deck between hatches (port or starboard side half)

l : Length (m) of hatch

μ , b : As per **Fig. 5.9.1.2-2** (m)

(6) Where the sectional area of longitudinals, which are unable to be continued due to factors such as the arrangement of small hatch openings are compensated by adjacent ones, they may be included in the calculation of the section modulus of the transverse section.

3 Openings in strength decks

Openings in strength decks outside the line of hatch openings are to be treated as mentioned below.

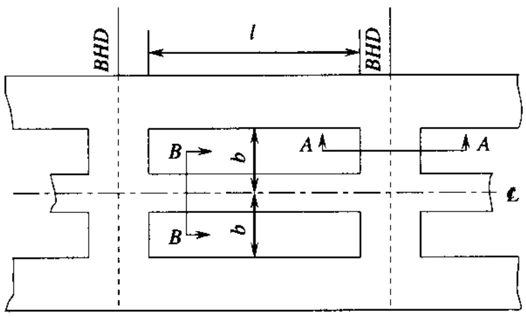
(1) Where the shape and dimensions do not meet the conditions in **Table 5.9.1.2-2**, reinforcement by means of rings, thicker plates, etc. is required (*See* **Fig. 5.9.1.2-3** and **Fig. 5.9.1.2-4**)

(2) Where the intervals between centres of holes *e* do not meet the conditions in **Fig. 5.9.1.2-5**, reinforcement as per **(1)** above is needed.

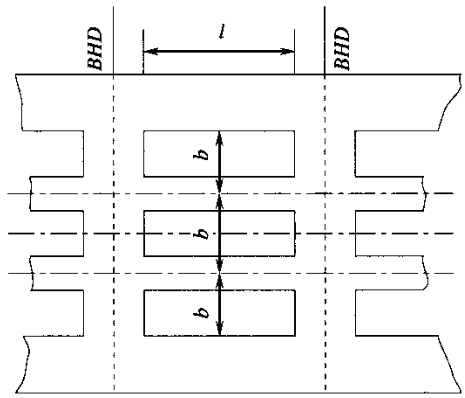
9.1.3 Loading Manual

For loading manuals required for ships, the provisions of **C34.1.2**, **Part C of the Guidance for the Survey and Construction of Steel Ships** are to be applied.

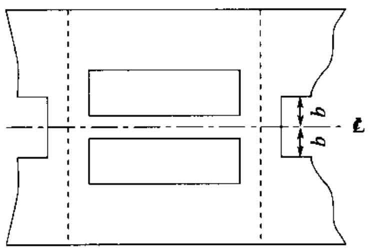
Fig. 5.9.1.2-2 l, b and μ



$\mu = 0$

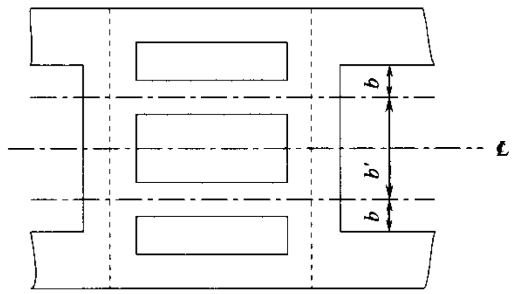


$\mu = 1$



$\mu = 0$

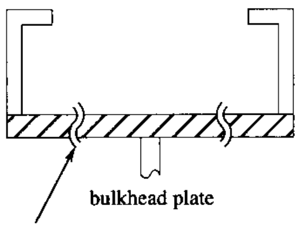
2-row hatches



$\mu = \frac{b'}{b}$

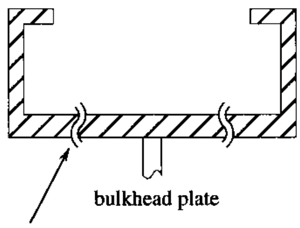
3-row hatches

Section *A*-*A*



bulkhead plate

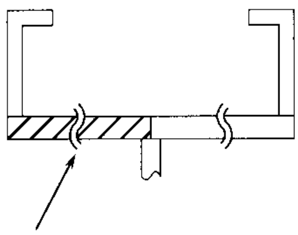
a_C Area of hatched part



bulkhead plate

I_C Moment of inertia of hatched part

Section *B*-*B*



a Area of hatched part

Table 5.9.1.2-2

	Elliptic holes	Circular holes
Oil tankers	$\frac{a}{b} \leq \frac{1}{2}, a \leq 0.06B$ ($a_{max} = 900$ mm)	$a \leq 0.03B$ ($a_{max} = 450$ mm)
Cargo ships	$\frac{a}{b} \leq \frac{1}{2}, a \leq 0.03(B - b_H)$ ($a_{max} = 450$ mm)	$a \leq 0.015(B - b_H)$ ($a_{max} = 200$ mm)

Fig. 5.9.1.2-3 Where Elliptic Hole and Circular Hole are in Same Cross-section

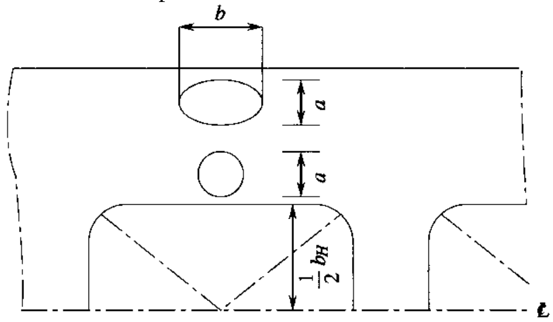


Fig. 5.9.1.2-4 Reinforcement by Means of Ring

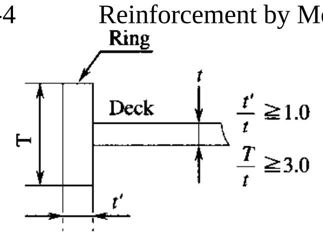
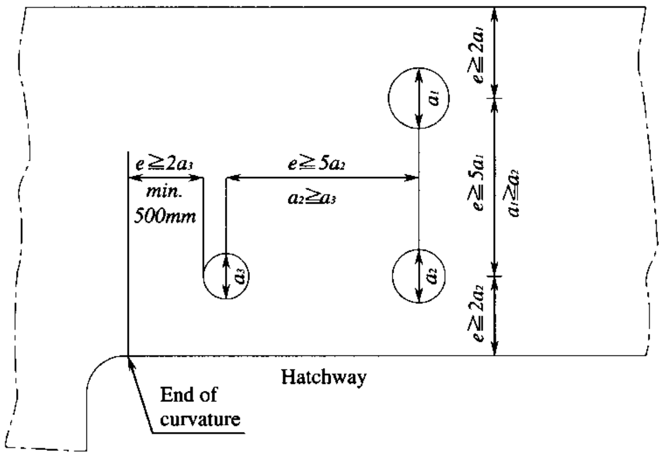


Fig. 5.9.1.2-5 Intervals Between Centres of Holes



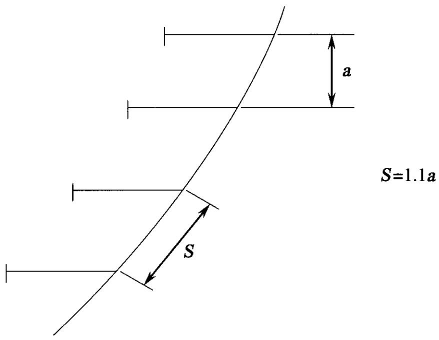
Chapter10 SHELL PLATING

10.2 Shell Plating

10.2.2 Thickness of Side Shell Plating

The thickness of side shell plating of curved parts within 0.3*L* from the forward and aft end may be calculated with the value of *S* taken as equal to 1.1 *times* the vertical or horizontal distance between frames *a* (*See* **Fig. 5.10.2.2-1**)

Fig. 5.10.2.2-1 Relation of *S* and *a* in End Parts



10.2.3 Thickness of Bottom Shell Plating

The thickness of bottom shell plating of curved parts within 0.3*L* from the forward and aft end may be in accordance with the requirements specified in **10.2.2**

Chapter 11 DECKS

11.1 General

11.1.1 Steel Deck Plating

Decks which are not fully plated

(1) Stringer plates

Decks not fully plated are to have stringer plates of an appropriate breadth and of a thickness not less than that determined for deck plating in accordance with the requirements in **11.4, Part5 of the Rules** for the positions concerned. The stringer plates of effective decks are to be effectively connected to the shell plating.

(2) Tie plates

Tie plates are to be provided along hatch sides, in way of pillars, on the under-deck girders and under deckhouse coamings. These tie plates are to have an appropriate breadth and a thickness not less than that determined for deck plating in accordance with the requirements in **11.4, Part 5 of the Rules** for the positions concerned.

(3) In way of transverse bulkheads and at the ends of deck openings

In way of transverse bulkheads and at the ends of deck openings, the deck is to be suitably plated with steel plates.

11.1.3 Compensation for Openings

All corners of openings on decks, such as hatchways, are to be well rounded, properly smoothed and reinforced, as necessary, by thickening the deck plating or by means of doubling plates.

(1) Regions where thicker plating or doubling plates are required

Strength deck: Within 0.75L⌧

Effective 2nd deck: Within 0.6L⌧

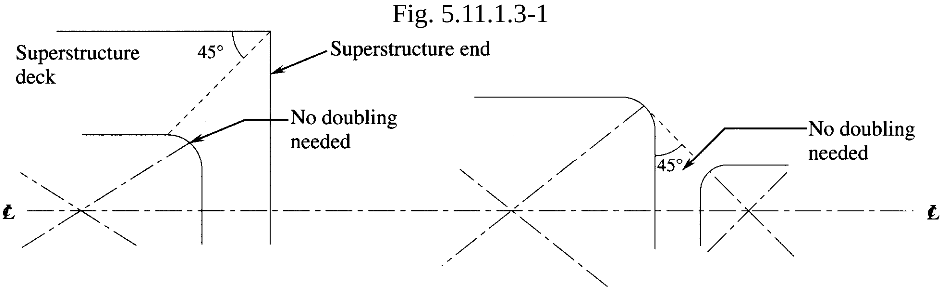
3rd deck and lower decks: No doubling needed, as a rule

Superstructures and long deckhouse:

Doubling within 0.6L⌧ for decks immediately above the strength deck

(2) Plate thickening and doubling plates may be properly reduced depending upon their locations. (*See* **Fig. 5.11.1.3-1**)

Fig. 5.11.1.3-1



(3) The dimensions and thickness of doubling plates or ranges of thickening are to be determined considering the degree of stress concentration around the openings.

(4) The minimum radii at the corners are to be as follows:

Within 0.5L⌧ of strength deck: 250 *mm*

Elsewhere: 200 *mm*

The radius may be suitably reduced for small openings. For companionways and similar small openings, the radius at the corners may be 150 *mm* in the strength deck.

(5) For corners of openings having a radius not less than 600 *mm* or having a parabolic or similar shape, neither doubling plates nor thickening of the plating is required. The recommended corner shape is as shown in **Fig. 5.11.1.3-2**.

(6) No welded joints are permitted at the corners of openings in the strength deck. The welded joints are to be properly off the end of the curvature. (*See* **Fig. 5.11.1.3-3**)

Fig. 5.11.1.3-2

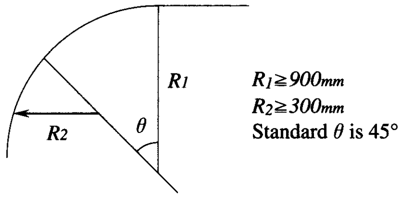
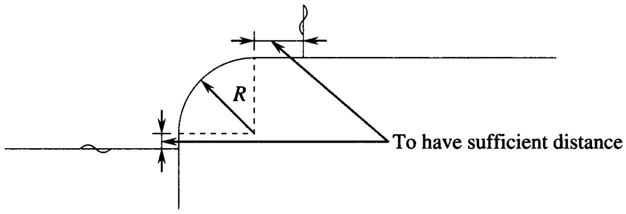


Fig. 5.11.1.3-3



11.2 Deck Load

11.2.1 Value of Deck Load *h*

Suitable documents which specify values of the deck load h (kN/m^2) prescribed in **11.2.1-1, Part 5 of the Rules** (*e.g.* Loading Manual) are to be provided on board to aid the ship's master.

11.3 Effective Sectional Area of Strength Deck

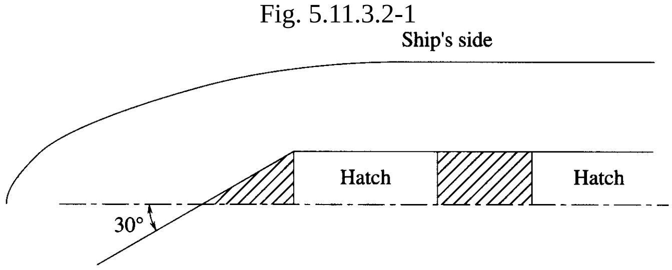
11.3.2 Effective Sectional Area of Strength Deck

1 Members to be included in the calculation of the actual sectional area of strength deck

In addition to the deck plating, members attached to the deck plating, such as stringer angles and longitudinal beams, which are included as longitudinal strength members are to be included in the calculation of the actual sectional area. The shaded areas in the figure below are not to be included in the calculation. (*See* **Fig. 5.11.3.2-1**)

2 Where round gunwales are provided, the sectional area is to be calculated assuming that the plate of the round gunwale is horizontally extended to the ship's side.

Fig. 5.11.3.2-1



Chapter 13　HATCHWAYS AND OTHER DECK OPENINGS

13.2　Hatchways

13.2.2　Protection of Hatchways

"where the measures deemed appropriate by the Society" referred to in **13.2.2, Part 5 of the Rules**, are ,for example, where appropriate drainage is provided in the hold or where appropriate shipping operation are planned, etc.

Chapter 14 EQUIPMENT

14.1 Anchors, Chain Cables and Ropes

14.1.1 General

1 In applying **14.1.1-4, Part 5 of the Rules**, where equipment which is less than that given in **Table 5.14.1** is provided, the request stating rational reasons taking into account environmental conditions in which the ship will operate, etc. is to be submitted to the Society.

2 In applying **14.1.1-4, Part 5 of the Rules**, where omission of equipment is requested the following are to be complied with.

(1) In case of omission of anchors, the request of omission of anchors together with such statement that the barge is intended to be moored only on quay, is to be submitted to the Society.

(2) In case of omission of mooring lines, the request of omission of mooring lines together with such statement that the mooring lines have been arranged on the shore where the barge is intended to be moored, is to be submitted to the Society.

Part 6 INTACT STABILITY

Chapter 2 INTACT STABILITY REQUIREMENTS

2.2 General Stability Requirements

2.2.1 Stability Curves

Tugs are to comply with the following requirements, in addition to the requirements of **2.2.1, Part 6 of the Rules**.

(1) G_0M is not to be less than 0.15 *m*.

(2) The stability curves are to comply with the following **(a)** or **(b)**:

(a) The residual area between a righting lever curve and a heeling lever curve developed from the bollard pull force is not to be less than 0.09 *m-rad*. The area is to be determined between the first interception of the two curves and the second interception or the angle of down flooding whichever is less. (The area as specified by "*A*" in **Fig. 6.2.2.1-1**)

(b) The area under a righting lever curve ("*A*" + "*B*" in **Fig. 6.2.2.1-1**) is not to be less than 1.4 *times* the area under a heeling lever curve developed from the bollard pull force ("*B*" + "*C*" in **Fig. 6.2.2.1-1**). The areas are to be determined between 0 *degree* and the 2nd interception or the angle of down flooding whichever is less.

In the application of the above requirements, the heeling lever (l_h) curve developed from the bollard pull force is to be derived by using the following formula. For tugs intended for towing astern, such lever is to be that for towing ahead or that for towing astern, whichever is larger.

$$l_h = \frac{\kappa \cdot T \cdot h \cdot \cos\theta}{9.81 \cdot \Delta} \quad (m)$$

Where:

κ : Coefficient relating to type of propulsion, is to be taken equal to 0.7 for tugs with azimuth thruster(s) and 0.5 for other tugs.

T : Maximum bollard pull (*kN*). In principle, maximum bollard pull is to be derived from the actual test at the maximum continuous output of the engine(s). However, a nominal bollard pull specified by constructor of the considered tug may be accepted, provided that such value is not less than value given by **Table 6.2.2.1-1** as a standard, unless records of bollard pull tests in similar tugs or sufficient information provided by the constructor.

h : Vertical distance (*m*) between the towing hook and the centre of the propeller.

Δ : Displacement (*ton*)

(3) Maximum bollard pull used in the application of **(2)** above is to be clearly stated in the stability information and drawings relating to towing arrangements. Such maximum bollard pull is also to be indicated at an appropriate position on each of the towing arrangements.

(4) In principle, tugs are to be provided with an appropriate device being capable of releasing the towing cable in an instant or appropriate safety procedures for emergency are to be stated in the stability information.

Fig. 6.2.2.1-1 Heeling Lever Curve Developed from the Bollard Pull Force

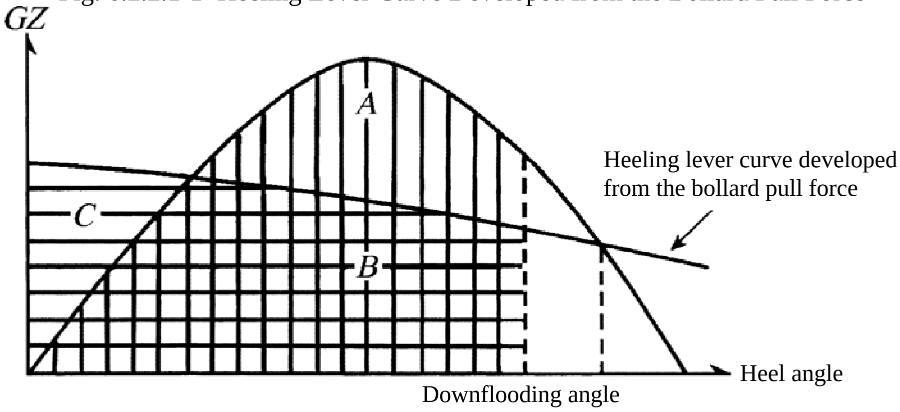


Table 6.2.2.1-1 Maximum Bollard Pull (kN)

	Towing ahead	Towing astern	
		For azimuth thruster(s)	For others
For propeller(s) not fitted with nozzles	0.16 H	0.14 H	0.08 H
For propeller(s) fitted with nozzles	0.19 H	0.17 H	0.10 H

H : Maximum continuous output of engine(s) (kW)

Note: For tugs other than conventional tugs having propulsion(s) in the aft end, a special consideration is to be given for each tug.

Part 7 MACHINERY INSTALLATIONS

Chapter 1 GENERAL

1.1 General

1.1.1 Scope

1 In **Part 7 of the Rules**, "main propulsion machinery" means the following machinery which generates or converts motive power capable of propelling a ship at the speed specified in **2.1.9**, **Part 1 of the Rules**:

(1) Diesel engines (including superchargers)

(2) Generating plants for propulsion and motors for propulsion (excluding **Chapter 14**)

2 Means provided to complement the motive power generated by the main propulsion machinery specified in **-1** that are connected directly to propulsion shafting systems, are to be included in the shafting system. Any means not connected directly to propulsion shafting systems are to be included in auxiliary machinery essential for main propulsion.

1.1.3 Machinery Installations with Novel Design Features

1 For the waterjet propulsion systems, **Annex D1.1.3-1** "Guidance for the Survey and Construction of Waterjet Propulsion Systems", **Part D of the Guidance for the Survey and Construction of Steel Ships** is to apply.

2 For installations in ships having main and essential auxiliary boilers that burn coal as fuel, the requirements specified in **Annex D1.1.3-2** "Guidance for the Survey and Construction of Coal Burning Installations in Ships", **Part D of the Guidance for the Survey and Construction of Steel Ships** are to apply; however, these requirements (excluding in **1.1.3**, **1.1.5** and **1.1.6**) may be regarded as reference for considering plans.

3 For azimuth thrusters, **Annex D1.1.3-3** "**GUIDANCE FOR THE SURVEY AND CONSTRUCTION OF AZIMUTH THRUSTERS**", **Part D of the Guidance for the Survey and Construction of Steel Ships** is to apply.

1.1.4 Modification of Requirements

For those machinery installations specified in **1.1.4**, **Part 7 of the Rules** (excluding those specified in other Parts of the Rules), some requirements of **Part 7 of the Rules** may be modified as follows:

(1) Prime movers (including power transmission systems and shafting systems; hereinafter the same) driving main propulsion machinery, generators, auxiliary machinery essential for main propulsion and auxiliary machinery for manoeuvring and the safety:
    (a) Prime movers with an output less than 110 *kW*
        i) Submission of drawings may be omitted.
        ii) Materials which comply with the requirements of any national standard may be accepted for the principal components. In this case, materials (excluding valves and pipe fittings) are to be manufactured by a manufacturer approved by the Society.
        iii) Shop tests in the presence of the Surveyor may be substituted for manufacturer's tests. In this case, submission or presentation of test records may be required by the Surveyor.
    (b) Prime Movers with an output not less than 110 *kW* but less than 1,000 *kW*.
        i) Materials used for principal components may be dealt with under the requirements specified in **(a)ii)**.
        ii) Hydrostatic tests as well as dynamic balancing tests, overspeed tests and trial runs of turboblowers at the manufacturer may be dealt with under the requirements specified in **(a)iii)**.

(2) Prime movers for auxiliary machinery for cargo handling:
    (a) Prime movers with an output less than 1,000 *kW* may be dealt with under the requirements of **(1)(a)**.
    (b) Prime movers with an output 1,000 *kW* or over may be dealt with under the requirements of **(1)(b)**.

(3) Fittings of boilers and pressure vessels of Groups I and II with a design pressure less than 3 *MPa* or with a nominal diameter less than 100 *mm*:

Materials which comply with any national standards may be accepted.

(4) For auxiliary machinery essential for main propulsion and auxiliary machinery for manoeuvring and safety:
   (a) Hydrostatic tests may be dealt with under the requirements of **(1)(a)iii)**.
   (b) For any asterisked auxiliary machinery in **Table 7.1.1.5-1**, operation tests may also be dealt with under the requirements of **(1)(a)iii)**.

(5) Auxiliary machinery for cargo handling:
   (a) In cases where prime mover output is less than 1,000 *kW*, shop tests may be dealt with under the requirements of **(1)(a)iii)**.
   (b) In cases where prime mover output is 1,000 *kW* or greater, shop tests excluding the operation test may be dealt with under the requirements of **(1)(a)iii)**.

(6) Pipes, valves and pipe fittings of piping systems with both a design pressure less than 1 *MPa* and a design temperature of 230 *°C* or less:
   Hydrostatic tests may be dealt with under the requirements of **(1)(a)iii)** except for those valves directly fitted to the ship's side below the designed maximum load line.

(7) Hydraulic piping system excluding those for steering gears and controllable pitch propellers:
   In radiographic inspection on butt welded pipe joints, sampling test under the instructions by the Surveyor of the Society may be accepted.

1.1.5 Terminology

In the Rules, "auxiliaries" are classified as in **Table 7.1.1.5-1**.

1.3 General Requirements for Machinery Installations of Tugs and Pushers

1.3.1 General

1 The "navigable speed" referred to in **1.3.1-2**, **Part 7 of the Rules** means a speed at which the ship is capable of being steered and kept navigable for an extended period of time (period required to get to the nearest port for repairs). Normally, 7 *knots* or a speed corresponding to 1/2 of the speed specified in **2.1.9**, **Part 1 of the Rules** at the ship's full loaded draught may be regarded as a navigable speed.

2 Unconventional machinery referred to in **1.3.1-2**, **Part 7 of the Rules** is any machinery with novel design features specified in **1.1.3**, **Part 7 of the Rules**.

1.3.7 Communication between the Navigating Bridge and Control Stations for the Speed and Direction of Thrust of the Propellers

1 It is recommended that engine room telegraph under the requirements of **1.3.7(1)**, **Part 7 of the Rules** is such that it issues alarm upon loss of power supply.

2 The means of communication provided under the requirements of **1.3.7(2)**, **Part 7 of the Rules** are to be capable of directly indicating orders and responses.

3 Engine room telegraph systems are to be provided independently from any remote control systems of main propulsion machinery on the navigation bridge; however, both systems may use a common handle.

1.5 Tests

1.5.4 Tests after Installation on Board

In "to be tested to the satisfaction of the Society at an appropriate time before being put into service in order to verify" referred to in **1.5.4-2**, **Part 7 of the Rules**, the following items are to be verified:

(1) The location of river water suction and overboard discharge pipes specified in **Chapter 11**, **Part 7 of the Rules**;
(2) Prevention of leakages of flammable gases and harmful gases, and prevention of fire;
(3) Insulation of highly heated parts and protection of moving parts; and
(4) Ventilation at the place of operation.

Table 7.1.1.5-1 Kinds of Auxiliaries

Kind of auxiliary		Auxiliary machinery items
Auxiliary Machinery essential for main propulsion	Auxiliary machinery for cooling systems	Jacket cooling water pumps, Piston cooling water (oil) pumps, Fuel valve cooling water (oil) pumps, Turbocharger cooling water pumps, Circulating water pumps, Cooler cooling water pumps, Generator engine cooling water (oil) pumps, Air compressors cooling water pumps
	Auxiliary machinery for feed water, condensate and draining systems	Boiler water circulating pumps, Condensate pumps, Exhaust gas economizer feed pumps, Drain pumps, Feed water pumps
	Auxiliary machinery for fuel oil systems	F.O. supply (service) pumps, F.O. transfer pumps, Boiler burning pumps, F.O. purifiers
	Auxiliary machinery for lubricating oil systems	Cam shaft L.O. pumps, Turbocharger L.O. pumps, Crosshead L.O. pumps, Reduction gear L.O. pumps, Stern tube L.O. pumps (not applicable for gravitational circulation systems), L.O. purifiers
	Auxiliary machinery for hydraulic systems	Hydraulic oil pumps (pumps to supply hydraulic oil to hydraulic circuits for driving or controlling equipment relevant to main propulsion, e.g., controllable pitch propeller oil pumps)
	Other auxiliary machinery	Boiler draught fans, Air compressors (excluding air compressors for emergency use), Distilling plants (when distillate is used for essential boilers), Others as deemed essential by the Society.
Auxiliary machinery for manoeuvring and safety	Pumps	Bilge pumps (including pumps for oil-water separators*), Ballast pumps, Fire pumps*
	Steering-related auxiliary machinery	Steering engines, Side thrusters*, Stabilizers
	Deck machinery	Windlasses, Mooring winches*, Hydraulic pumps used for windlasses, Hydraulic pumps used for mooring winches*
	Ventilating fans, blowers, etc.	Ventilating fans (installed in hazardous areas due to flammable gases or gases harmful to the health of personnel in engine room*, boiler room*) Others as deemed essential by the Society.
Auxiliary machinery for cargo handling	Cargo handling machinery and gear	Hydraulic pumps used for Cargo handling appliances (items subject to “Rules for the Survey and Construction of Cargo Handling Appliances of Ships”), Hoisting machinery, Operating equipment
	Other auxiliary machinery	Others as deemed essential by the Society
Auxiliary machinery for specific use	Cargo handling equipment for specific Use	Unloaders (Shipborne units), Refrigerating machines for heat insulated containers, etc.
	Public working equipment	Dredging equipment, Drilling machines, Pile-driving equipment, etc.
	Fishing equipment	Winches, etc.
	Marine-products processing equipment	Canning/packing equipment, Conveyors, Ice-making machines, etc.
	Equipment for specific operations	Equipment specifically designated by the Society

Remarks:

For those items of auxiliary machinery marked by an asterisk, *see* **7.1.1.4(4)**

Chapter 2 DIESEL ENGINES

2.1 General

2.1.1 Scope

The wording "the requirements specified otherwise by the Society" in **2.1.1-2**, **Part 7 of the Rules** means "**GUIDANCE FOR THE ADDITIONAL REQUIREMENTS ON ELECTRONICALLY-CONTROLLED DIESEL ENGINES** in **Annex D2.1.1**, **Part D of the Guidance for the Survey and Construction of Steel Ships**".

2.1.2 Drawings and Data

1 For the engine manufacturer producing engines with the drawings and data of the engine's designer (hereinafter referred to as "licenser") which have already been approved by the Society (hereinafter the engine manufacturer referred to as "licensee"), a list of identification numbers, including the revision status of all drawings and data, may be accepted as substitution for those drawings and data specified in **2.1.2, Part 7 of the Rules**.

2 In cases where the licensee proposes design modifications to components relevant to the drawings and data mentioned in **-1**, all associated documents are to be submitted by the licensee for approval or for reference. In cases where significant modifications are made, a statement confirming the licenser's acceptance of these modifications is also to be submitted.

3 In all cases, including those according to **-1** and **-2** above, a complete set of documents are to be kept in the manufacturing work shop and to be available for review by the attending Surveyor.

4 The "Operation and service manuals for the engine" specified in **2.1.2(2)(w), Part 7 of the Rules** are to contain maintenance requirements, including the details of any special tools and gauges that are to be used with their fittings/settings together with any test requirements on completion of maintenance.

2.3 Crankshafts

2.3.1 Solid Crankshafts

1 In **2.3.1-1, Part 7 of the Rules**, coefficients A and B for engines having unequal firing intervals are to be in accordance with **Table 7.2.3.1-1**.

2 In cases where the diameter of crankpins or journals is less than the required diameter d_c given in **2.3.1-1**, **Part 7 of the Rules**, consideration will be given in each case on the basis of the stress levels in fillets, the torsional stress levels in crankpins and journals and the material of the crankshaft. In this connection, the stress levels in fillets are to be in accordance with the following **(1)** or **(2)**:

(1) In cases where the torsional stress in crankpins and journals are evaluated without carrying out a forced vibration calculation including the stern shaftings:
The diameter may be acceptable where the value of equivalent stress amplitude σ_e calculated by the **Annex D2.3.1-2(1)** "**GUIDANCE FOR CALCULATION OF CRANKSHAFT STRESS I**", **Part D of the Guidance for the Survey and Construction of Steel Ships** is not more than the allowable stress σ obtained from the formula below with the coefficient shown in **Table 7.2.3.1-2.**

$$\sigma = \sigma_a \cdot f_m \cdot f_s + \alpha \quad (N/mm^2)$$

However, where deemed appropriate by the Society, the diameter in consideration of the allowable stress of crankshafts, including fillet parts, that have been hardened by surface treatment and the resultant stress distribution may be acceptable.

(2) In cases where the torsional stress in crankpins and journals are evaluated by carrying out a forced vibration calculation including the stern shaftings: The diameter may be acceptable where the value of the acceptability factor Q calculated by the **Annex D2.3.1-2(2)** "**GUIDANCE FOR CALCULATION OF CRANKSHAFT STRESS II**", **Part D of the Guidance for the Survey and Construction of Steel Ships** complies with the following formula:

$$Q \geq 1.15$$

3 In cases where the dimensions of crankwebs fail to meet the requirements specified in **2.3.1-2(1)** or **(2)**, **Part 7 of the Rules**, consideration will be given in accordance with the following:

(1) The dimensions of the crankwebs may be acceptable in cases where the actual diameters of crankpins and journals are not less than the required diameter d_c calculated by **2.3.1-1**, **Part 7 of the Rules** by replacing M and T with those specified below.

In this case, the dimensions are to be within the following ranges;

$0 \le q/r \le 1$, $-0.3 \le h/d \le 0.4$, $8 \le d/r \le 27$

$1.1 \le b/d \le 2.1, 0.2 \le t/d \le 0.56$

$M = 10^{-2} A P_{max} L \alpha_{KB} / 5$

$T = 10^{-2} B P_{mi} S \alpha_{KT} / 1.8$

Where:

α_{KB}: Stress concentration factor for bending, as specified below;

$$\alpha_{KB} = 4.84 f_1 f_2 f_3 f_4 f_5$$

$$f_1 = 0.420 + 0.160\sqrt{d/r - 6.864}$$

$$f_2 = 1 + 81\left\{0.769 - \left(0.407 - \frac{h}{d}\right)^2\right\}\left(\frac{q}{r}\right)\left(\frac{r}{d}\right)^2$$

$$f_3 = 0.285\left(2.2 - \frac{b}{d}\right)^2 + 0.785$$

$$f_4 = 0.444\left(\frac{d}{t}\right)^{1.4}$$

$$f_5 = 1 - \left\{\left(\frac{h}{d} + 0.1\right)^2 / \left(4\frac{t}{d} - 0.7\right)\right\}$$

$$\cdots (t/d \ge 0.36)$$

$$f_5 = 1 - 1.35\left(\frac{h}{d} + 0.1\right)^2$$

$$\cdots (t/d < 0.36 \text{ and } h/d > -0.1)$$

$$f_5 = 1$$

$$\cdots (t/d < 0.36 \text{ and } h/d \le -0.1)$$

α_{KT} :Stress concentration factor for torsion, as specified below;

$$\alpha_{KT} = 1.75 g_1 g_2 g_3$$

$$g_1 = 31.6(0.152 - r/d)^2 + 0.67$$

$$g_2 = 1.04 + 0.317 h/d$$

$$g_3 = 1.31 - 0.233 b/d$$

d : actual diameter of crankpin or journal (mm)

r : radius in fillet (mm)

q : recess (mm)

h : overlap between crankpin and journal (mm)

$$h = \frac{1}{2}\left(d_p + d_j - S\right) \ (mm)$$

Other symbols are the same as those used in **2.3.1**, **Part 7 of the Rules**.

(2) In cases where the dimensions of the crankwebs fail to meet the requirements even after applying **(1)** above, the acceptance criteria specified in **(a)** or **(b)** below may be used:

(a) In cases where the torsional stresses in crankpins and journals are evaluated without carrying out a forced vibration calculation including the stern shaftings:

The dimensions may be acceptable in cases where the value of the equivalent stress amplitude σ_e calculated by the **Annex D2.3.1-2(1) "GUIDANCE FOR CALCULATION OF CRANKSHAFT STRESS I"**, **Part D of the Guidance for the Survey and Construction of Steel Ships** is not more than the allowable stress σ obtained from the formula below with the coefficient shown in **Table 7.2.3.1-2.**

$$\sigma = \sigma_a \cdot f_m \cdot f_s + \alpha \quad (N/mm^2)$$

However, where deemed appropriate by the Society, the dimensions in consideration of the allowable stress of crankshafts, including fillet parts, that have been hardened by surface treatments and the resultant stress distribution may be acceptable.

(b) In cases where the torsional stresses in crankpins and journals are evaluated by carrying out a forced vibration calculation including the stern shaftings:

The dimensions may be acceptable where the value of the acceptability factor Q calculated by the **Annex D2.3.1-2(2)** "**GUIDANCE FOR CALCULATION OF CRANKSHAFT STRESS II**", **Part D of the Guidance for the Survey and Construction of Steel Ships** complies with the following formula:

$$Q \geq 1.15$$

4 The dimensions of the crankweb breadth b, crankweb thickness t, radius in fillet r and recess q used for **2.3.1-2**, **Part 7 of the Rules** and **-3** above are to be in accordance with the following (*See* **Fig. 7.2.3.1-1**):

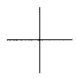
(1) As for "*b*", the breadth on the perpendicular bisector of the line between the crankpin centre and journal centre is to be used.

(2) As for "*t*", the thickness at the same section specified in **(1)** is to be used. In this case, the recess q need not be accounted in the thickness even when it is provided.

(3) As for "*r*", the radius connecting to the crankpin or journal is to be used when a composite radius is provided.

Table 7.2.3.1-1 Values of Coefficients *A* and *B*

(1) 4-stroke cycle in-line engines

Number of cylinders	Arrangement of crank	*A*	*B*
4		1.25	4.7

(2) 2-stroke cycle vee engines

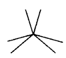
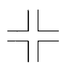
Number of cylinders	Minimum firing interval between two clyinders on one crankpin	Arrangement of crank	*A*	*B*
12	60°		1.00	21.6
				15.0
16				26.3

Table 7.2.3.1-2 Coefficient of Allowable Stress at Fillet

<table>
<tr><td rowspan="5">σ_a
(N/mm^2)</td><td rowspan="2">Stroke cycle of engine</td><td rowspan="2">Type of crankshaft</td><td colspan="3">Shaft diameter ϕ (1) (mm)</td></tr>
<tr><td>$d \geq 200$</td><td>$200 > d \geq 100$</td><td>$100 > d$</td></tr>
<tr><td rowspan="2">2-cycle</td><td>Semi-built-up</td><td>54</td><td>——</td><td>——</td></tr>
<tr><td>Solid</td><td>74</td><td>142-0.34d</td><td rowspan="2">108</td></tr>
<tr><td>4-cycle</td><td>Solid</td><td>83</td><td>133-0.25d</td></tr>
<tr><td>f_m</td><td colspan="5">$1+\frac{2}{3}\left(\frac{T_s^{(2)}}{440}-1\right)$</td></tr>
<tr><td rowspan="3">f_s</td><td colspan="5">Manufacturing method</td></tr>
<tr><td>Ordinary method</td><td colspan="2">Method (1) for K_s specified in 2.3.1-1, Part 7 of the Rules</td><td colspan="2">Method (2) for K_s specified in 2.3.1-1, Part 7 of the Rules</td></tr>
<tr><td>1</td><td colspan="2">1.15</td><td colspan="2">$1+\rho^{(3)}/100$</td></tr>
<tr><td rowspan="3">α
(N/mm^2)</td><td colspan="5">Main bearing material</td></tr>
<tr><td colspan="2">White metal</td><td colspan="3">Aluminum or kelmet</td></tr>
<tr><td colspan="2">0</td><td colspan="3">10</td></tr>
</table>

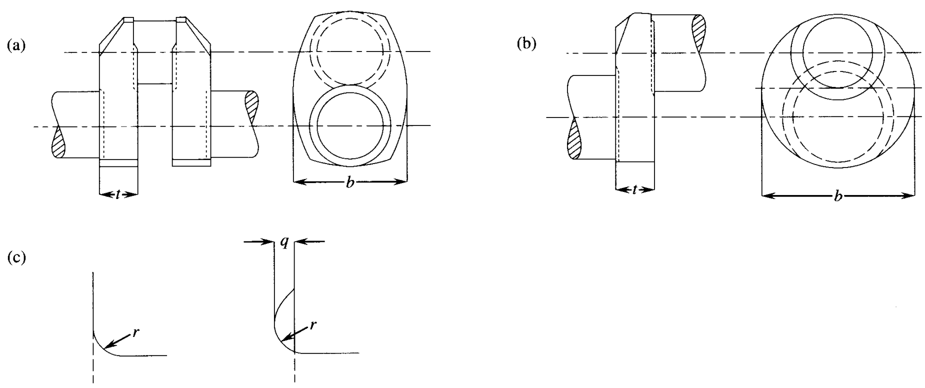
Notes :

(1) d is to be the actual diameter of crankpin or journal, whichever is larger.

(2) T_s signifies the minimum specified tensile strength (N/mm^2) of the crankshaft materials.
The limit of T_s for computing f_m is to be in accordance with the requirements in **2.3.1-1**, **Part 7 of the Rules**.

(3) ρ signifies the degree of strength improvement (%) approved by the Society relative to surface hardening.

Fig. 7.2.3.1-1 Dimensions for Webs of Solid Crankshafts



2.3.2 Built-up Crankshafts

1 The wording "maximum torque at the shrinkage fit" in **2.3.2-1(2)**, **Part 7 of the Rules** means, in principle, $M_{T\max}$ shown in **1.3.2-1 of the Annex D2.3.1-2(2) "GUIDANCE FOR CALCULATON OF CRANKSHAFT STRESS II"**, **Part D of the Guidance for the Survey and Construction of Steel Ships**.

2 In cases where the dimensions of crankwebs fail to meet the requirements in **2.3.2-2(1)**, **Part 7 of the Rules**, they may be acceptable provided that either the following **(1)** or **(2)** is satisfied.

(1) In cases where the maximum torque at the shrinkage fit is evaluated without carrying out a forced vibration calculation including the stern shaftings:

$$d_h^2 t P_m \geq CTD^2$$

Where:

C : 103 for 2-stroke cycle in-line engines
165 for 4-stroke cycle in-line engines

P_m : Surface pressure at shrinkage fit, as given by the following formula

$$P_m = Y\left\{\log_e K + \frac{1}{2}\left(1 - \frac{K^2}{r_s^2}\right)\right\}\left(1 - R^2\right)$$

$$K = 0.9\sqrt{\frac{206\alpha}{Y} + 0.25}$$

Other symbols are the same as those used in **2.3**, **Part 7 of the Rules**.

(2) In cases where the maximum torque at the shrinkage fit is evaluated by carrying out a forced vibration calculation including the stern shaftings:

$$\alpha \geq \frac{4 \times 10^3 S_R M_{T\max}\left(1 - \frac{R^2}{r_s^2}\right)}{\pi \mu E d_h^2 t \left(1 - \frac{1}{r_s^2}\right)\left(1 - R^2\right)}$$

Where:

$M_{T\max}$: Maximum torque at shrinkage fit, as shown in **1.3.2-1 of the Annex D2.3.1-2(2)** "**GUIDANCE FOR CALCULATION OF CRANKSHAFT STRESS II**", **Part D of the Guidance for the Survey and Construction of Steel Ships** (*N-m*)

E : Modulus of longitudinal elasticity (*N/mm*^{2})

Other symbols are the same as those used in **2.3**, **Part 7 of the Rules**.

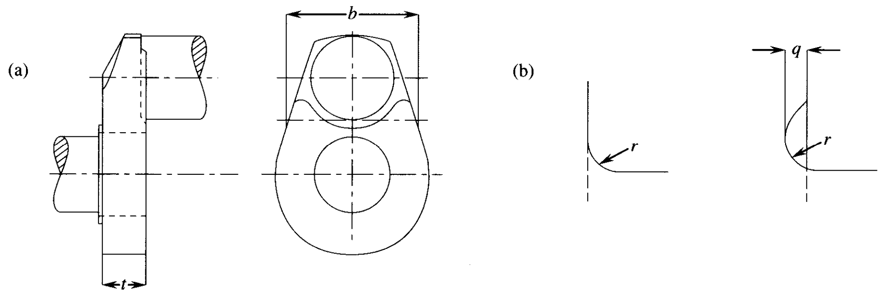
3 In cases where **2.3.2-2(1)**, **Part 7 of the Rules** is applied and where **2.3.1-2**, **Part 7 of the Rules** including **2.3.1-3** above is applied in accordance with **2.3.2-2(2)**, **Part 7 of the Rules**, the dimensions of the crankweb breadth *b*, crankweb thickness *t*, radius in fillet *r* and recess *q* above are to be in accordance with the following (*See* **Fig. 7.2.3.2-1**):

(1) As for "*b*", the breadth on the line perpendicularly intersected to the line between the crankpin centre and journal centre and tangent to the crankpin is to be used.

(2) As for "*t*", the thickness at the same section specified in **(1)** is to be used. In this case, the recess *q* need not be accounted in the thickness even when it is provided, and the ring around the shrinkage hole is not to be included in the thickness.

(3) As for "*r*", the radius connecting to the crankpin or journal is to be used when a composite radius is provided.

Fig. 7.2.3.2-1 Dimensions for Webs of Semi-built-up Crankshafts



2.3.3 Shaft Couplings and Coupling Bolts

The wording "to be of sufficient strength" in **2.3.3-2**, **Part 7 of the Rules** means to be in accordance with the following **(1)** or **(2)**:

(1) The thickness of shaft coupling flanges at the pitch circle of the bolt holes is to be not less than the diameter of the bolts determined by the formula in **2.3.3-1**, **Part 7 of the Rules** by using 440 *N/mm*^{2} for T_b. The radius at the fillet transition between the flange and shaft is to be not less than 0.08 *times* the shaft diameter. In this case, the fillet is not to be recessed in way of the bolt heads and nuts.

(2) Detailed calculation sheets for the strength of couplings (for the procedures and contents of these calculations, the following **(a)** to **(f)** are to be considered as standards) are to be submitted to the Society for approval. In this case, it is to be verified that the thickness of the coupling flange is larger than the diameter of the bolts determined by the formula in **2.3.3-1**, **Part 7 of the Rules** using the tensile strength of the bolt material assumed to be equivalent to the tensile strength of the crankshaft material.

(a) With the procedures specified in the following **(b)** to **(f)**, it is to be verified that the stress at the coupling is less than the allowable value. As the stress value in this case, comparisons are to be made by applying appropriate safety factors for yield points for bending stress, bending fatigue limits, yield points for torsional stress and torsional fatigue limits of the crankshaft material considering four types of stress, such as the maximum bending stress, fluctuating bending stress, the maximum torsional stress and fluctuating torsional stress.

(b) The maximum bending moment and fluctuating bending moment of this portion are to be determined in accordance with the requirements specified in **Annex D2.3.1-2(1)** "**GUIDANCE FOR CALCULATION OF CRANKSHAFT STRESS I**", **Part D of the Rule for the Survey and Construction of Steel Ships** or **Annex D2.3.1-2(2)** "**GUIDANCE FOR CALCULATION OF CRANKSHAFT STRESS II**", **Part D of the Guidance for the Survey and Construction of Steel Ships** Mean torque of this portion is to be determined.

(c) Torsional vibratory torque is to be determined by inverse operations from the allowable torsional vibratory stress value, which is to be taken as the fluctuating torque value.
By adding the fluctuating torque value, thus determined, to the mean torque value determined in the preceding sub-paragraph **(b)**, the sum is to be taken as the maximum torque value. (When the torsional vibratory torque value at this portion can be accurately determined through detailed torsional vibration calculations, the calculated torque may be used as the torsional vibratory torque value.)

(d) From the maximum bending moment and fluctuating bending moment of this portion, and the rigidity of the crankshaft, deflection angles of the crankshaft for respective cases are to be determined.

(e) Bending moments in magnitudes that cause the coupling flange of the crankshaft to assume the respective deflection angles determined in the preceding sub-paragraph **(d)** are to be determined, and the maximum bending stress and fluctuating bending stress of this portion are to be determined by dividing above by the section modulus of the coupling flange.

(f) Respective tangential forces are to be determined by dividing the maximum torque value and fluctuating torque value determined in the preceding sub-paragraph **(c)** by the diameter of the crankshaft at the root of the coupling flange. The maximum torsional stress and fluctuating torsional stress are to be determined by dividing the above tangential forces by the sectional area of the coupling flange (crankshaft diameter $\times \pi \times$ flange thickness) at the root, and by multiplying the stress concentration factor.

2.4 Safety Devices

2.4.3 Protection against Crankcase Explosion

1 The wording "explosion relief valves of approved type" in **2.4.3-1, Part 7 of the Rules** means those valves approved by the Society in accordance with **Chapter 10, Part 6 of the Guidance for the Approval and Type Approval of Materials and Equipment for Marine Use**.

2 The total volume of the stationary parts within the crankcase may be discounted in estimating the crankcase gross volume specified in **2.4.3-1**, **Part 7 of the Rules**. Rotating and reciprocating components are to be included in the gross volume.

3 The installation and maintenance manual specified in **2.4.3-1(5)**, **Part 7 of the Rules** is to contain the following information:

(1) Description of valve with details of function and design limits
(2) Copy of type test certification
(3) Installation instructions
(4) Maintenance in service instructions to include testing and renewal of any sealing arrangements
(5) Actions required after a crankcase explosion

2.4.5 Crankcase Oil Mist Detection Arrangements

1 The wording "devices as deemed appropriate by the Society" specified in **2.4.5-1, Part 7 of the Rules** means to the types of temperature monitoring devices for main bearings, crankpin bearings and crosshead bearings approved by the Society or equivalent devices.

2 The wording "crankcase oil mist detection arrangements required to be fitted to engines are to be approved type" stipulated in **2.4.5-2, Part 7 of the Rules** refers to crankcase oil mist detection arrangement approved in accordance with **Chapter 6, Part 7 of the Guidance for the Approval and Type Approval of Materials and Equipment for Marine Use**.

2.5 Associated Installations

2.5.3 Starting Arrangements

1 For main propulsion machinery starting arrangements operated by compressed air, the following requirements, in addition to those in **2.5.3**, **Part 7 of the Rules**, are to be complied with:

(1) Starting air reservoirs for main propulsion machinery are to be of approximately the same capacity.

(2) For ships designed to use the compressed air stored in starting air reservoirs for main propulsion machinery for purposes other than starting, the capacity of such air reservoirs is to take into account total compressed air consumption.

(3) For main propulsion machinery starting arrangements operated by compressed air, at least one of the starting air compressors is to be driven by a power source other than one used for the main propulsion machinery, and the capacity of this compressor is to be 50% or more of the total capacity specified in **2.5.3-2**, **Part 7 of the Rules**.

(4) It is recommended that starting air compressors for main propulsion machinery are to be of approximately the same capacity.

2 For diesel engine starting arrangements operated by batteries, the following requirements, in addition to **2.5.3-3**, **Part 7 of the Rules**, are to be complied with:

(1) Two sets of batteries provided for starting main propulsion machinery are to be arranged so that no parallel connections can be made, and so that each battery is capable of starting main propulsion machinery in a cold state after all of the starting preparations have been completed.

(2) The starting arrangements for main generator engines are to be such that either they are provided with two sets of separate batteries; or a single battery set in cases where power for starting can also be fed through a separate circuit from those batteries used for the starting of main propulsion machinery. However, a single battery set may only be accepted in cases where only one main generator engine is provided. The capacity of this single battery set is to be such that it is sufficient for starting the engine at least three times.

(3) Batteries for starting are to be used only for starting and for monitoring diesel engines. Arrangements are to be made so that the energy stored in the batteries can be maintained at all times.

2.6 Tests

2.6.1 Shop Tests

1 The programme for the overspeed tests required by **2.6.1-3**, **Part 7 of the Rules** is to be in accordance with the following:

(1) An overspeed test for the duration of 3 *minutes*, at 120% of the maximum speed at room temperature or at 110% of the maximum speed at working temperature, is to be carried out.

(2) For forged impellers and inducers subject to quality control through an approved non-destructive test method, overspeed tests may be dispensed with.

2 The programme for the shop trials required by **2.6.1-4**, **Part 7 of the Rules** is to be in accordance with the following:

(1) For exhaust gas turboblowers with novel design features or for the first unit of those with no service record, a 1-hour mechanical running test at maximum speed and maximum working temperature is to be carried out. exhaust gas turboblowers other than the first unit are to comply with the following requirements from **(2)** to **(4)**.

(2) A 20-minute mechanical running test at maximum speed is to be carried out. However, the Society may reduce the duration of the test after taking test records, etc. into consideration.

(3) In cases where exhaust gas turboblowers are produced under an approved quality system and the type of exhaust gas turboblowers has sufficient test records, the test in **(2)** may be carried out on a sample basis.

(4) For manufacturers who have facilities at their works for testing exhaust gas turboblowers on the engines for which they are intended, the trial run may be replaced by a trial run on said engine for 20 *minutes* at 110% of the maximum continuous output of the engine.

3 The programme for shop trials in **2.6.1-5**, **Part 7 of the Rules** is to be in accordance with the following:

(1) For all stages of testing, the pertaining operation values are to be measured and recorded by the engine manufacturer. All results are to be compiled in an acceptance protocol to be issued by the manufacturer. In addition, crankshaft deflection is to be checked and recorded in the results in cases where such a check is required by the manufacturer during the operating life of the engine.

(2) All measurements conducted at the various load points are to be carried out under steady operating conditions. The readings for 100% power (rated power at rated speed) are to be taken twice at an interval of at least 30 *minutes*.

(3) In cases where a no-load operation is conducted for adjusting engine conditions, the fuel delivery system, manoeuvring system and safety devices are to be properly adjusted by the manufacturer before the operation.

(4) The programme shown in **Table 7.2.6.1-1** is to be used as the standard for the shop trials of diesel engines. In this case, refer to the *JIS* specified below or those considered equivalent thereto for more details on each respective testing procedure:

(a) For the main engines of diesel ships or electrical propulsion ships;
JIS F 4304 “Shipbuilding - Internal combustion engines for propelling use-shop test code”

(b) For diesel engines driving generators or essential auxiliary machinery;
JIS F 4306 “Shipbuilding - Water cooled four-cycle generator diesel engines”

Table 7.2.6.1-1 Programme for Shop Trials of Diesel Engines

<table>
<tr><th rowspan="2">Test items</th><th colspan="3">Use of engines</th></tr>
<tr><th>Main engines of diesel ships(1)</th><th>Main engines of electric propulsion ships(2)</th><th>Diesel engines driving generators or auxiliaries(2) (excluding auxiliary machinery for specific use)</th></tr>
<tr><td>110% power run(3)</td><td>45 minutes at engine speed in accordance with nominal propeller curve</td><td>45 minutes at n_o (n_o is the rated engine speed.)</td><td rowspan="7">same as for diesel ships</td></tr>
<tr><td>100% power run(4)</td><td>2 hours at n_o</td><td>same as for diesel ships</td></tr>
<tr><td>Normal continuous cruise power run(5)</td><td rowspan="4">30 minutes at engine speed in accordance with nominal propeller curve</td><td>—</td></tr>
<tr><td>75% power run(6)</td><td rowspan="2">30 minutes at n_o</td></tr>
<tr><td>50% power run(6)</td></tr>
<tr><td>25% power run(5)</td><td>—</td></tr>
<tr><td>Starting manoeuvres</td><td>○</td><td>○</td><td>○</td></tr>
<tr><td>Reversing manoeuvres (7)</td><td>○</td><td>—</td><td>—</td></tr>
<tr><td>Governing characteristics</td><td>○</td><td>○</td><td>○</td></tr>
<tr><td>Performance of monitoring, alarm and safety devices</td><td>○</td><td>○</td><td>○</td></tr>
<tr><td>Open-up inspection</td><td>○</td><td>○</td><td>○</td></tr>
</table>

Notes :

(1) After testing has been completed, the fuel delivery system is to be blocked so as to limit the engines to run at not more than 100% power.

(2) After testing has been completed, the fuel delivery system is to be adjusted such that overload (110% power) can be given in service after installation on board, so that the governing characteristics including the activation of generator protective devices can be fulfilled at all times.

(3) The testing time may be shorten to 20 *minutes* for engines having cylinder bores of 400 *mm* or less and to 30 *minutes* for engines having cylinder bores exceeding 400 *mm* when deemed appropriate by the Society, in consideration of the conditions of quality assurance, etc. of the manufacturer. However, for the main diesel engines of diesel ships, submission of a test report for the same type engine proving their compatibility for over-loaded operation may be accepted as substitutions for the 110% power run.

(4) The testing time may be shortened to one hour when deemed appropriate by the Society, in consideration of the conditions of quality assurance, etc. of the manufacturer.

(5) The test item may be dispensed when deemed appropriate by the Society.

(6) The testing time may be shortened to 20 *minutes* for engines having cylinder bores of 400 *mm* or less when deemed appropriate by the Society.

(7) The test item applies only to direct reversible engines.

Chapter 3 POWER TRANSMISSION SYSTEMS

3.2 Materials and Construction

3.2.1 Materials

In **3.2.1-1, Part 7 of the Rules**, the requirements specified in **K6.1.15-4, Part K of the Guidance for the Survey and Construction of Steel Ships** need not be complied with.

3.2.4 General Construction of Power Transmission Systems other than Gearings

1 The wording "having sufficient strength against transmitted power" in **3.2.4-1, Part 7 of the Rules** means complying with the following requirements in addition to the requirements in **6.2.4-3, Part 7 of the Rules**:

Flexible couplings used in main propulsion shafting systems are to withstand the torque (T) calculated by the following formula:

$$T = 3.0 \times 10^4 \frac{H}{N_0}$$

Where:

T : Maximum allowable torque of flexible couplings (N-m)

H : Maximum continuous output of main propulsion machinery (kW)

N_0 : Rotational speed (rpm) of flexible couplings at maximum continuous output of main propulsion machinery

2 The wording "heating due to hysteresis" in **3.2.4-1, Part 7 of the Rules** means to give consideration to any heat built-up by power loss of rubber, etc. with respect to the strength of rubber couplings.

3 The wording "deemed appropriate by the Society" in **3.2.4-2, Part 7 of the Rules** means as follows:

(1) Electromagnetic couplings are to be constructed in a manner that permits the periodical inspection of the clearance of the magnetic circuits, and are to be provided with gauges of adequate graduations necessary for inspection.

(2) Electromagnetic couplings are at least to be of drip-proof construction; and, in cases other than the enclosed-type constructions, means are to be provided to prevent operators from coming into contact with any rotating units as well as preventing any foreign matter from entering the inside.

4 Emergency fixing bolts used to hold the clutch in place may be used as the "appropriate unit" referred to in **3.2.4-3(2), Part 7 of the Rules**.

5 The wording "to be constructed so that inspections can be performed as easily as possible" in **3.2.4-4, Part 7 of the Rules** means to be constructed so that an external inspection of rubber elements and a measurement of surface hardness or permanent deformation may be easily made. For this purpose, ships are to be provided with gauges for measuring surface hardness or permanent deformation of rubber elements.

3.3 Strength of Gears

3.3.1 Application

In the case of bevel gear, the wording "deemed appropriate by the Society" in **3.3.1, Part 7 of the Rules** means as follows:

(1) The bending strength at the root sections of gear teeth and limiting tooth surface strength are to be according to AGMA standards or as deemed appropriate by the Society.

(2) Evaluation of the strength of the interior of gear teeth may be required where deemed necessary by the Society. In such cases, the Vickers hardness (HV) of the interior of gear teeth is not to be less than the value obtained from the following formula:

If $\frac{z}{w} < 0.79$ then $\frac{z}{w}$ is to be taken as 0.79.

$$HV = 1.11 S_H\, p \left[\frac{z}{w} - \frac{\left(\frac{z}{w}\right)^2}{\sqrt{1+\left(\frac{z}{w}\right)^2}} \right]$$

HV : Vickers hardness

S_H : Safety factor for contact stress is to comply with the requirements in **Annex D5.3.5 "GUIDANCE FOR CALCULATION OF STRENGTH OF GEARS" 1.6.3-9, Part D of the Guidance for the Survey and Construction of Steel Ships**.

p : Real hertzian stress (*MPa*)

$p = AS_c$

S_c : Contact stress (*MPa*), to be calculated according to *ANSI/AGMA 2003* standards.

A : If S_c is calculated according to *ANSI/AGMA 2003* standards, then the coefficients are to be determined, in consideration of analysis results, by the Society on a case by case basis. In addition, if S_c is calculated according to *ANSI/AGMA 2003-A86* standards, A is to be taken as 1.7

w: Half the hertzian contact width (*mm*), to be calculated by the following formula:

$$w = \frac{p\rho_C}{56300}$$

$$\rho_C = \frac{\rho_1\rho_2}{\rho_1 + \rho_2}$$

$$\rho_1 = 0.5 d_{vn1} \sin\alpha_n$$

$$\rho_2 = 0.5 d_{vn2} \sin\alpha_n$$

$$d_{vn1} = d_{m1} \frac{\sqrt{1+u^2}}{u} \frac{1}{\cos^2\beta_{vb}}$$

d_{m1} :Mean pitch diameter of pinion（*mm*）

u : Gear ratio

$\beta_{vb} = \arcsin(\sin\beta_m \cos\alpha_n)$

β_m : Mean spiral angle

α_n : Normal pressure angle

$d_{vn2} = u^2 d_{vn1}$

z : Depth from teeth surface to evaluation point (*mm*)

3.3.3 Allowable Tangential Loads for Bending Strength

Tangential loads for the bending strength of internal cylindrical gears with involute teeth are to comply with the following conditions:

$$P_{MCR} \le 47.6(K_1 S_b - K_2) K_3 m_n$$

Symbols in the formula are the same as in **3.3.3, Part 7 of the Rules**.

3.3.4 Tangential Loads for Surface Strength

Tangential loads for the surface strength of internal cylindrical gears with involute teeth, except for any reversing gears for astern operation, are to comply with the following conditions:

$$P_{MCR} \le 9.81(K_1 S_s - K_2) K_3 K_4 \frac{i}{i-1} D_1$$

Symbols in the formula are the same as in **3.3.4, Part 7 of the Rules**.

3.3.5 Detailed Evaluation for Strength

It is acceptable that the bending and surface strength of gears are calculated based on **Annex D5.3.5** "**GUIDANCE FOR CALCULATION OF STRENGTH OF GEARS**", **Part D of the Guidance for the Survey and Construction of Steel Ships**.

Chapter 4 SHAFTINGS

4.2 Materials, Construction and Strength

4.2.2 Intermediate Shafts

For ships of less than 30 *m* in length, the diameters of intermediate shafts may be calculated with the value for F_1 in **4.2.2** and **4.2.3-1, Part 7 of the Rules** equal to 95. In such cases, the allowable limit of torsional vibration stress is to be in accordance with the requirements specified in **6.2.2-3, Part 7 of the Guidance**.

4.2.3 Thrust Shafts

For ships of less than 30 *m* in length, the diameters of thrust shafts may be calculated with the value for F_1 in **4.2.2** and **4.2.3-1, Part 7 of the Rules** equal to 95. In such cases, the allowable limit of torsional vibration stress is to be in accordance with the requirements specified in **6.2.2-4, Part 7 of the Guidance**.

4.2.4 Propeller Shafts and Stern Tube Shafts

1 As for the diameter of propeller shaft Kind 2 or stern tube shafts Kind 2 made of carbon steel or low alloy steel, the wording "to be deemed appropriate by the Society" specified in **4.2.4-1, Part 7 of the Rules** means to calculate the required diameter by the following formula:

$$d_s = 100 k_3 \sqrt[3]{\frac{H}{N_0}}$$

d_s : Required diameter of propeller shaft (*mm*)

H : Maximum continuous output of main propulsion machinery (*kW*)

N_0 : Number of revolutions of shaft at maximum continuous output (*rpm*)

k_3 : Factor concerning shaft design, given in **Table 7.4.2.4-1**

2 The value of k_3 for propeller shafts and stern tube shafts made of stainless steel forgings, etc. other than those indicated in the **Table 7.4.4** which is for k_3 specified in **4.2.4-2, Part 7 of the Rules**, is to be in accordance with **Table 7.4.2.4-2**. Furthermore, this requirement may be applied to propeller shafts Kind 2 and stern tube shafts Kind 2.

Table 7.4.2.4-1 Values of k_3

	Application	k_3
1	The portion from the big end of the tapered part of a propeller shaft (in the case of a flange connected propeller, the forward end of the of the flange) to the forward end of the after most stern tube bearing or to 2.5 d_s , whichever is larger	1.33
2	Excluding any portion specified in 1 above, the portion in the direction toward the bow side up to the forward end of the forward stern tube sealing assembly	1.21(1)
3	The portion between the forward end of the forward stern tube sealing assembly and the intermediate shaft coupling	1.21(2)

Notes :

(1) The diameter of the boundary portion should be reduced with either a smooth taper or a blending radius nearly equal to the change in diameter.

(2) The diameter may be reduced, by either a smooth taper or a blending radius nearly equal to the change in diameter, up to the diameter calculated by the formula given in **4.2.2-1, Part 7 of the Rules** where it is assumed that T_s = 400 N/mm^2.

Table 7.4.2.4-2 Values of k_3

	Application	Shaft material	
		Austenitic stainless steel with 0.2% proof stress not less than 205 N/mm^2	Precipitation hardened martensite stainless steel with 0.2% proof stress not less than 400 N/mm^2
1	The portion from the big end of the tapered part of a propeller shaft (in the case of a flange connected propeller, the forward end of the flange) to the forward end of the after most stern tube bearing or to 2.5 d_s , whichever is larger	1.28	1.05
2	Excluding the portion shown in 1 above, the portion in the direction toward the bow side up to the forward end of the forward stern tube sealing assembly	1.16(1)	0.94(1)
3	The portion between the forward end of the forward stern tube sealing assembly and the intermediate shaft coupling	1.16(2)	0.94(2)

Notes :

(1) The diameter of the boundary portion should be reduced with either a smooth taper or a blending radius nearly equal to the change in diameter.

(2) The diameter may be reduced, by either a smooth taper or a blending radius nearly equal to the change in diameter, up to the diameter calculated by the formula given in **4.2.2-1, Part 7 of the Rules** where it is assumed that T_s = 400 N/mm^2.

3 For ships of less than 30 m in length, the diameters of propeller shafts and stern tube shafts may be calculated using values given for k_2 in **Table 7.4.3**, k_3 in **Table 7.4.4**, k_3 in **Table 7.4.2.4-1** or k_3 in **Table 7.4.2.4-2, Chapter 4, Part 7 of the Rules** multiplied by 0.92. The allowable limit of the torsional vibration stress, however, is to comply with the following:

(1) For propeller shafts and stern tube shafts made of carbon steels or low alloy steels which are effective at preventing corrosion by water, the allowable limit of the torsional vibration stress is to be calculated with the value for C_k given in **Table 7.6.1, Chapter 6, Part 7 of the Rules** equal to 0.45.

(2) For propeller shafts made of carbon steels or low alloy steels which are not effective at preventing corrosion by water as well as propeller shafts made of stainless steels, the allowable limit of the torsional vibration stress is to be calculated using the values for A, B and C given in **Table 7.6.2.2-1** multiplied by 0.8.

4 The diameters of propeller shafts of vessels whose main propulsion machinery falls under one of the classes of high speed diesel engines may be in accordance with **(1)** to **(3)** below. However, the requirements in **-3** are not to be applied in such cases.

(1) The definition of "high speed diesel engine"

The term "high speed diesel engine" in this sub-paragraph is defined as those engines simultaneously complying with the following conditions:

$$\frac{Sn^2}{1.8\times10^6}\geq 90$$

$$\frac{\pi d_j n}{6.0\times10^4}\geq 6$$

S : Length of stroke (mm)

n : Number of revolutions at maximum continuous output of engine (rpm)

d_j : Diameter of crank journal (mm)

(2) Required diameter of propeller shafts

The diameter of propeller shafts is to be not less than the value determined by the following formula:

$$d_s = 100k_3\sqrt[3]{\frac{H}{N_0}}$$

d_s : Required diameter of propeller shaft (mm)

H : Maximum continuous output of main propulsion machinery (kW)

N_0 : Number of revolutions of shaft at maximum continuous output (*rpm*)

k : Factor given in **Table 7.4.2.6-1**. For those propeller shafts Kind 1 or stern tube shafts kind 1 which are made of carbon steel or low alloy steel with tensile strength exceeding 400 *N/mm*^{2}, the factor k may be multiplied by the following factor K_{m1}.

$$K_{m1} = \sqrt[3]{\frac{560}{T_s + 160}}$$

T_s : Specified tensile strength (*N/mm*^{2})

(3) Torsional vibration

The torsional vibration for those shafting systems, to which these requirements applied, is to comply with the requirement **6.2.6-2, Part 7 of the Guidance**.

Table 7.4.2.6-1 Values of *k*

Carbon steel or low alloy steel		*KSUSF*316 *KSUS*316-*SU*	*KSUSF*316*L* *KSUS*316*L*-*SU*	Precipitation hardened martensite stainless steel
Kind 1	Kind 2			
1.00	1.05	1.03	1.08	0.85

4.2.6 Detailed Evaluation for Strength

1 In cases where stresses acting on the shaft simultaneously satisfy the conditions below, the shaft diameter may be accepted as being equivalent to those required by the formulae specified in **Chapter 4, Part 7 of the Rules**.

$$\beta_m \tau_m + \beta_t \tau_D \leq \frac{\tau_y}{S_y}$$

$$\beta_t \tau_D \leq \frac{\tau'_f}{S_f}$$

τ_m : Mean torsional stress acting on the shaft. In cases where mean bending stress acts simultaneously, τ_{me} given by the following formula is to be used: (*N/mm*^{2})

$$\tau_{me} = \sqrt{\tau_m^2 + \frac{1}{3}\sigma_m^2}$$

τ_{me} : Equivalent mean torsional stress (*N/mm*^{2})

σ_m : Mean bending stress (*N/mm*^{2})

β_m : Notch factor against static stress

τ_D : Alternating torsional stress acting on the shaft. In cases where alternating bending stress acts on the shaft simultaneously, τ_{De} given by the following formula is to be used: (*N/mm*^{2})

$$\tau_{De} = \sqrt{\tau_D^2 + \frac{1}{3}\left(\frac{\beta_b}{\beta_t}\sigma_D\right)^2}$$

τ_{De} : Equivalent alternating torsional stress (*N/mm*^{2})

σ_D : Alternating bending stress (*N/mm*^{2})

β_b : Notch factor for bending stress

β_t : Notch factor for torsional stress

τ_y : Torsional yielding stress of shaft material (*N/mm*^{2})

S_y : Safety factor for yielding

τ'_f : Torsional fatigue strength of the shaft material acting under the mean stress τ_m (or τ_{me}) (*N/mm*^{2})

S_f : Safety factor for fatigue

2 Fatigue strength and yielding stress of the shaft material in **-1** above is to be determined on a case by case basis by the Society, with consideration being given to materials, heat treatments, surface treatments, etc. on the basis of information and data submitted by the applicant. In addition, safety factors for fatigue and yielding are to be determined on a case by case basis by the Society with consideration being given to the purpose of the shaft, working conditions, etc.

4.2.7 Corrosion Protection of Propeller Shafts and Stern Tube Shafts

1 Shafts effectively protected against corrosion caused by water using a means approved by the Society in **4.2.7-1(1), Part 7 of the Rules** are to be either of the following **(1)** to **(4)**:

(1) Shafts effectively protected from any contact with water in ships having oil lubricated stern tube bearings (including shaft bracket bearings when used) equipped with approved sealing devices.

(2) Shafts effectively protected from any contact with water by continuous copper alloy sleeves fitted onto the shafts by shrinkage fit in ships having water lubricated stern tube bearings (including shaft bracket bearings when used).

(3) Shafts fitted with shrunk-on copper alloy sleeves in cases where they are supported by stern tube bearings (including shaft bracket bearings when used) and covered with rubber or other synthetic resin materials so that they may be effectively protected from any contact with water in ships having water lubricated stern tube bearings.

(4) Shafts of other designs specially approved by the Society.

2 The wording "corrosion resistant materials approved by the Society" in **4.2.7-1(3)** means those materials which have been subjected to approval tests specified in **2.4.2-5, Chapter 2, Part 6** of the "**Guidance for the Approval and Type Approval of Materials and Equipment for Marine Use**" and then which obtain type approval of use of machinery and equipment as a corrosion resistant material for propeller shafts or stern tube shafts.

4.2.10 Stern Tube Bearings and Shaft Bracket Bearings

1 The wording "provisions specified elsewhere and specially approved by the Society" in **4.2.10-1(2)(a)**, **Part 7 of the Rules** means the following:

The length of a bearing may be less than that required by **4.2.10-1(2)(a)**, **Part 7 of the Rules**; however, the minimum length of the bearing is not to be less than 1.5 *times* the actual diameter of the propeller shaft.

(1) Shaft alignment calculations are to be carried out in accordance with the requirements in **Annex D6.2.13** "**GUIDANCE FOR CALCULATION OF SHAFT ALIGNMENT**", **Part D of the Guidance for the Survey and Construction of Steel Ships**.

(2) For improving the lubricating condition of the bearing, the following measures are to be taken:

  (a) A lubricating oil inlet is to be provided at the aft end of the bearing to ensure the forced circulation of the lubricating oil.

  (b) Either of the following devices to measure stern tube bearing metal temperature at the aft end bottom along with high temperature alarms (with a preset value of 60°*C* or below) is to be provided:

    i) Two or more temperature sensors embedded in the metal; or

    ii) An embedded temperature sensor, replaceable from inboard the ship, and a spare temperature sensor. In this case, the replacement of such sensors according to procedures submitted beforehand is to be demonstrated.

  (c) Low level alarms are to be provided for lubricating oil sump tanks.

2 The wording "construction and arrangement specially approved by the Society" in **4.2.10-1(3)(a)**, **Part 7 of the Rules** means the following:

The length of a bearing may be less than that required by **4.2.10-1(3)(a)**, **Part 7 of the Rules**; however, the minimum length of a bearing is not to be less than 1.5 *times* the actual diameter of the propeller shaft.

(1) Nominal bearing pressure (determined by the static bearing reaction divided by the projected area of the shaft in way of the bearing, hereinafter defined the same way in this Chapter), etc. calculated in accordance with **Annex D6.2.13** "**GUIDANCE FOR CALCULATION OF SHAFT ALIGNMENT**", **Part D of the Guidance for the Survey and Construction of Steel Ships** are to be within the allowable limits specified in the Type Approval Certificate.

(2) The measures for lubricating condition specified in **-1(2)** are to be taken.

3 The wording "construction and arrangement specially approved by the Society" in **4.2.10-1(3)(b)**, **Part 7 of the Rules** means the following:

The length of a bearing may be less than that required by **4.2.10-1(3)(b)**, **Part 7 of the Rules**; however, the minimum length of a bearing is not to be less than 2 *times* the required diameter of the propeller shaft given by the formula in **4.2.4-1**, **Part 7 of the Rules** or 1.5 *times* the actual diameter, whichever is greater.

(1) Nominal bearing pressure, under the assumption that the weight of shaft and propeller are loaded solely on the

aftermost bearing, is to be within the allowable limit specified in the Type Approval Certificate.

(2) Forced lubrication using water pumps is to be adopted and a non-flow alarm is to be provided at the lubricating water inlet.

4.2.12 Shaft Alignment

For the approval of the shaft alignment calculation required in **4.2.12**, **Part 7 of the Rules**, a calculation sheet in accordance with **Annex D6.2.13** "**GUIDANCE FOR CALCULATION OF SHAFT ALIGNMENT**", **Part D of the Guidance for the Survey and Construction of Steel Ships** is to be submitted.

4.3 Tests

4.3.2 Tests after Installation on Board

The "confirmation tests relating to shaft alignment" referred to in **4.3.2-2, Part 7 of the Rules** are to include the confirmation of any optical or laser sighting of shaft centers and the confirmation of crankshaft deflection values to ensure they are within engine manufacturer recommended ranges.

Chapter 5 PROPELLERS

5.2 Construction and Strength

5.2.1 Thickness of Blade

1 In cases where the materials used for propellers are either grey cast iron or steel castings, the values specified in **Table 7.5.2.1-1** are to be used for *K* in the formulae given in **5.2.1-1, Part 7 of the Rules**.

Table7.5.2.1-1 Values of *K*

Material		*K*
Steel castings	*KSC*, Tensile strength is greater than or equal to 480 N/mm^2	1.0
	KSC, Tensile strength is less than 480 N/mm^2	0.9
Grey cast iron		0.6

2 The thickness of highly skewed propeller blades, depending on the skew angle (the angle, on the expanded blade drawing, between the line connecting the centre of the propeller shaft with the point at the blade tip on the centre line of blade width and the tangential line drawn from the centre of the propeller shaft to the centre line of blade width (*See* **Fig. 7.5.2.1-1**.)) is to comply with the following requirements:

(1) In cases where the skew angle exceeds 25° but is 60° or less

(a) The blade thicknesses at radii 0.25*R* (0.35*R* for controllable pitch propellers) and 0.6*R* are not to be less than the values obtained from multiplying those values calculated by the formula in **5.2.1-1, Part 7 of the Rules**, by the coefficient *A* given in the formula below;

$$A = 1 + B\frac{\theta - 25^\circ}{60^\circ}$$

Where:

θ : skew angle (*degree*)

B : 0.2 at radii 0.25*R* (or 0.35*R* for controllable pitch propeller)
0.6 at radii 0.6*R*

(b) Blade thickness t_x at any radius between 0.6*R* and 0.9*R* is not to be less than the value determined by the following formula. Moreover, this thickness is provide sufficient strength against loads imparted during reversing manoeuvres, etc.

$$t_x = 0.003D + \frac{(1-x)(t_{0.6} - 0.003D)}{0.4} \quad (mm)$$

Where:

D : diameter of propeller (*mm*)

x : ratio of the radius (= 2*r/D*, *r* is the radius (*mm*))

$t_{0.6}$: blade thickness at 0.6*R* as required in **(a)** above (*mm*)

(2) In cases where the skew angle exceeds 60°
Based on the precise calculation sheet of propeller strength submitted by the manufacturer or designer, blade thickness is to be determined by the Society on a case by case basis.

3 In accordance of **5.2.1-1, Part 7 of the Rules**, the following **(1)** to **(3)** are to be applied to Δw and w when using experimental data taken from model ships which are 6*m* or more in length.

(1) Δw and w are to be calculated using a wake distribution for those model ship or be calculated using a method deemed equivalent thereto.

(2) The wake distribution is to be converted into the full scale value, using a suitable method.

(3) w is to be calculated by averaging the square measure of the wake distribution inside the propeller's circumference.

4 The standard method of detailed calculation of a propeller blade thickness is shown as follows:

(1) The hydraulic forces on a propeller blade during a propeller rotation are calculated by the lifting-surface theory, and the stresses on the propeller blade are calculated by structural analysis using the hydraulic forces. The wake distribution used for the calculation of the hydraulic forces is to be experimental data taken from a sister vessel or a model ship (data is to be corrected appropriately to the actual ship's scale). In cases where such data is not known, the data shown in **Fig.7.5.2.1-2** or **Table 7.5.2.1-3** may be used for high speed craft ($C_b \le 0.6$), excluding those with unconventional stern constructions (such as multi-shafting arrangements), instead.

(2) The stress ratio σ_a / σ_m is calculated using the maximum value of stress amplitude σ_a and mean stress σ_m (both of which are calculated by the method given in **(1)**) on each radius location of the propeller blade during propeller rotation.

(3) Mean stress at maximum continuous revolutions $(\sigma_m)_{MCR}$ is calculated by the method given in **(1)**. Absorbed output of propellers, or the torque factor K_Q (calculated from the hydraulic force calculation), is to be equal to the output of main propulsion machinery at the maximum continuous revolutions, or the torque factor K_Q (= H/30 $N_0^3 D^5$) at maximum continuous revolutions.

In place of that calculation, $(\sigma_m)_{MCR}$ may also be calculated by the following formula:

$$(\sigma_m)_{MCR} = 100 \frac{K_1 H K}{Z N_0 l t_a^2 K_2}$$

t_a : Actual thickness of propeller blade (*cm*)

Other parameters: As specified in **5.2.1, Part 7 of the Rules**.

(4) $(\sigma_m)_{MCR}$ is calculated by following formula using the value of σ_a / σ_m determined by **(2)**.

$$(\sigma_a)_{MCR} = (\sigma_m)_{MCR} \times (\sigma_a / \sigma_m)$$

(5) In consideration of the effects of heavy weather, the stresses on the propeller blade are calculated by the following formulae:

$$\sigma_m = (\sigma_m)_{MCR} \times S$$

$$\sigma_a = (\sigma_a)_{MCR} \times S$$

S : As specified in **5.2.1, Part 7 of the Rules**.

(6) In cases where the stress amplitude σ_a and the mean stress σ_m calculated in **(5)** satisfy the following allowable stresses of propeller materials, these stresses are to be considered compliant with **5.2.1, Part 7 of the Rules**:

$\sigma_a \le k_1 - k_2 \sigma_m$ (N/mm^2)

$\sigma_m \le k_3$ (N/mm^2)

k_1, k_2 and k_3 : As specified in **Table 7.5.2.1-2**.

Fig. 7.5.2.1-1 Definition of Skew Angle

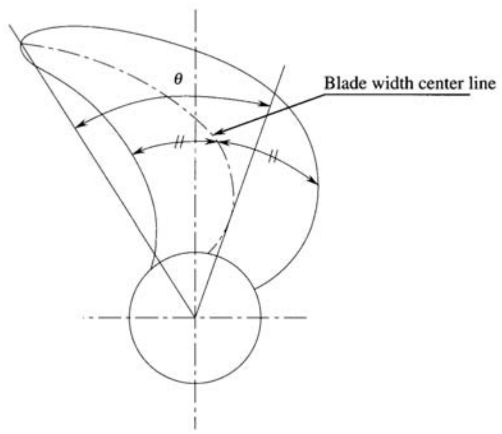


Fig. 7.5.2.1-2 Standard wake distribution for high speed craft

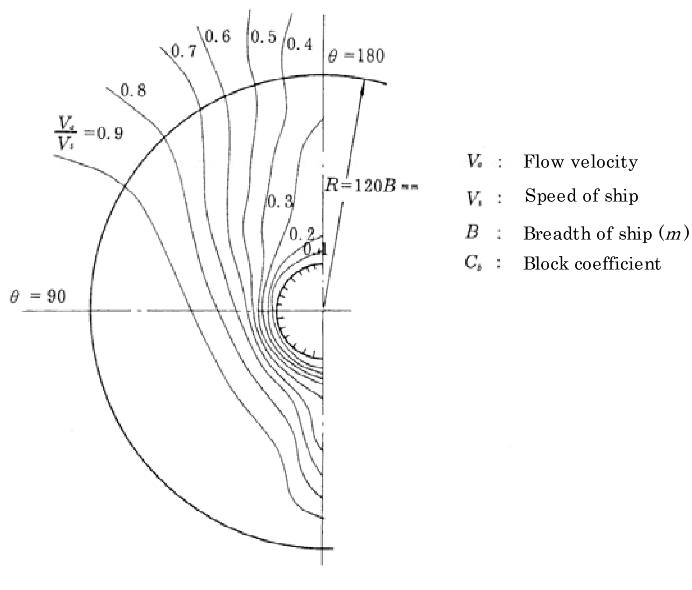


Table 7.5.2.1-2 Values of k_1,k_2 and k_3

Materials	k_1	k_2	k_3
*KHBsC*1	32.4	0.22	61.6
*KHBsC*2			
*KAlBC*3	37.3	0.22	70.8
*KAlBC*4	32.4	0.22	61.6

Table 7.5.2.1-3 Standard wake distribution for high speed craft (V_a/V_s)

Rotation angle of propeller (θ)	Radius of propeller (*mm*)					
	36*B*	48*B*	60*B*	78*B*	96*B*	114*B*
0	0.390	0.520	0.560	0.660	0.820	0.930
10	0.406	0.610	0.706	0.841	0.924	0.984
20	0.444	0.688	0.799	0.929	0.981	1.000
30	0.490	0.750	0.850	0.950	1.000	1.000
40	0.509	0.788	0.874	0.959	1.000	1.000
50	0.520	0.807	0.889	0.964	1.000	1.000
60	0.526	0.810	0.900	0.970	1.000	1.000
70	0.521	0.807	0.889	0.966	1.000	1.000
80	0.505	0.784	0.873	0.952	0.996	1.000
90	0.490	0.740	0.850	0.930	0.980	1.000
100	0.439	0.682	0.808	0.907	0.949	0.976
110	0.389	0.618	0.748	0.866	0.914	0.947
120	0.350	0.550	0.670	0.800	0.870	0.910
130	0.303	0.469	0.571	0.703	0.796	0.849
140	0.262	0.398	0.473	0.599	0.696	0.765
150	0.230	0.340	0.390	0.500	0.580	0.660
160	0.201	0.284	0.333	0.403	0.417	0.533
170	0.184	0.240	0.278	0.317	0.361	0.401
180	0.180	0.220	0.240	0.270	0.290	0.320

Note:

B : Breadth of ship (*m*)

5.2.2 Controllable Pitch Propellers

1 Blades are to be fitted securely to pitch control gears by giving all of the fixing bolts an adequate initial fitting force. It is to be regarded as standard practice that the initial fitting force complies with the following condition;

$$\frac{1.3}{n}\left(\frac{AK_3}{L}+F_c\right)< T_0 < 0.55\sigma_0 d^2$$

Where:

T_0 : Initial fitting force (*N*)

σ_0 : Yield strength or 0.2*%* proof strength of bolt material (*N/mm*^{2})

Other symbols are the same as in the formula shown in **5.2.2-2, Part 7 of the Rules**.

2 The Society may specially approve fixing bolts that satisfy the strength requirements specified in the Rules upon consideration of the following documents (**(a)** to **(e)**).

(a) Calculation sheet for the load sharing factor k of the bolt

Where:

$$k=\frac{k_b}{k_b+k_f}$$

k_b : Rigidity of bolt tension

k_f : Rigidity of flange compression

(b) Static stress and dynamic stress acting on the bolt

(c) Specifications of bolt material (including the manufacturing process)
(d) Endurance limit curve of the bolt (both in air and in water)
(e) Securing method of the bolt

3 Pitch fixing devices may be used as the "appropriate unit" referred to in **5.2.2-8(2), Part 7 of the Rules**.

5.3 Force Fitting of Propellers

5.3.1 Pull-up Length

1 Special consideration is required in cases where propellers are force fitted onto propeller shafts through sleeves, because the formulae of pull-up length in **5.3.1-1, Part 7 of the Rules** are not able to be applied.

2 In cases where the material of a propeller shaft is something other than forged steel or the material of a propeller boss is something other than that specified in **5.3.1-1, Part 7 of the Rules**, the values of K_E, K_C and K_W are to be determined by following formula:

$$K_E = \frac{R_0}{tan\alpha}\left\{\left(\frac{K_{R1}^2+1}{K_{R1}^2-1}+\frac{1}{m_b}\right)\frac{1}{E_b}+\left(\frac{1+K_{R2}^2}{1-K_{R2}^2}-\frac{1}{m_s}\right)\frac{1}{E_S}\right\}$$

$$K_C = \left\{(\lambda_b-\lambda_s)+\frac{(C_b-C_s)}{(C_b-C_0)}\lambda_s\right\}\left(l_0-\frac{R_0}{\tan\alpha}\right)$$

$$K_W = 0.7\sigma_{0.2}$$

m_b : Poisson's number of the propeller boss material
m_s : Poisson's number of the propeller shaft material
E_b : Modulus of elasticity of the propeller boss material (*N/mm*^{2})
E_s : Modulus of elasticity of the propeller shaft material (*N/mm*^{2})
λ_b : Coefficient of linear thermal expansion of the propeller boss material (*mm/mm °C*)
λ_s : Coefficient of linear thermal expansion of the propeller shaft material (*mm/mm °C*)
$\sigma_{0.2}$:0.2% proof stress of the propeller boss material (*N/mm*^{2})

Other symbols are to be in accordance with those shown in **5.3.1, Part 7 of the Rules**.

3 In the provision of coefficient "*c*" used in the calculation of tangential force F_v, specified in **5.3.1-1, Part 7 of the Rules**, the wording "the satisfaction of the Society", means determining "*c*" in accordance with **(2)** below using maximum torque Q_{max} as derived from **(1)** below:

(1) Q_{max}, which is the value of the maximum torque acting on the propeller's fitted portion, is to be determined by measurements or precise estimation complying with the following **(a)** or **(b)**, and approved by the Society:
(a) In cases where Q_{max} is determined by measuring, the measurements are to be carried out on a sister ship (complete same design including the main engine, shafting system and so on) under a fully loaded condition at the time of the astern tests required under the provision of **2.3.1-1 (1), Part 2 of the Rules**.
(b) In cases where Q_{max} is determined by estimation, the estimation method is to be verified with an estimation error not exceeding 10% when compared with the results of actual measurements taken at the time of the astern tests.

(2) When using a value for Q_{max} determined above, the coefficient "*c*" in **5.3.1-1, Part 7 of the Rules** is to be 1.2 or the value given by following formula, whichever is greater:

$$c = 5.08\times\frac{N_0 Q_{max}}{H}\times 10^{-3}$$

N_0, H : Same as those specified in **5.2.1-1, Part 7 of the Rules**
Q_{max} : Maximum torque acting on the propeller's fitted portion under every operation conditions including transient conditions, such as crash astern, derived from **(1)** above (*N-m*)

5.3.2 Propeller Boss

Heating temperature is not to exceed 100°*C* in cases where the propeller boss is drawn out of the propeller shaft.

5.4 Tests

5.4.1 Shop Tests

For built-up and controllable pitch propellers, the required static balancing test of the complete propeller may be replaced by an individual check of blade weight and gravity center position.

5.4.2 Tests after Installation On Board

1 In cases where propellers are force fitted onto propeller shafts by hydraulic force, the confirmation of the pull-up length specified in **5.4.2, Part 7 of the Rules** is to be made assuming that the true relative starting point is the point where the pull-up load equals zero on an approximate line drawn through the measured points plotted on a chart of the relationship between pull-up length and load.

2 In the force fitting test for keyless propellers, it is to be confirmed that the pull-up length measured according to **-1**. above is between the upper and lower limits specified in **5.3.1-1, Part 7 of the Rules**, and that the apparent coefficient of friction derived from following formula is not less than 0.1 and below 0.2.

$$\mu_r = \frac{K\dfrac{K_E}{S} - tan\alpha}{1 + K\dfrac{K_E}{S}tan\alpha}$$

μ_r : Apparent coefficient of friction derived from the results of force fitting tests

K : Rate of fitting force to pull-up length derived from the results of force fitting tests used for dry-fitting methods (*N/mm*)

K_E , S , α :Same as those specified in **5.3.1-1, Part 7 of the Rules**

3 In cases where propellers are force fitted onto propeller shafts with the use of key, the standard pull-up length is generally as follows;

$$L_4 = \frac{2d_p}{tan\alpha} \times 10^{-4}$$

L_4 : Standard pull-up length (*mm*)

d_p : Diameter of propeller shaft (cone part large end) (*mm*)

α : Half-angle of the taper at the propeller shaft cone part (*deg*)

Chapter 6 TORSIONAL VIBRATION OF SHAFTINGS

6.2 Allowable Limit

6.2.2 Intermediate Shafts, Thrust Shafts, Propeller Shafts and Stern Tube Shafts

1 The allowable limit of the torsional vibration stress for propeller shafts Kind 1 made of approved corrosion-resistant materials or propeller shafts Kind 2 is to be calculated by the following formulae in place of the formulae for τ_1 shown in **6.2.2-1(1), Part 7 of the Rules**.

$$\tau_1 = A - B\lambda^2 \left(\lambda \leq 0.9\right)$$
$$\tau_1 = C\left(0.9 < \lambda\right)$$

Where:

λ : ratio of the number of revolutions to the number of maximum continuous revolution

A , B , C : constants dependent on shaft materials, given in **Table 7.6.2.2-1**.

2 For ships powered by steam turbines, or gas turbines; diesel engines having slip couplings such as electro-magnetic couplings or fluid couplings between engine and propulsion shafting; and, ships with electric propulsion systems, the allowable limits of torsional vibration stress on the intermediate shafts, thrust shafts, propeller shafts and stern tube shafts are to be calculated by applying the values of C_K given in the following **Table 7.6.2.2-2** to the formula specified in **6.2.2-1(1), Part 7 of the Rules**.

3 For ships applying the requirements specified in **4.2.2**, the value for C_K specified in **Table7.6.1** is to be replaced by the value for C_K specified in **Table7.6.2.2-2** when calculating the allowable limit of torsional vibration stress**.**

4 For ships applying the requirements specified in **4.2.3**, the value for C_K specified in **Table7.6.1** is to be replaced by the value for C_K specified in **Table7.6.2.2-2** when calculating the allowable limit of torsional vibration stress**.**

Table 7.6.2.2-1 Values of *A*, *B* and *C*

	Carbon steel or low alloy steel without effective protection against water corrosion	Austenitic stainless steel with 0.2% proof stress not less than 205 N/mm^2	Precipitation hardened martensite stainless steel with 0.2% proof stress not less than 400 N/mm^2
A	32.4	40.7	61.1
B	24.6	30.5	47.3
C	12.5	16.0	22.8

Note:
Values for materials other than those given above are to be determined by the Society on a case by case basis.

Table 7.6.2.2-2 Values of C_K

Intermediate shafts			Thrust shafts		Propeller shafts and stern tube shafts
Integral flange couplings	Shrinkfit couplings	Keyways	On both sides of the thrust collar	In way of axial bearings where a roller bearings is used as a thrust bearing	—
0.75	0.75	0.45	0.65	0.65	0.35

Note:
Values of C_K other than those given above are to be determined by the Society on a case by case basis.

6.2.4 Power Transmission Systems

The wording "the provisions specified elsewhere" in **6.2.4-3, Part 7 of the Rules** means the following with respect to rubber couplings.

(1) When the number of revolutions is within the range of 80% to 105% of the number of maximum continuous revolutions, the torsional vibration torque amplitude is not to exceed the T_1 value shown below:

$$T_1 = 2.5 \times 10^3 \times \frac{H}{N_0}$$

Where:

T_1: Allowable limit of torsional vibration torque amplitude within the speed range of 80% to 105% of the number of maximum continuous revolutions (*N-m*)

H: Maximum continuous output of engine (*kW*)

N_0: Number of revolutions of rubber couplings at the maximum continuous output of engine (*rpm*)

However, in cases where some margin exists between the allowable mean torque for a rubber coupling and its actual mean torque, T_1 may be multiplied by the coefficient F calculated from the following formula:

$$F = T_n / T_m$$

Where:

T_n: Allowable mean torque approved for the rubber coupling concerned (*N-m*)

T_m: Mean torque obtained by the maximum continuous output of an engine and rotational speed of the coupling corresponding to the number of maximum continuous revolutions of an engine (*N-m*)

(2) When the number of revolutions is within the range of 80% and below the number of maximum continuous revolutions, the torsional vibration torque amplitude is not to exceed the value for T_2 shown below. In cases where the torsional vibration torque amplitude exceeds the value of T_1 specified in **(1)** above, a barred speed range for avoiding continuous operation as specified in **6.3.1** is to be provided.

$$T_2 = 8 \times T_1$$

Where:

T_2: Allowable limit of torsional vibration torque amplitude at an engine speed within the range of 80% and below the number of maximum continuous revolutions (*N-m*)

(3) In cases where rubber couplings, whose torque is transmitted in the direction of shearing rubber elements, are used in main propulsion shafting powered by diesel engines having outputs of 3,500 *kW* or more, the main propulsion shafting is to comply with the following **(a)** and **(b)**:

(a) Audible and visual alarms, which come into action when the vibratory torque exceeds the allowable limit T_1 of torsional vibration torque specified in **(1)** above, are to be provided at main control stations. However, in cases where no vibratory torque is likely to exceed the allowable limit T_1, within the operational speed range, as the result of the torsional vibration calculation specified in **(b)**, the requirements may be dispensed with.

(b) Means are to be provided to show the safe operation range by torsional vibration calculations under a one cylinder cut condition.

6.2.6 Detailed Evaluation for Strength

1 In cases where the torsional stresses acting on the shafts satisfy the conditions specified in **4.2.6-1** and **-2**, alternating torsional stress τ_D in the said conditions may be used for determining the allowable limit of torsional vibration stress in lieu of τ_1 specified in **Chapter 6, Part 7 of the Rules**.

2 In cases where the diameter of shafts are determined in accordance with **4.2.6-3**, allowable limit of torsional vibration stress τ_1 and τ_2 are to be calculated in accordance with the following:

(1) When the number of revolutions is within the range of 80% to 105% of the number of maximum continuous revolutions, the torsional vibration allowable limit τ_1 is to be calculated by the following formulae:

$$\tau_1 = A - B\lambda^2 (\lambda \le 0.9)$$

$$\tau_1 = C(0.9 < \lambda)$$

τ_1: Allowable limit of torsional vibration stresses for the range of $0.8 < \lambda \le 1.05$ of the number of maximum continuous revolutions (*N/mm*^{2})

λ: Ratio of the number of revolutions to the number of maximum continuous revolutions

A , B , C : Constants dependent on shaft materials, given in **Table 7.6.2.6-1.**

(2) When the number of revolutions is within the range of 80% and below, the allowable limit of torsional vibration stresses τ_2 is to be calculated by the following formula. In cases where torsional vibration stress exceeds τ_1, the barred speed range specified in **6.3, Part 7 of the Rules** is to be imposed.

$\tau_2 = 2.3\tau_1$

τ_2 : Allowable limit of torsional vibration stresses for the range of $\lambda \le 0.8$ of the number of maximum continuous revolutions (*N/mm*^{2})

τ_1 : Value calculated by the formula for $\lambda \le 0.9$ in **(1)** above (*N/mm*^{2})

λ : Ratio of the number of revolutions to the number of maximum continuous revolutions

3 In cases where intermediate shafts with longitudinal slots given in **Table 7.6.1, Chapter 6, Part 7 of the Rules** are equipped, the value of C_K may be determined by using the following formulae:

$$C_K = 1.45/scf$$

$$scf = \alpha_{t(hole)} + 0.80\frac{(l-e)/d_a}{\sqrt{\left(1-\dfrac{d_i}{d_a}\right)\dfrac{e}{d_a}}}$$

Where:

scf :Stress concentration factor at the end of slots defined as the ratio between the maximum local principal stress and $\sqrt{3}$ *times* the nominal torsional stress determined for the hollow shafts without slots

l : Slot length

e : Slot width

d_i : Inside diameter of the hollow shaft at the slot

d_a : Outside diameter of the hollow shaft

$\alpha_{t(hole)}$: Stress concentration factor of radial holes (in this context, e = hole diameter) determined by the following formula (an approximate value of 2.3 may be used as well)

$$\alpha_{t(hole)} = 2.3 - 3\frac{e}{d_a} + 15\left(\frac{e}{d_a}\right)^2 + 10\left(\frac{e}{d_a}\right)^2\left(\frac{d_i}{d_a}\right)^2$$

Table 7.6.2.6-1 Values of *A*, *B* and *C*

	Carbon steel or low alloy steel		Austenitic stainless steel		Precipitation hardened martensite stainless steel
	Shaft Kind 1	Shaft Kind 2	*KSUSF*316 *KSUSF*316-*SU*	*KSUSF*316*L* *KSUSF*316*L*-*SU*	
A	24.5	21.0	26.4	24.4	39.6
B	24.3	20.0	27.1	25.3	39.0
C	4.8	4.8	4.5	3.9	8.1

Note:

Values for materials other than those given above are to be determined by the Society on a case by case basis.

For a propeller shaft Kind 1 made of carbon steel or low alloy steel with a specified tensile strength exceeding 400 *N/mm*^{2}, the values determined by above formulae may be multiplied by the coefficient K_{m2} given below:

$$K_{m2} = \frac{T_s + 160}{560}$$

T_s : Specified tensile strength of the shaft material (*N/mm*^{2})

6.3 Barred Speed Range

6.3.1 Barred Speed Range for Avoiding Continuous Operation

In cases where torsional vibration torque amplitude exceeds the allowable limit T_1 specified in **6.2.4(1)** above, the barred speed range for avoiding continuous operation specified in **6.3.1, Part 7 of the Rules** is to be calculated by replacing τ_1 with T_1.

Chapter 7 BOILERS, ETC. AND INCINERATORS

7.1 General

7.1.3 Drawings and Data to be Submitted

The operating Instructions specified in **7.1.3(2)(c), Part 7 of the Rules** are to include the following information:

(1) Feed water treatment and sampling arrangements
(2) Operating temperatures (exhaust gas and feed water temperatures)
(3) Operating pressures
(4) Inspection and cleaning procedures
(5) Records of maintenance and inspections
(6) The need to maintain adequate water flows through economizers under all conditions
(7) Periodical operational checks of safety devices to be carried out by operating personnel and to be documented accordingly
(8) Procedures for using exhaust gas economizers in dry conditions
(9) Procedures for the maintenance and overhaul of relief valves

7.3 Construction of Thermal Oil Heaters

7.3.3 Safety Devices, etc. for Thermal Oil Heaters Directly Heated by the Exhaust Gas of Engines

The wording "Fixed fire extinguishing and cooling systems as deemed appropriate by the Society" in **7.3.3-7, Part 7 of the Rules** means combinations of fixed gas fire-extinguishing systems and systems for cooling heating coils, headers, casings, etc., and heater themselves such as water-spray. Fixed fire extinguishing cooling systems can be water-drenching systems able to discharge copious amounts of water. In such cases, the suitable means for collection and drainage, to prevent any water from flowing into diesel engines, are to be provided on exhaust ducting below heaters, and such drainage is to be led to suitable places.

7.4 Incinerators

7.4.3 Construction and Fittings

The wording "to be subject to the recognition of the Society" in **7.4.3(3)(c), Part 7 of the Rules** signifies that means are provided to prevent the passage of any exhaust gases into other boilers, thermal oil heaters and incinerators, and furthermore, means are also provided to enable operators to verify their operating conditions.

Chapter 8 PRESSURE VESSELS

8.2 Materials and Welding

8.2.1 Materials

The interpretation of the meaning of the pressure parts of pressure vessels specified in **8.2.1-1**, **Part 7 of the Rules,** which are required to use materials complying with the requirements in **Part K of the Rules for the Survey and Construction of Steel Ships,** is to be based on the information given in **D9.2.1, Part D of the Guidance for the Survey and Construction of Steel Ships**.

8.2.6 Non-destructive Testing for Cast Steels and Cast Irons

The criteria for non-destructive tests in cases where cast steels are used for shells of Group I or Group II pressure vessels are to be in accordance with the following:

(1) The testing method of radiographic tests is to be in accordance with *JIS G* 0581. Any cracks or insufficient fusion are to be judged unacceptable. Gas and blowholes, sand spots, inclusions, and internal shrinkage are judged acceptable in cases where the defects are classified as Grade 1 in accordance with the above standard. Gas and blowholes, sand spots, and inclusions of Grade 2 are judged acceptable in cases where the thickness of Group II pressure vessels in defect area is 25 *mm* or more.

(2) The testing method and the criteria for acceptable defects detected by magnetic particle tests are to be in accordance with those in **D9.2.4(2), Part D of the Guidance for the Survey and Construction of Steel Ships**.

(3) The testing method of liquid penetrant testing is to be in accordance with *JIS Z* 2343. The criteria for acceptable defects detected by liquid penetrant testing is to be in accordance with those in **(2),** above.

(4) Defects judged unacceptable by **(1)**, **(2)**, or **(3)** may be repaired. Welding for such repairs is to be in accordance with the requirements specified in **5.1.11, Part K of the Rules for the Survey and Construction of Steel Ships**.

8.3 Design Requirements

8.3.2 Design Loads

When designing pressure vessels, the load or external force specified in **8.3.2-1** and **-2**, **Part 7 of the Rules** is to be taken into account in the cases specified below:

(1) In cases where the static head of contained fluid cannot be disregarded in the strength calculation of **8.5**, **Part 7 of the Rules**.
In this case, the value of P_0+P_1 (P_0: design pressure, P_1: static head of contained fluid) is to be used as the internal pressure at the part to be examined in the strength calculation concerned to the membrane stress.

(2) In cases where the internal pressure may become lower than the external pressure during in service.
In this case, the calculation procedure is to be taken in accordance with Section VIII, Division 2, Appendix 2 of the "Boiler and Pressure Vessel Code" of *ASME*.

(3) In cases where dynamic loads caused by ship's motions can be considered.
In this case, the dynamic loads are to be estimated under the conditions of inclination angle specified in **Table 7.1.1**, **Part 7 of the Rules**, and also the calculation procedure is to be taken in accordance with Section VIII, Division 2, Appendix 4 of the "Boiler and Pressure Vessel Code" of *ASME*.

(4) In cases where fatigue due to thermal stress cannot be disregarded.
In this case, the calculation procedure is to be taken in accordance with Section VIII, Division 2, Appendix 5 of the "Boiler and Pressure Vessel Code" of *ASME*.

(5) In cases where loads from fittings cannot be disregarded.
In this case, the calculation procedure is to be taken in accordance with Section VIII, Division 2, Appendix 4 and 5 of the "Boiler and Pressure Vessel Code" of *ASME*.

(6) In cases where loads of hydraulic test pressure cannot be disregarded.

In this case, the measure specified in **(1)** is to be applied, or the test pressure is to be taken such that any calculated value of primary general membrane stress due to test pressure is not more than 90% (135% for local membrane stress) of the yield point or proof stress of the material at the test temperature.

8.9 Tests

8.9.1 Shop Tests

Pressure vessels for which hydraulic tests are considered necessary by the Society, as specified in **8.9.1-2(1)(b)**, **Part 7 of the Rules**, are pressure vessels such as those given in **(1)** or **(2)** below:

(1) Pressure vessels in cases where the product of the design pressure (*MPa*) and internal capacity (m^3) exceeds 1.0

(2) Heat exchangers such as fresh water coolers, lubricating oil coolers, hydraulic oil coolers, lubricating oil heaters, fuel oil heaters, condensers, feed water heaters, air coolers, etc., and air tanks such as control air tanks, etc. which are necessary for the operation of the following installations as well as other essential pressure vessels:

(a) Main propulsion machinery and shafting;

(b) Boilers and thermal oil installations (main boilers, essential auxiliary boilers, and other boilers and thermal oil installations used for any fuel oil heating necessary for the operation of main propulsion machinery or cargo heating that is continuously required); or

(c) Electric generators and auxiliaries (excluding auxiliary machinery for specific use, etc.) and their prime movers.

Chapter 9 WELDING FOR MACHINERY INSTALLATIONS

9.2 Welding Procedure Qualification Tests

9.2.1 Requirements for Tests

The detailed data and information to be submitted in connection with the welding procedure qualification tests are, in general, to be as follows:

(1) Outline of plant facilities and equipment (outline of plant installations, type and number of important welding machines, outline of facilities for heat treatment and installations for test and inspection)
(2) Qualifications and number of welders
(3) Production records of conspicuous welded constructions
(4) Data covering the welding quality control system and working process standards
(5) Welding procedures intended to be tested, and type or name of product to which such welding procedures are to be applied
(6) Maximum plate thickness of products referred to above, kind and specification of material
(7) Draft proposal for welding procedure qualification tests (type of welding machine, welding rod, type of flux, welding conditions, welding procedures including preheating and post weld heat treatment are to be specified in the proposal. Also, type of test, sampling procedure of test specimens and dimensions of test specimens are to be specified.)

9.3 Post Weld Heat Treatment

9.3.1 Procedure of Post Weld Heat Treatment

Procedures of post weld heat treatments for alloy steels other than those specified in **9.3.1-1, Part 7 of the Rules** are to be as follows:

(1) The temperature to be maintained in the post weld heat treatment is to be as given in **Table 7.9.3.1-1**.
(2) The requirements in **9.3.1-1, Part 7 of the Rules** apply to procedures of heat treatments other than post weld heat treatments for alloy steel referred to above.

Table 7.9.3.1-1 Post-welding Temperature to be Maintained

Kind of steel	Minimum temperature to be maintained (°*C*)
2-2.5*Ni* steel 3.5*Ni* steel	600

Note:
For 5-9*Ni* steel, the post weld heat treatment is not required.

9.4 Welding of Boilers

9.4.3 Post Weld Heat Treatment

Post weld heat treatment for boilers may be omitted in cases where those welded parts comply with the following conditions and specially approved by the Society.

(1) Plate material is *KP*42, *KP*46 or *KP*49, and plate thickness is 19 *mm* or less.
(2) The Charpy *U*-notch impact test value of the base metal and welded joint through the use of test specimen *U*4 at a temperature of 0°*C* is to be 27.5 *J* or more. Regarding the values of welded joints, an impact test is to be added to the production weld tests in order to verify the values of welded joints.
(3) The joints between shells and end plates or tube plates are to be butt weld.

9.4.4 Production Weld Tests

The wording “bend test jig which deemed appropriate by the Society” referred to in **9.4.4-4(2), Part 7 of the Rules** means those bend test jigs specified in **Fig.M3.1**, **Fig.M3.2** and **Fig.M3.3**, **Part M of the Rules for the Survey and Construction of Steel Ships** or equivalent thereto.

9.4.5 Radiographic Testing for Longitudinal and Circumferential Joints

The criteria for evaluating radiographic testing are as follows:

(1) Classification of defects
Defects shall be classified into 4 types in accordance with **Table 7.9.4.5-1**.

(2) Type 1 defects
Type 1 defects are to be rejected, if the score of a particular defect exceeds the value of the acceptable score specified in **Table 7.9.4.5-2** according to thickness of the base metal. However, the score of one defect is determined on the basis of the axis length of the defect shown in **Table 7.9.4.5-3**. In cases where the axis length of a defect is shorter than the value specified in **Table 7.9.4.5-4**, the score may be uncounted. The score of two or more defects is to be sum of the scores for each defect in the sight of test field.

(3) Type 2 defects
Type 2 defects are to be rejected, if the length of a defect exceeds the value of the acceptable score specified in **Table 7.9.4.5-5** according to thickness of the base metal. The length of defect is to be determined by measuring the length of a defect. However, in cases where the defects are present in a row and the mutual distance between the defects does not exceed the length of the larger defect, the length of all defects including the spaces between them is to be measured as the length of the defect specified in **Table 7.9.4.5-5**.

(4) Type 3 defects
Any type 3 defect is to be rejected.

(5) Type 4 defects
The acceptable criteria and score of defects are to be according to the requirements specified in **(2)** (in this case, “type 1 defect” is to be read as “type 4 defect”). However, in cases where the type 4 defects coexistent with the type 1 defects in the sight of the test field, the score of defect is to be the sum of both scores.

Table 7.9.4.5-1 Classification of defects

	Kind of defects
Type 1	Round blow holes and similar defects
Type 2	Elongated slag inclusions, pipes, incomplete penetration, incomplete fusion, and similar defects
Type 3	Cracks and similar defects
Type 4	Tungsten inclusions

Table 7.9.4.5-2 Acceptable criteria for type 1 defects

Thickness of base metal (*mm*)	10 or less	More than 10, 25 or less	More than 25, 50 or less	More than 50
Score of one defect	3	6	12	15
Test field of vision (*mm*)	10×10		10×20	

Table 7.9.4.5-3 Score of type 1 defects

Axis length of one defect (*mm*)	1.0 or less	More than 1.0, 2.0 or less	More than 2.0, 3.0 or less	More than 3.0, 4.0 or less	More than 4.0, 6.0 or less	More than 6.0, 8.0 or less	More than 8.0
Score	1	2	3	6	10	15	25

Table 7.9.4.5-4 Maximum axis length of type 1 defects for an uncountable score

Thickness of base metal (*mm*)	Axis length of one defect (*mm*)
20 or less	0.5
More than 20, 50 or less	0.7
More than 50	1.4% of thickness of base metal

Table 7.9.4.5-5 Acceptable criteria for type 2 defects

Thickness of base metal (*mm*)	Length of defect (*mm*)
12 or less	3
More than 12, 48 or less	1/4 of the base metal thickness
More than 48	12

9.4.6 Non-destructive Testing for Other Welds

1 The "important welds" means, for example, the following parts with a plate thickness of 6 *mm* or more:

(1) Welds between flat end plates or cover plates and shell plates

(2) Welds between furnaces or ogee rings and shell plates

(3) Welds for manholes

(4) Welds for nozzles

2 The standards for ultrasonic tests are to be in accordance with the following:

(1) The testing method is to be in accordance with *JIS Z* 3060 (1994) or equivalent thereto.

(2) Any indicated defect length according to L-line sensitivity specified in the method in **(1)**, which exceeds the value given in **Table 7.9.4.6-2** with respect to plate thickness, is not acceptable. Two or more defects existing at a same depth, separated by an interval shorter than the length of the largest defect are to be regarded as a continuous defect which includes the interval between them.

3 The standards for magnetic particle tests are to be in accordance with the following:

(1) The testing method is to be in accordance with *JIS Z* 2320-1 to -3 or equivalent thereto.

(2) The result of a magnetic particle test is acceptable, provided the following **(a)** through **(d)** are complied with.

  (a) There are no magnetic particle indications due to surface cracks.

  (b) The maximum length of linear magnetic particle indications is 2 *mm* or less.

  (c) The major axis length of circular magnetic particle indications is 2 *mm* or less.

  (d) The point total specified in **Table 7.9.4.6-3** with respect to the type of magnetic particle indications is 6 or less within an area of 2500 mm^2 for scattering magnetic particles.

4 The standards for liquid penetrant tests are to be in accordance with the following:

(1) The testing method is to be in accordance with *JIS Z* 2343 or equivalent thereto.

(2) The criteria for acceptable defects detected by liquid penetrant testing are to be in accordance with those specified in **-3(2)**.

Table 7.9.4.6-2 Acceptable Criteria for Indicated Defect Length

Plate thickness t (*mm*)	Length of defect (*mm*)
$t < 12$	3
$12 \leq t < 48$	$t/4^{(1)}$
$48 \leq t$	12

Note:

(1) t is the plate thickness on the open edge side of the base material (*mm*). However, in cases where the value of the thickness of the base material and value of the thickness of the section at the butt welding are different, the lesser of the two values is to be taken as the plate thickness.

Table 7.9.4.6-3 Points for Scattering Magnetic Particle Indication

Magnetic particle pattern of defect	Magnetic particle indications of 2 *mm* or less
Linear	3
Circular	1

9.5 Welding of Pressure Vessels

9.5.3 Stress Relieving

1 The mechanical stress relieving is, in principle, to be given by hydraulic means in cases where the applicable plate thickness is to be 40 *mm* or less.

2 The required conditions for omitting stress relieving in cases where material having superior notch toughness is used are to be as specified below:

(1) The base metal is to be of steel plate with a rule required impact test value of 47.1 *J* or more by the use of test specimens *U*4 at a temperature of 0°*C*.

(2) The impact test value of welds in the production weld tests is not to be less than the rule required value of the base metal at a temperature of 0°*C*.

(3) The plate thickness of the material is to be 40 *mm* or less.

9.5.4 Production Weld Tests

For tensile tests of joints conducted as part of production weld tests, if a test specimen cannot be tested at its actual thickness due to test equipment limitations, the test specimen is to be cut into smaller pieces which have a thickness appropriate for the test equipment. However, for all other tensile tests of joints, representative test specimens only need to be tested in cases where the strength distribution in the through-thickness direction can be verified in advance through welding procedure qualification tests, etc.

9.5.5 Radiographic Testing for Welded Joints

1 The criteria for acceptable defects detected by radiographic testing are to be in accordance with those specified in **9.4.5.**

2 The criteria for acceptable defects detected by ultrasonic testing are to be in accordance with those specified in **9.4.6-2.**

9.5.6 Non-destructive Testing for Other Welded Parts

1 The criteria for radiographic testing are to be in accordance with the requirements specified in **9.4.5-2** to **-7, Part 7 of the Rules**. The criteria for acceptable defects detected by radiographic testing are to be in accordance with the requirements specified in **9.4.5-1**.

2 The criteria for acceptable defects detected by ultrasonic testing are to be in accordance with the requirements specified in **9.4.6-2**.

3 The criteria for acceptable defects detected by magnetic particle testing and liquid penetrant testing are to be in accordance with those in **9.4.6-3** and **9.4.6-4** respectively.

9.6 Welding of Piping

9.6.2 Alignment of Joints

The following values are to be taken as standard values for the allowable limits of the offset of joints referred to in paragraph **9.6.2, Part 7 of the Rules** in cases where a pipe and pipe fitting as well as pipe and pipe are butt welded:

(1) In cases where a backing strip is used; 0.5 *mm*

(2) In cases where no backing strip is used

(a) In cases where the nominal diameter is less than 150*A*, and the thickness is 6 *mm* or less; 1 *mm* or 25% of the thickness, whichever is smaller.

(b) In cases where the nominal diameter is less than 300*A*, and the thickness is 9.5 *mm* or less; 1.5 *mm* or 25% of the thickness, whichever is smaller (excluding those cases that correspond to **(a)** above).

(c) In cases where the nominal diameter is not less than 300*A* or the thickness exceeds 9.5 *mm*; 2 *mm* or 25% of the thickness, whichever is smaller.

9.6.3 Preheating of Welds

Preheating for pipes referred to in paragraph **9.6.3, Part 7 of the Rules** is to be carried out at the minimum preheating temperature specified in **Table 7.9.6.3-1** according to the grade of the materials and their thickness.

9.6.5 Non-destructive Testing

1 The criteria for acceptable defects detected the radiographic testing are to be in accordance with those specified in **9.4.5**.

2 The criteria for acceptable defects detected by ultrasonic testing are to be in accordance with the requirements specified in **9.4.6-2(2)**.

3 The criteria for acceptable defects detected by magnetic particle testing and liquid penetrant testing are to be in accordance with those in **9.4.6-3(2)** and **9.4.6-4(2)** respectively.

Table 7.9.6.3-1 Minimum Preheating Temperature

Grade(1)		Thickness of weld (t) (mm)	Minimum preheating temperature($°C$)
Grade 1 Grade 2 Grade 3	$C+\frac{Mn}{6}\leq 0.4$	$t\geq 20$(2)	50
	$C+\frac{Mn}{6}> 0.4$	$t\geq 20$(2)	100
Grade 4	No.12	$t\geq 13$(2)	100
	No.22 No.23	$t<13$(3)	100
		$t\geq 13$	150
	No.24	$t<13$(3)	150
		$t\geq 13$	200

Notes:

(1) Grades are as specified in Section **4.2, Part K of the Rules for the Survey and Construction of Steel Ships**. Materials not specified in this table are to be as deemed appropriate by the Society.

(2) In cases where welding is carried out at an ambient temperature less than 0 $°C$, it is necessary to preheat the welding object to at least the minimum preheating temperature irrespective of the thickness, excluding those cases where sufficient consideration has been given to any possible moisture.

(3) Preheating may be omitted for thickness of 6 *mm* or less depending on the results of hardness tests in cases where sufficient consideration has been given to any possible moisture.

Chapter 10 PIPES, VALVES, PIPE FITTINGS AND AUXILIARIES

10.1 General

10.1.5 Service Limitations for Materials

1 The wording "deemed acceptable by the Society" in **10.1.5-1(2), Part 7 of the Rules** means, for example, as follows:

(1) For control oil piping used to control each valve in machinery spaces, copper alloy pipes may be used.

(2) For instrumentation piping for saturated steam piping with a design pressure of 1.6 *MPa* or less, copper pipes and copper alloy pipes may be used.

(3) For thermal oil piping used for heat tracing of F.O. piping in machinery spaces, which are provided with appropriate protection, copper pipes may be used.

2 The wording "where deemed as appropriate by the Society after consideration has been given to their construction and purpose" in **10.1.5-2(2)(b), Part 7 of the Rules** means in cases where cast iron valves, which have a rigid construction and a design breaking pressure of not less than 10 *times* the maximum working pressure, are provided in hydraulic piping systems to control the direction of the flow.

3 The wording "where deemed as appropriate by the Society after consideration has been given to their construction and purpose" in **10.1.5-2(3), Part 7 of the Rules** means in cases where cast iron valves, which have a rigid construction and a design breaking pressure of not less than 5 *times* the maximum working pressure, are provided in hydraulic piping systems to control the direction of the flow.

10.1.6 Use of Special Materials

1 In cases where rubber hoses, Teflon hoses or nylon hoses are used for the following pipes; those approved under the requirements of the "**Guidance for the Approval and Type Approval of Materials and Equipment for Marine Use**" are to be used:

(1) Pipes of Group I or Group II

(2) Pipes likely to cause fire or flooding in cases where they rupture

2 In cases where plastic pipes are used, the requirements specified in **Annex D12.1.6-2 "GUIDANCE FOR THE SURVEY AND CONSTRUCTION OF PLASTIC PIPES", Part D of the Guidance for the Survey and Construction of Steel Ships** are to be complied with.

3 In cases where aluminum alloy pipes are used; the following requirements are to be complied with:

(1) As a rule, aluminum alloy pipes are to be in accordance with the requirements of the code deemed appropriate by the Society, and are to be of seamless drawn pipes or seamless extruded pipes.

(2) Aluminum alloy pipes are not to be used for any of the following applications:

  (a) As a rule, pipes with a design temperature exceeding 150°*C*.

  (b) Any pipes which penetrates either an "*A*-Class division" or a "*B*-Class division."

  (c) Piping in which the use of copper alloy pipes is prohibited by **Table 7.10.2, Part 7 of the Rules**.

(3) The required thickness of aluminum alloy pipes subject to internal pressure are to be in accordance with the following requirements:

Pipe thickness is to be determined using the formula in **10.2.1-1, Part 7 of the Rules**. In this case, allowable stress (f) is to be the smallest of the following values. However, in cases where the design temperature is not in the creep region of the material, no consideration needs to be given to the value of f_3.

$$f_1 = \frac{R_{20}}{4.0}, \quad f_2 = \frac{E_t}{1.5}, \quad f_3 = \frac{S_R}{1.6}$$

Where:

R_{20} : Rule-required minimum tensile strength (N/mm^2) of the material at room temperature (less than 50°*C*)

E_t : 0.2% proof stress (N/mm^2) of the material at design temperature

S_R : Mean value of creep breaking stress (N/mm^2) of the material after 100,000 *hours* at design temperature

10.2 Thickness of Pipes

10.2.1 Required Thickness of Pipes Subject to Internal Pressure

1 The joint efficiency (*J*) for forge-welded carbon steel pipes used in ordinary piping arrangements is to be 0.85.

2 The corrosion allowance for CO_2 pipes used for fire extinguishing may be zero.

10.2.2 Minimum Thickness of Pipes

1 In cases where the requirement for minimum thickness of the corrosion resistant alloy steel pipes in **10.2.2-1, Part 7 of the Rules** is applied, the minimum thickness of any stainless steel pipes used for cargo oil pipes is to be the value specified in **S5.1.6-1, Part S of the Guidance for the Survey and Construction of Steel Ships**.

2 The "fresh water pipes" in **Table 7.10.6(1), Part 7 of the Rules** means those fresh water pipes used for boiler feed water and drinking water. For other fresh water pipes, notwithstanding the requirements specified in **Table 7.10.6(1), Part 7 of the Rules**, those pipes with the thickness of Ⓒ specified in **Table 7.10.6(2), Part 7 of the Rules** may be applied to those pipes. However, pipes with a thickness less than 6 *mm* may not be used. The hot water pipes used for heating oil tanks are not regarded as fresh water pipes.

3 The minimum wall thickness for pipes whose nominal diameter is more than 450 *mm* in **Table 7.10.6(2)**, **Part 7 of the Rules** is to be in accordance with national or international standards. In this case, the wall thickness is not to be less than the minimum value indicated in the appropriate column of **Table 7.10.6(2)** for those pipes of 450 *mm* in nominal diameter.

10.3 Construction of Valves and Pipe Fittings

10.3.1 General

Rubber seated butterfly valves are to be dealt with under the following requirements:

(1) Application

Rubber seated butterfly valves (hereinafter referred to as the "butterfly valves") may, in principle, not be used for the following applications:

- (a) Outlet valves fitted to tanks, carrying flammable or combustible liquids (*e.g.*, fuel oil, crude oil, etc.) and subjected to liquid head, installed in engine rooms or other areas susceptible to fire.
  (However, butterfly valves may be used for those valves installed within the cargo oil tanks or as outlet valves leading to the pump rooms of oil tankers.)
- (b) Valves in piping systems with a design pressure exceeding 1.6 *MPa*
- (c) Valves in piping systems with a design temperature exceeding 70°*C*
- (d) Valves in piping systems handling special liquids other than water and oil
- (e) Valves in the flammable oil piping systems within engine rooms in cases where they have such a construction that the internal rubber lining is extended to the abutting face of a flange in order to be used as a gasket.

(2) Construction

The construction of the butterfly valves is to conform to the following requirements:

- (a) A stopper, which can be engaged at designated "Open" and "Shut" positions, is to be provided.
- (b) Valves serving at an intermediate valve disc position are to be able to maintain their position when locked and the locking system is not to be loosened between "Open" and "Shut" by vibrations, mechanical impacts or liquid flows, etc.
- (c) The valve is to be able to be operated by a single person.
- (d) Means are to be provided to indicate valve disc position.
- (e) Valve stems are to be of sufficient strength and valve discs are to be fitted to valve stems in such a way of that there is no possibility of loosening.
- (f) Sufficient consideration is to be given to the corrosion resistance and wear resistance properties of all materials used for the main parts of valves.
- (g) Butterfly valves used as river water suction valves or overboard discharge valves are, in principle, to be of a flange type.

(3) Product markings of

The butterfly valve is to be marked with the following items at a conspicuous place on the product:

(a) Design pressure
(b) Valve box material
(c) Nominal diameter
(d) Name of manufacturer

10.3.3 Mechanical Joints

The wording “mechanical joints are to be of a Society approved type” stipulated in **10.3.3-1, Part 7 of the Rules** refers to those mechanical joints approved in accordance with **Chapter 9, Part 6 of the Guidance for the Approval and Type Approval of Materials and Equipment for Marine Use**.

10.3.4 Flexible Hose Assemblies

1 The wording “to be approved by the Society” in **10.3.4-2, Part 7 of the Rules** means that approval is to be made in accordance with **2.4.2-11, Chapter 2, Part 6 of the Guidance for the Approval and Type Approval of Materials and Equipment for Marine Use**.

2 “Where specially approved by the Society” stipulated in **10.3.4-3(3)(a), Part 7 of the Rules** refers to the use of materials such as Teflon or nylon which are unable to be reinforced. However, the hoses are to have external wire braid protection as practicable.

10.4 Connection and Forming of Piping Systems

10.4.3 Connection of Pipes with Pipe Fittings

1 The following pipe joints may be used as those “deemed appropriate by the Society” referred to in **10.4.3-1, Part 7 of the Rules**:

(1) Types of pipe joints with bell-mouthed pipe ends as shown in **Fig. 7.10.4.3-1** may be used for pipes in Group III and pipes in Group I or II with a design pressure of 1.0 *MPa* or less and with a nominal diameter of 50*A* or less.

(2) One side welded flange joints shown in **Fig. 7.10.4.3-2** may be used for drinking water piping, scupper piping and sanitary piping located above the designed maximum load line as well as overflow piping, air vent piping, exhaust gas piping, gas vent piping of crank chambers, exhaust steam piping and foam fire extinguishing agent discharge piping having open ends. Furthermore, pipes in Group III which are used in ways other than those given above may be used for pipes with a nominal diameter of 40*A* or less except for those pipes used for flammable oils.

2 In cases where non-ferrous metal valves and fittings are soldered to non-ferrous metal piping referred to in **10.4.3-2, Part 7 of the Rules**, the procedures for soldering copper pipes and pipe flanges are to be as shown below:

(1) The portion to be soldered is to be provided with a suitable molten pool, and the pipe end is to be bell-mouthed.

(2) Fillet welding is not recommendable for connecting copper pipes with pipe flanges. However, this recommendation may be waived when a special soldering method such as silver soldering or *TIG* welding is applied.

(3) Copper pipes connected by soldering may be used in cases where the design temperature is 200°*C* or below.

Fig. 7.10.4.3-1 Flange Joint (Bell-mouth)

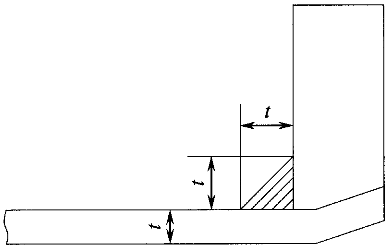
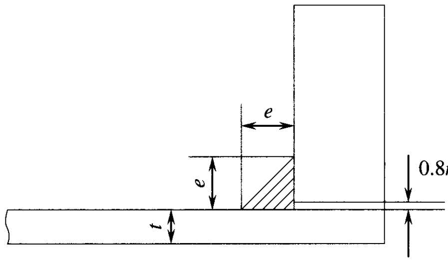


Fig. 7.10.4.3-2 Flange Joint (One-side welded)



10.4.4 Forming of Pipes and Heat Treatment after Forming

The wording “a suitable heat treatment” specified in **10.4.4-2, Part 7 of the Rules** means, as a rule, the following:

(1) For steel pipes of Grade 2, No. 4, Grade 3, No. 4 and Grade 4 that are specified in **Table 7.9.6, Part 7 of the Rules**, stress-relieving heat treatments are to be carried out in accordance with the requirements relative to the holding temperature and holding period specified in **9.3.1, Part 7 of the Rules**.

(2) In cases where steel pipes of Grade 2, No. 4, Grade 3, No. 4 and Grade 4 that are specified in **Table 7.9.6, Part 7 of the Rules** are subjected to bending processes in such a manner that the bending radius of the pipe centre line is 4 times or less the outside diameter of the pipe, they are to be subjected to annealing or annealing and tempering according to the type of pipe materials. The type and temperature of this heat treatment are to be as shown in **Table 7.10.4.4-1**.

Table 7.10.4.4-1 Type and Temperature of Heat Treatment

Grade (Note 1)		Type and temperature of heat treatment (°*C*)
Grade 2, No.4 and Grade 3, No.4		Normalizing: from 880 to 940
Grade 4	No.12	Normalizing: from 900 to 940
	No.22 No.23	Normalizing: from 900 to 960 Tempering: from 640 to 720
	No.24	Normalizing: from 900 to 960 Tempering: from 640 to 780

Note

1. Grades are as specified in **4.2, Part K of the Rules for the Survey and Construction of Steel Ships**.

10.5 Construction of Auxiliary Machinery and Storage Tanks

10.5.1 General

1 Plate thickness of fuel oil storage tanks

The “small tanks” specified in **10.5.1-2, Part 7 of the Rules** means fuel oil storage tanks with a capacity of 1,000 *litres* or less.

10.6 Tests

10.6.1 Shop Tests

The wording of “free standing fuel oil storage tanks” referred to in **10.6.1-8, Part 7 of the Rules** means those free standing tanks storing the following liquids:

(1) Fuel oil for main propulsion machinery, prime movers for driving generators (including emergency generators) and boilers, etc.

(2) Fuel oil additives

(3) Washing oil (light oil, kerosene, etc.)

10.6.2 Tests after Installation on Board

The hydrostatic tests for piping systems, after installation on board, specified in **10.6.2, Part 7 of the Rules** may be omitted in cases where adequate nondestructive tests have been carried out on welded joints with results free from defects.

Chapter 11 PIPING SYSTEMS

11.1 General

11.1.2 Drawings and Data

1 Piping diagrams of those tanks which form part of the hull construction are to be accompanied by a piping list that follows the format given in **Table 7.11.1.2-1**.

2 Regarding those distance pieces directly fitted to the sides of ships, drawings of their construction and fitting details are to be submitted for approval.

Table 7.11.1.2-1

Tank	Name
	Type
Sounding pipes	Nominal diameter
	Outside diameter
	Inside diameter
	Thickness
	Type
	Remarks
Air vent pipes (overflow pipes)	Nominal diameter
	Outside diameter
	Inside diameter
	Thickness
	Sum of section area
	Type
	Remarks
Filling pipes	Nominal diameter
	Outside diameter
	Inside diameter
	1.25 × sectional area
	Type
	Remarks

11.2 Piping

11.2.3 Penetration of Pipes

Penetration of valve stems

Valve stems of various valves are, in principle, not to penetrate through the part subjected to liquid head such as the bottom plate of shoulder tanks and tank top of double bottom used for tanks. In cases where such penetrations are unavoidable, considerations are to be taken by providing such means as protection pipe to prevent liquid head from imposing on the stuffing box.

11.2.4 Slip-on Joints

Slip-on joints may be used for suction pipes for double bottoms within tanks containing the same liquid as that passing through the piping.

11.2.5 Bulkhead Valves

1 Pipes penetrating stern tanks are to be fitted with stop valves at the fore side of the bulkhead.

2 The requirements for pipes piercing collision bulkheads specified in **11.2.5-1 and -2, Part 7 of the Rules** apply only to those extending below the bulkhead deck.

3 The maximum number of the pipes specified in **11.2.5-2, Part 7 of the Rules** which may pass through a collision bulkhead is two.

11.3 River Water Suction Valves and Overboard Discharge Valves

11.3.2 Location and Construction of River Water Suction Valves, Overboard Discharge Valves, etc.

1 The wording "overboard discharges" in **11.3.2-1, Part 7 of the Rules** means those openings discharging due to pressure from pumps and not including those discharging due to pressure from natural forces (*i.e.*, gravity).

2 The wording "the locations of overboard discharges are not to be such that water can be discharged" specified in **11.3.2-1, Part 7 of the Rules** means areas other than that within the diagonal line section of **Fig. 7.11.3.2-1**.

3 In cases where overboard discharges are located areas within the diagonal line section of **Fig. 7.11.3.2-1** by necessity, either of the followings is to be arranged as a "special provisions" specified in **11.3.2-1, Part 7 of the Rules.**

(1) Means to guide water flow to the shell plating with consideration being given to the direction of the water flow.

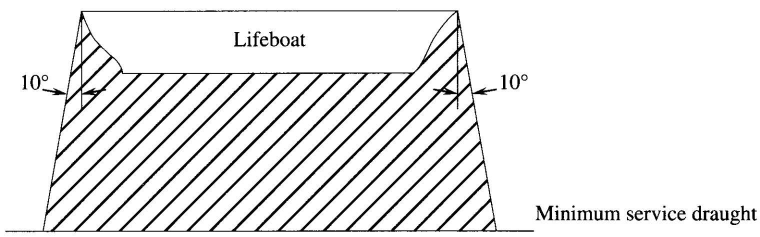
(2) Means to stop any water discharge which can be operated from a position on the weather deck in the vicinity of the lifeboat installation location. In this case, operating switches or operating handles that are different from those stopping devices specified in **4.1.1-2** and **4.1.2-2** through **4.1.2-4, Part 9 of the Rules** are to be provided.

4 The wording "rigid construction" in **11.3.2-3(2), Part 7 of the Rules** means that the pipe thickness of distance pieces is to be not less than the values given in the following **Table 7.11.3.2-1**:

Table 7.11.3.2-1

de : Outside diameter (mm)	Wall thickness (mm)
$de \leq 80$	7.0
$80 < de \leq 180$	$0.03de + 4.6$
$180 < de \leq 220$	$0.0625de - 1.25$
$220 < de$	12.5

Fig. 7.11.3.2-1



11.4 Scuppers, Sanitary Discharges, etc.

11.4.1 General

Scupper pipes within superstructures

Scupper piping within the superstructure is not to be connected to any scupper piping on the weather deck.

11.5 Bilge and Ballast Piping

11.5.1 General

1 Omission of bilge suction pipes

For small compartments such as echo sounder recesses, etc., the provision of bilge suction pipes may be omitted with Society approval.

2 Valves on bilge suction piping

Valves on the bilge suction piping are to be operable from a position in machinery spaces or shaft tunnels, or to be capable of being remotely controlled from a readily accessible place.

11.5.3 Size of Bilge Suction Pipes

In ships with double hull construction, the inside diameter of bilge suction pipes may be determined by using the distance between the inner hull in place of the breadth of the ship.

11.5.4 Bilge Pumps

In cases where one of the independently powered bilge pumps specified in **11.5.4, Part 7 of the Rules** falls short of its required capacity, the pump may still be considered to be in compliance with the aforementioned requirements in the following cases:

(1) In cases where only two powered pumps are provided, the capacity of the pump in question is 80% or more than its required capacity and the combined total capacity of the two pumps is 200% or more of the capacity required for a single pump.

(2) In cases where three or more pumps are provided and two pumps fall short of their required capacities, the combined total capacity of the two pumps in question is 80% or more of the capacity required for a single pump and the combined total capacity of these two pumps and one other pump is 200% or more of the capacity required for a single pump. In such cases, the capacity distribution of the two pumps in question may be as deemed appropriate.

11.6 Air Pipes

11.6.2 Open Ends of Air Pipes

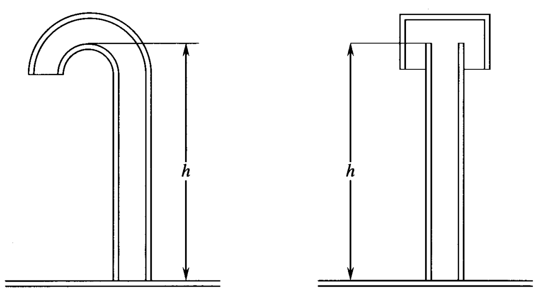
1 Air pipe heads may be of a bonnet type instead of a gooseneck type.

2 In cases where hinge steel covers are provided as the closing devices of air pipe heads, it is recommended that either spring-type covers or covers tightened using spring-type butterfly nuts be used instead of covers tightened with standard butterfly nuts because of the fear of tank overpressure.

11.6.4 Height of Air Pipes

The height of air pipes above deck is to be measured as shown in **Fig. 7.11.6.4-1**.

Fig. 7.11.6.4-1 The Height of Air Pipe



11.8 Sounding Pipes

11.8.3 Construction of Sounding Pipes

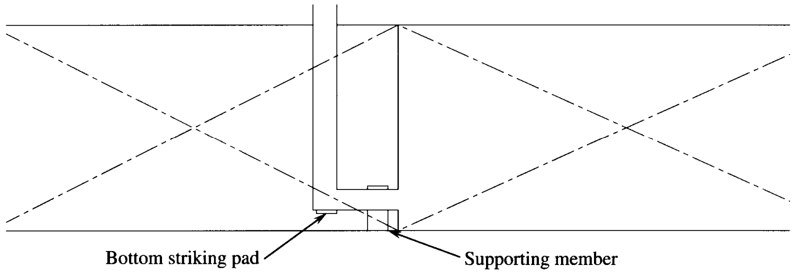
1 Elbow type sounding pipes

In cases where the use of elbow type sounding pipes is unavoidable, sufficient support is to be provided for the arm of the pipe. However, no elbow type sounding pipes are to be used for deep tanks. In addition, bottom striking pads are to be of a sufficient thickness. (*See* **Fig. 7.11.8.3-1**)

2 Striking plates

The standard value of striking plate thickness is approximately 10 *mm* for small ships and 12 *mm* for large ships.

Fig. 7.11.8.3-1 Example of Elbow Type Sounding Pipe Arrangements



11.8.4 Construction of Liquid Level Indicators

The wording “a type that has been approved by the Society” in **11.8.4, Part 7 of the Rules** means those liquid level indicators approved in accordance with the requirements of **Chapter 4, Part 7 of the Guidance for the Approval and Type Approval of Materials and Equipment for Marine Use** and the wording “other standards approved by the Society” means *JIS F 7211* “5K level gauges with valves”, *JIS F 7215* “Flat glass oil level gauges” or any equivalent standards.

11.9 Fuel Oil Systems

11.9.1 General

No fuel oil pipes are to be run through potable fresh water tanks. No pipes used for potable fresh water tanks are to be run through fuel oil tanks. Feed water pipes for boilers are to be in accordance with **11.14.1, Part 7 of the Rules.**

11.9.3 Fuel Oil Transfer Pumps

In cases where main propulsion machinery output is 375 *kW* or less, a single manually operated pump may be used as the fuel oil transfer pump.

11.9.4 Drip Trays and Drainage Systems

Fuel oil drainage is to be dealt with by the following requirements:

(1) For those fuel oil piping systems that employ sediment tanks, drain valves are to be either automatic shut off valves or locked valves (or cocks).

(2) In cases where the possibility exists that the design pressure of a fuel oil heater will be exceeded, relief valves are to be fitted and either drainage is to be led into a drainage tank or other means are to be in place to prevent any spraying of fuel oil.

11.9.6 Fuel Oil Systems for Diesel Engines

One self-cleaning filter will also be accepted as a filter capable of being cleaned without stopping the supply of filtered oil required by **11.9.6-3, Part 7 of the Rules**.

11.10 Lubricating Oil Systems and Hydraulic Oil Systems

11.10.1 General

Electric heaters provided in double bottom tanks and deep tanks are to comply with the requirements specified in **11.9.5**.

11.10.3 Lubricating Oil Filters

One self-cleaning filter will also be accepted as a filter capable of being cleaned without stopping the supply of filtered oil required by **11.10.3-2, Part 7 of the Rules**.

11.11 Thermal Oil Systems

11.11.3 Pumps for Thermal Oil Heaters

1 The wording "Thermal oil heaters of important use" specified in **11.11.3, Part 7 of the Rules** refers to those in which thermal oil is used for any of the following:

(1) Fuel oil heating necessary for main propulsion machinery operation

(2) Any cargo oil heating that is continuously required

2 Notwithstanding the requirements in **11.11.3**, **Part 7 of the Rules**, thermal oil heaters of important use may be provided with only one fuel injection pump in cases where one complete spare unit of a pump, capable of being replaced within a short period of time, is equipped on board.

11.12 Cooling Systems

11.12.3 Cooling Systems for Diesel Engines

In cases where oil tanks are heated by cooling fresh water from main propulsion machinery, adequate means are to be provided to detect any oil contamination in the cooling fresh water piping system.

Chapter 12 STEERING GEARS

12.1 General

12.1.1 Scope

1 Manual steering gears are to be in accordance with the requirements of **12.1**, **12.2.1** through **12.2.3**, **12.2.8** through **12.2.10**, **12.3.1, 12.4** (excluding **12.4.8-2**) and **12.5, Part 7 of the Rules** and the requirements applicable of this **Chapter 12**.

2 Quadrants, chains, rods and leading-block of manual steering gears are to be as specified in the following requirements:

(1) The scantlings of quadrants are to comply with the following requirements in **(a)** to **(c)**:

(a) In cases where three arms are provided, scantlings of quadrants are not to be less than those given in the following:

i) Boss:

$$H_c = 4.27\sqrt[3]{T_R K_Q} \quad (mm)$$

$$D_c = 7.69\sqrt[3]{T_R K_Q} \quad (mm)$$

ii) Arm at its root:

$$B_c = 3.29\sqrt[3]{T_R K_Q} \quad (mm)$$

$$T_c = 1.67\sqrt[3]{T_R K_Q} \quad (mm)$$

iii) Arm at its outer end:

$$B_0 = 2.22\sqrt[3]{T_R K_Q} \quad (mm)$$

$$T_0 = 1.07\sqrt[3]{T_R K_Q} \quad (mm)$$

Where:

T_R : Rudder torque specified in **2.1.5, Part 4 of the Rules** (*N-m*).

K_Q : Material coefficient of the quadrant, specified in **2.1.2, Part 4 of the Rules**.

H_c : Required depth of boss (*mm*).

D_c : Required outer diameter of boss (*mm*).

B_c : Required breadth of arm at its root (*mm*).

T_c : Required thickness of arm at its root (*mm*).

B_0 : Required breadth of arm at its end (*mm*).

T_0 : Required thickness of arm at its end (*mm*).

(b) In cases where two arms are provided, the breadth and thickness of such arms are to be not less than 1.1 *times* those specified in **(a)**. In cases where four arms are provided, the breadth and thickness of such arms may be reduced to 0.9 *times* those specified in **(a)**.

(c) In cases where loose quadrants are used in addition to tillers fixed to rudder stocks, any arms of loose quadrants may be of the dimensions given in **(a)iii)** throughout their length.

(2) The diameter of studless chains for steering is not to be either less than 9.5 *mm* or less than the value obtained from the following formula, whichever is greater.

$$d_s = 3.36\sqrt{\frac{T_R K_c}{R}}$$

Where:

d_s : Required diameter of chains for steering (*mm*).

T_R : Rudder torque specified in **2.1.5, Part 4 of the Rules** (*mm*).

K_c : Material coefficient of the chain, specified in **2.1.2, Part 4 of the Rules**.

R : Length of tiller or radius of quadrant measured from the centre of rudder stock to the centre line of steering chains (*mm*).

(3) The diameter of steering rods is to be equal to or larger than 1.25 *times* the diameter of the steering chains obtained from **(1)** above.
(4) Leading blocks of steering chains are to be so arranged as to make the length of such steering chains as short as practicable, to lead the chains easily to the quadrant and to avoid any sharp bends.
(5) The diameter of lead block sheaves, measured at the centre line of steering chains, is to be equal to or larger than 16 *times* the diameter of the chains. The diameter of sheave pins is to be two times or more of that of chains.
(6) In cases where steering chains are led at angles less than 120° , the diameters of sheaves and pins are to be made 1.25 *times* those specified in **(4)** above or larger respectively.
(7) Frames, base plates, pins and other parts of blocks subjected to mechanical shocks are not to be of cast iron. Furthermore, the sum of the sectional areas of those bolts connecting blocks to hulls is to be equal to or larger than the value obtained by following formula:

$$A_B = 2.4 d_s^{\ 2} \quad (cm^2)$$

Where:
A_B : Required total sectional area of bolts (cm^2).
d_s : Required diameter of chains for steering (mm).

(8) For sheaves intended to be used with steering wire ropes, the radius of rope groove is to be of the value obtained by adding 0.8 *mm* to the radius of rope, and the radius of sheaves is to be equal to or larger than 14 *times* that of the rope.

12.1.3 Drawings and Data

Operating instructions specified in **12.1.3(2)(b), Part 7 of the Rules**, are to include information about the importance of hydraulic fluid quality and its influence on the probability of hydraulic locking possibilities of two simultaneously operated power units. Operating instructions containing the same contents as those mentioned above, are to be kept on board.

12.2 Performance and Arrangement of Steering Gears

12.2.1 Number of Steering Gears

1 Adequate installation of blocks and tackles operating tillers or quadrants may be accepted as auxiliary steering gear.
2 In cases where manual steering gear is being used as the main steering gear, spare steering chains for the portion connected to the tiller are to be provided.
3 In cases where the auxiliary steering gear as specified in **12.2.1-1, Part 7 of the Rules** is of hydraulic type, the rudder actuator can serve in common with that for the main steering gear. Furthermore, parts of the hydraulic piping for rudder actuators of main steering gear may be used in common with those for auxiliary steering gear. However, in these cases, pipe lengths of common use parts are to be as short as practicable.

12.2.3 Performance of Auxiliary Steering Gear

For auxiliary steering gear in ships with a speed as defined in **2.1.9, Part 1 of the Rules** that is less than 7 *knots*, the requirement of **12.2.3(1), Part 7 of the Rules** apply by construing the wording “at one half of the speed specified in **2.1.9, Part 1 of the Rules** or 7 *knots*, whichever is greater” therein as “at navigable speed.”

12.2.7 Electrical Installations for Electric and Electrohydraulic Steering Gear

In cases where steering gear circuits, fed through electronic inverter units which control steering gear turning speed controls and their currents, are limited to being not more than the rated current of such electronic inverters, the requirements to provide protection devices against excess current specified in **12.2.7-5, Part 7 of the Rules** may be omitted. In these cases, they are to comply with the following requirements:
(1) Over-current and over-voltage protection devices are to be provided in electronic inverter units. In cases where such protection devices are operated, audible and visual alarms are to be activated at navigation bridges and at positions from which main engines are normally controlled.
(2) Functions to reduce output power of electronic inverters working before those protection devices specified in **(1)** above are to be provided in electronic inverter units. In addition, in cases where such functions are operated, audible and visual alarms are to be activated at navigation bridges and at positions from which main engines are

normally controlled. However, in cases where there are fears that semiconductor elements will totally fail within a short period of time, it is acceptable to cut off the output power of electronic inverter units.

12.3 Controls

12.3.1 General

1 It may be acceptable that only one set of floating levers or other mechanical follow-up control systems are provided.

2 The two independent control systems specified in the requirements of **12.3.1-1(2), Part 7 of the Rules** are to be so arranged that a mechanical or electrical failure in one of them will not render the other one inoperative.

3 The control systems and relevant components specified in the requirements of **12.3.1-1(2), Part 7 of the Rules** are to comply with following requirements:

(1) Wires, terminals and the components for duplicated control systems installed in units, control boxes, switchboards or bridge consoles are to be separated as far as practicable. In cases where enough separation is not practicable, separation may be achieved by means of a fire retardant plate.

(2) All electric components of the control systems are to be duplicated.

(3) In cases where a joint steering mode selector switch (uniaxial switch) is employed for both control systems, the connections for the circuits of the control systems are to be divided accordingly and separated from each other by an isolating plate or by air gap.

(4) In cases where double follow-up controls are arranged (Refer to **Fig. 7.12.3.1-2**), the follow-up amplifiers are to be designed and independently supplied so as to be electrically and mechanically separated. In cases where both non-follow-up controls and follow-up controls are arranged, the follow-up amplifiers are to be protected selectively. (Refer to **Fig. 7.12.3.1-3**)

(5) Control circuits for additional devices, e.g. steering lever or autopilot, are to be arranged for all-pole disconnection. (Refer to **Fig. 7.12.3.1-1** to **Fig. 7.12.3.1-3**)

(6) In respect to control systems, in cases where feed-back units and limit switches are arranged, such devices are to be separated electrically and mechanically and connected to the rudder stock or rudder actuator separately.

(7) Hydraulic system components in the power actuating or hydraulic servo systems controlling the power systems of the steering gear (*e.g.* magnetic valves, etc.) are to be duplicated and arranged separately. In cases where there are two or more separate power units and the piping to each power unit can be isolated, the hydraulic system components in the control systems that are part of a power unit may be regarded as being duplicated and separated.

4 The control systems specified in the requirements of **12.3.1-1(2), Part 7 of the Rules** are to be provided with the following **(1)** and **(2)** failure detection functions:

(1) At least the following failures that may cause reduced or erroneous system performance are to be detected. In such cases, visible and audible alarms are to be given on the navigation bridge in the event of all failures:
   (a) Power supply failure
   (b) Loop failure in closed loop systems, both command and feedback loops
   (c) In cases where programmable electric systems are used:
      i) Data communication errors
      ii) Computer hardware and software failures
   (d) Hydraulic locking considering order given by steering wheel or lever

(2) In cases where, the above **(1)(b)** and **(c)** are not able to be detected due to the characteristics of the rudder, the monitoring of the following may be accepted as an alternative measure. In such cases, visible and audible alarms indicating rudder failure are to be given on the navigation bridge when detecting critical deviations between rudder order and response. All electric components of the control systems are to be duplicated.
   (a) Actual rudder positions are to follow the set value.
   (b) Actual rudder positions are to reach a set position within acceptable time limits.
   (c) The end actual position is to corresponded to the set value within the design offset tolerances.

5 Measures which result in the least critical of any new possible conditions by the most probable failures are to be provided for the control systems specified in the requirements of **12.3.1-1(2), Part 7 of the Rules**.

6 Amplifiers, relays, etc., included in control systems may also be used for automatic pilot systems.

7 For electrohydraulic steering gears equipped with power units comprising variable-displacement pumps, two sets each of hydraulic servo cylinders and associated hydraulic systems (including pump driving electric motors and control equipment) or electric servo motors for controlling displacement of pump plungers are to be provided.

8 In general, the following cases are not considered to be one of the cases "where hydraulic locking, caused by a single failure, may lead to loss of steering" that is specified in **12.3.1-4, Part 7 of the Rules**.

(1) Steering systems with performance at least equal to that required for auxiliary steering gear are fitted as stand-by systems and are operable from navigation bridges. In such cases, stand-by systems are to be designed so that they do not run parallel using interlocking devices, etc.

(2) Not less than 3 systems are operated parallel and, in the case of a single failure, steering capability at least equal to that required for auxiliary steering gears is maintained.

(3) Steering gears designed to avoid leading to any loss of steering by automatically by-passing failed systems using duplicated control valve systems. These arrangements are subject to special consideration with respect to any reduced reliability due to increased complexity.

9 Those "audible and visual alarms, which identify failed systems" specified in **12.3.1-4, Part 7 of the Rules**, are, in general, to be activated under the following conditions:

(1) In cases where positions of variable displacement pump control systems do not correctly respond to given commands.

(2) In cases where incorrect positions of 3-way full flow valves or similar constant delivery pump systems are detected.

10 The location of sensors for those alarms specified in the aforementioned **-9**, are to be as near as possible to actuators. However, in cases where two or more pumps are mechanically interconnected by floating bars or by similar devices, special consideration does not need to be given to their breakage. An example of some acceptable locations of alarm sensors is given in **Fig. 7.12.3.1-4**.

12.3.2 Change-Overs from Automatic to Manual Steering

1 At any rudder angle, change-overs from automatic to manual steering are to be available within 3 *seconds* and at most take two control operation attempts.

2 Change-overs from automatic to manual steering are to be available under any circumstances including cases of automatic pilot failure.

3 Devices to change-over from automatic to manual steering are to be installed close to positions where steering devices are normally operated.

12.4 Materials, Constructions and Strength of Steering Gears

12.4.7 Tillers, etc.

1 In cases where scantlings of arms are reduced in accordance with **12.4.7-2(4), Part 7 of the Rules**, the following requirements are to be complied with:

(1) For the tillers designed so that equal torque is applied on each arm:
Required values of Z_{TA} and A_R specified in **12.4.7-2(2)** and **(3), Part 7 of the Rules** respectively, may be multiplied by 1/*n*. In this case "*n*" means the number of arms.

(2) For the tillers designed so that unequal torque is applied on each arm:
Required values of Z_{TA} and A_R specified in **12.4.7-2(2)** and **(3), Part 7 of the Rules** respectively, may be multiplied by α . In this case " α " means the ratio of the torque applied to the arm to the total torque.

2 The wording "to the satisfaction of the Society" specified in **12.4.7-5, Part 7 of the Rules** means to comply with the requirements specified in the **Appendix C1** "Reference Data for Design", **Part C of the Guidance for the Survey and Construction of Steel Ships**.

3 Scantlings of tillers for the exclusive use of auxiliary steering gear are to be of a strength that is more than 1/2 of that specified in the requirements of **12.4.7-2, Part 7 of the Rules**.

12.4.9 Buffers

Steering gears using steering chains and rods are to be designed so that spring buffers are not be closed solid at loads that are 7/8 of the proof test load of such steering chains.

12.5 Testing

12.5.2 Tests after Installation On Board

The wording "steering gear is designed to avoid any hydraulic locking" specified in **12.5.2-3, Part 7 of the Rules** means those steering gears designed not to run parallel using interlocking devices, etc. In the case of steering systems where hydraulic locking is not anticipated to occur because mechanical linkages of floating bar or similar which the considerations of breakages are waived have been provided, these demonstrations may be omitted.

Fig. 7.12.3.1-1 Example Layout of Control Systems with Double Non Follow-up Control and Autopilot or Other Additional Control

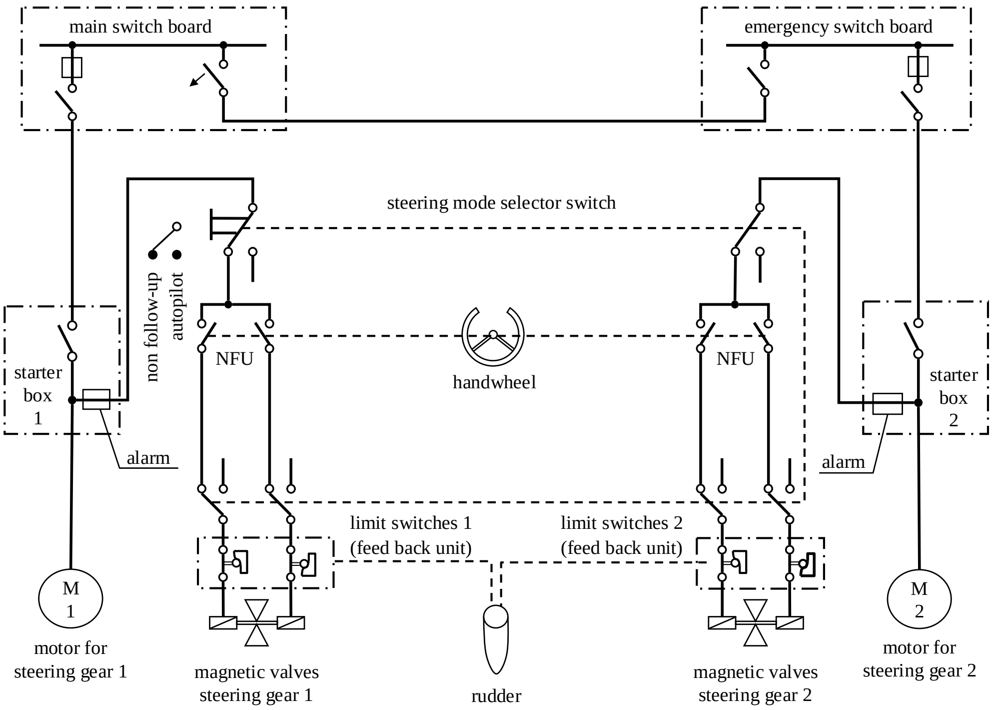


Fig. 7.12.3.1-2 Example Layout of Control Systems with Double Follow-up Control and Autopilot or Other Additional Control

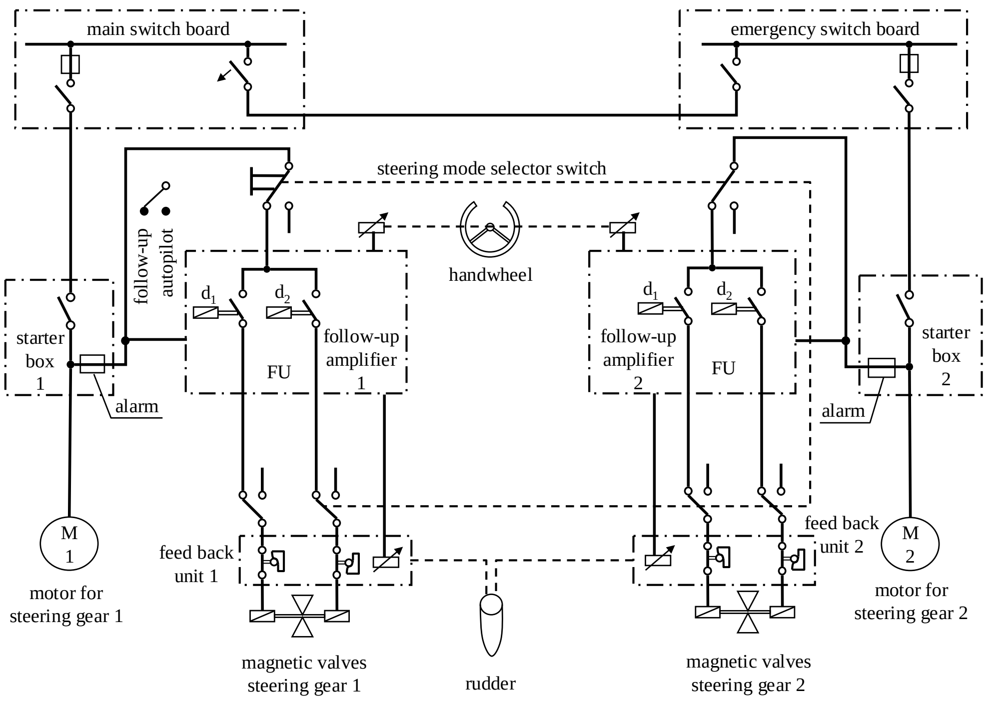


Fig. 7.12.3.1-3 Example Layout of Control Systems with Double Non Follow-up Control, Follow-up Control and Autopilot or Other Additional Control

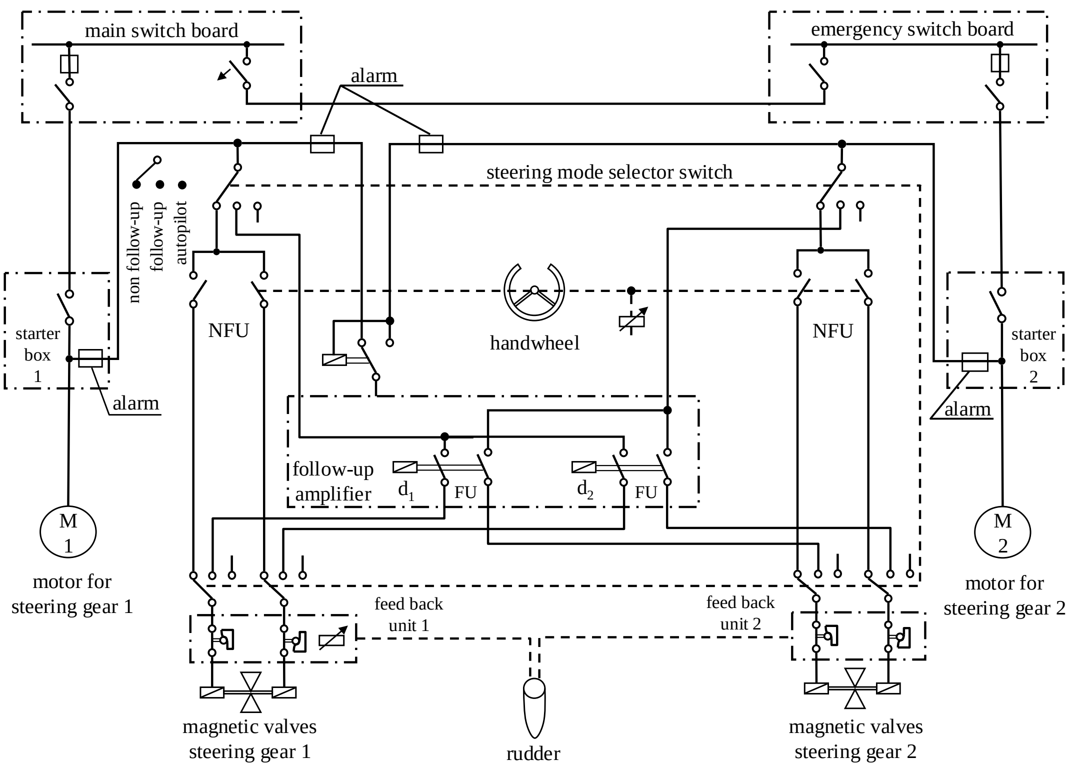
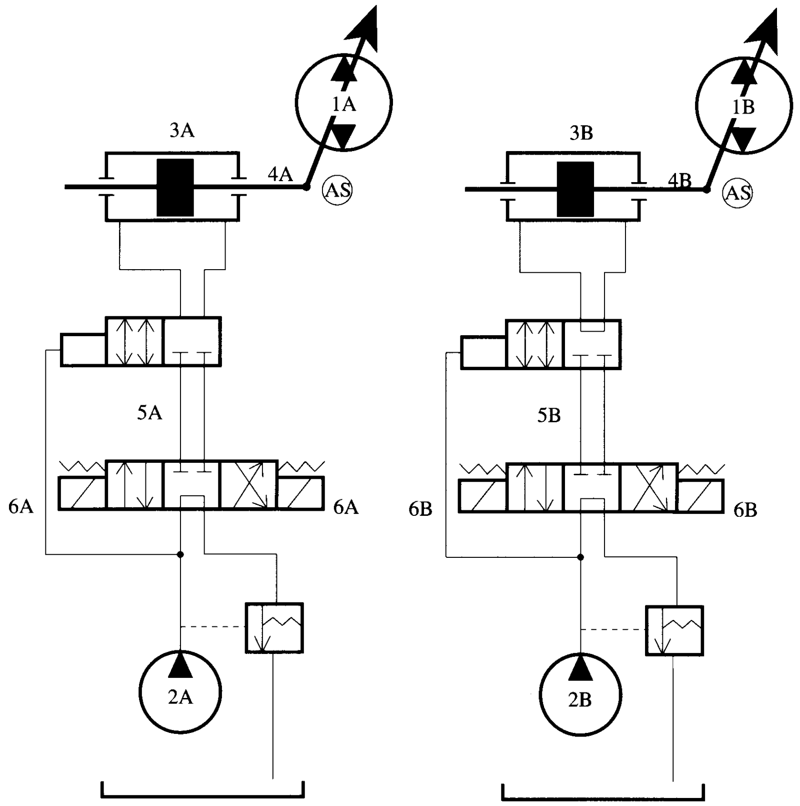


Fig. 7.12.3.1-4 Example Layout of Hydraulic Locking Alarm Sensors



(a) Separated system

AS denotes location of alarm sensors

1 Main pump of variable displacement type.

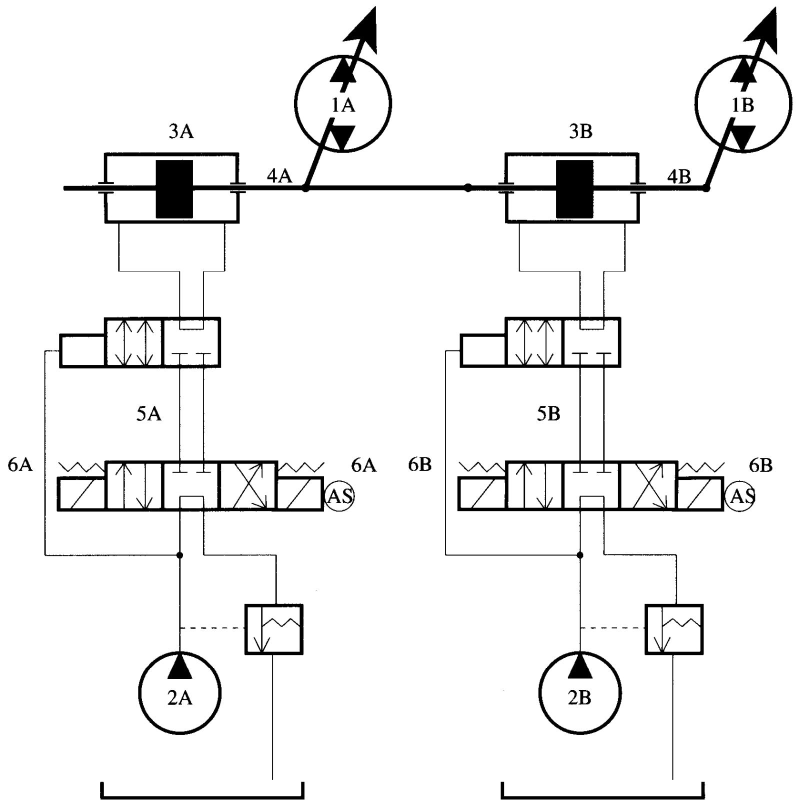
2 Pilot pump.

3 Control actuator.

4 Control linkage.

5 Solenoid controlled 3-way valve.

6 Solenoid.



(b) Mechanically interconnected system

(Note)
Where systems are so designed not to run 1A & 1B in (a) nor 2A & 2B in (b), the alarm devices are not required.

Chapter 14 AUTOMATIC AND REMOTE CONTROL

14.1 General

14.1.1 Scope

In cases where dynamic positioning systems (DPS), which are regarded as part of the automatic and remote control systems of main propulsion machinery, are installed, the requirements of **Chapter 14, Part 7 of the Rules** are to apply.

14.1.3 Drawings and Data

The drawings and data stipulated in **14.1.3(6), Part 7 of the Rules** refer to the following items that are standard for systems categorized as Categories II and III in **Table 7.14.1**. With respect to those automatic devices and equipment which have been already approved by the Society, only data on parts that differ from ship to ship need to be submitted.

(1) Hardware description
  (a) System block diagrams, showing the arrangement, input and output devices and interconnections
  (b) Connection diagrams including data communication, electrical power circuit diagrams
  (c) Back-up systems and back-up procedures
  (d) Protections against power failure and procedures for restarting the system after recovery of power

(2) Software description
  (a) Operating Systems and data communication software
  (b) Intended functions
  (c) Application software, control logic
  (d) Detailed descriptions of control and monitoring equipment, and safety systems

(3) Quality control of software
  (a) Quality standards
  (b) A quality plan for software lifecycle
  (c) Quality assurance procedures in production

(4) Documentation of software modification
Work procedures for modifying program contents and data including upgrades

(5) Failure analysis for systems
  (a) Verification process and results (including counter measures) by failure analysis methods such as FTA, FMEA and FMECA
  (b) Evidence that the failure of a system of Category I will not impact human safety, safety of the vessel, or the environment

(6) Engineering analysis
In accordance with requirements specified in **7.14.2.7-1, Part 7 of the Rules**, an engineering analysis deemed appropriate by the Society in cases where alternative designs or arrangements are used.

(7) Test procedures for hardware
Procedures according to the requirements of **7.14.7.1, Part 7 of the Rules**

(8) Test procedures for software
Procedures to verify that systems interact correctly to perform the intended functions and do not perform unintended functions (the test is carried out in each module, subsystem and whole system, if necessary)

(9) Test procedures to verify the integration of systems at factory (including failure simulation)
  (a) Operation test procedures for the completed system combining actual hardware and finalized software which were verified according to **(7)** and **(8)**
  (b) Confirmation method for the adequacy of the results of failure analysis methods such as FTA, FMEA and FMECA

(10) On-board test procedures

(a) Operation test procedures on board of the systems after installation of the software
(b) Verification test procedures related to the electromagnetic effects of at least the following in cases where wireless data communication systems are to be installed.
i) The electromagnetic effects of the wireless data communication system on other equipment.
ii) The effects of electromagnetic interference expected during normal operation on the wireless data communication system.

(11) Detailed descriptions of system modifications and their verification test procedures (where the modification influences the functionality or safety of the systems)
(12) Description of the wireless data communication system
(a) Details of the manufacturer recommended installation and maintenance practices
(b) Network plans (including the arrangement of all system devices) as well as the identification of the type and location of all antennas
(c) Specifications of wireless communication system protocols and management functions (refer to **14.2.7-4(2), Part 7 of the Rules**)
(d) Details of radio frequencies and power levels
(e) Evidence for approval of use from Society in accordance with **Chapter 1, Part 7 of "Guidance for the Approval and Type Approval of Materials and Equipment for Marine Use."**

(13) Spare parts and replacement procedures

14.2 System Design

14.2.6 Safety Systems

1 In the requirements specified in **14.2.6-2(1), Part 7 of the Rules**, the alarms issued when the fuel oil shut-off device comes into action under the conditions of **9.9.10-1(1)** through **(3), Part D of the Rules for the Survey and Construction of Steel Ships** are to be capable of distinguishing the cause of alarm condition.

2 Safety systems of those automatic reignition burning systems meeting the requirements in **14.4.2-2, Part 7 of the Rules** may not conform to the requirements in **14.2.6-2, Part 7 of the Rules** in the cases specified in **9.9.10-1(1)** and **(2), Part D of the Rules for the Survey and Construction of Steel Ships**.

14.2.7 Computers and Computerized Systems

1 Examples of computerized systems relevant to **Table 7.14.1, Part 7 of the Rules** are shown in the **Table 7.14.2.7-1**. Where independent effective backup or other means of averting danger is provided, a Category III system may be downgraded to Category II.

2 The computers "considered necessary by the Society" specified in **14.2.7, Part 7 of the Rules** means those used for the following systems in general. In this case, programmable controllers such as sequencers are included.

(1) Control systems for the machinery and equipment specified in **14.1.1-1(1)** through **(5), Part 7 of the Rules**.
(2) Alarm systems specified in **14.2.5, Part 7 of the Rules**.
(3) The safety systems for the machinery and equipment specified in **14.1.1-1, Part 7 of the Rules**
(4) Control systems, alarm systems and safety systems relevant to **Table 7.14.1, Part 7of the Rules**

3 The wording "requirements deemed appropriate by the Society" specified in **14.2.7-1, Part 7 of the Rules** means those cases where an alternative design or arrangement is used and the results of an engineering analysis conducted in accordance with relevant international or national standards acceptable to the Society are satisfactory and approved by the Society.

4 "The extent of effect due to a failure of part of circuits or components is limited to a minimum" specified in **14.2.7-2(2)(a), Part 7 of the Rules** means, for example, that in a system always controlled by two or more computers, the system can be made to cope with the failure of one computer without hindering performance.

5 The requirements "deemed appropriate by the Society" specified in **14.2.7-2(3)(a), Part 7 of the Rules** mean that the results of a failure analysis such as FMEA on the system are satisfactory and approved by the Society.

6 "Back-up means" specified in **14.2.7-2(3)(b), Part 7 of the Rules** refer to either of the following pieces of equipment or systems.

(1) Safety systems that do no rely on computers
(2) Stand-by computers

7 “Other arrangements deemed appropriate by the Society” specified in **14.2.7-2(3)(c), Part 7 of the Rules** means, for example, the combination of a VDU and an alarm printer.

8 “Requirements deemed appropriate by the Society” specified in **14.2.7-2(4), Part 7 of the Rules** means the following.

(1) In cases where secondary control systems or stand-by computers are installed for those control systems specified in **-2(1)** above, the independence of such control systems may not be required for individual machinery or equipment. In such cases, local control equipment fitted to main propulsion machinery in accordance with the requirements given in **14.3.2-3(2), Part 7 of the Rules** may not be regarded as the secondary control systems.

(2) In cases where safety systems conform to the requirement given in **-6**, the independence of individual machinery and equipment in systems, and their independence from other systems may not be required.

(3) In cases where secondary systems or stand-by computers are installed in both control systems and safety systems, the independence of individual machinery and equipment in their systems including alarm systems, and their independence from the other systems may not be required.

9 The wording “requirements deemed appropriate by the Society” specified in **14.2.7-4, Part 7 of the Rules** means that the results of the engineering analysis specified in **-3** are satisfactory and approved by the Society.

10 The wording “standards deemed appropriate by the Society” specified in **14.2.7-4(3), Part 7 of the Rules** means the requirements specified by the International Telecommunications Union (ITU) and the relevant flag state.

11 “Parameters” specified in **14.2.7-5(2), Part 7 of the Rules** means those settings specified in the relevant chapters of the equipment specified in **14.1.1-1, Part 7 of the Rules**.

Table 7.14.2.7-1 Examples of Computerized Systems

Category	Examples
I	- Maintenance support systems - Information and diagnostic systems
II	- Alarm and monitoring systems - Main propulsion remote control systems - Governor control systems - Control systems for auxiliary machinery - Bilge systems - Other systems considered necessary by the Society
III	- Control systems for propulsion with steering - Electronic fuel injection systems for main diesel engines - Burner control systems (for those main boilers and essential boilers defined in **7.1.2(2), Part 7 of the Rules**) - Power supply control systems - Other systems considered necessary by the Society

14.3 Automatic and Remote Control of Main Propulsion Machinery or Controllable Pitch Propellers

14.3.1 General

The requirements given in **14.3, Part 7 of the Rules** may not apply to local control handle which are transferred from the engine sides of main propulsion machinery to the main control stations located inside the same space where such main propulsion machinery is installed and not separated by walls.

14.3.2 Remote Control Devices for Main Propulsion Machinery or Controllable Pitch Propellers

1 The wording “alarm devices necessary for the control” specified in **14.3.2-1(6), Part 7 of the Rules** means the following **(1)** to **(3)**:

(1) Alarm systems activating in the following cases:

(a) Pressure drops of lubricating oil

(b) Pressure drops of cooling water, or temperature rises of cooling water or the stopping of cooling water pumps

(c) Pressure drops of hydraulic oil or compressed air, or failures of the electric power for remote controls
(d) Activation of emergency stopping devices

(2) Alarm devices activating in the following cases in addition to those specified in **(1)**, in the case of ships which have propulsion motors as their main propulsion machinery:
(a) Electric insulation resistance drops in power supply circuits
(b) Abnormal stopping of the cooling fans of semiconductor converters
(c) Pressure drops of cooling water, temperature rises or the stopping of the cooling water pumps of semiconductor converters
(d) Activation of the semiconductor protection devices of semiconductor converters

(3) Visual alarms capable of distinguishing the machinery and equipment and the kinds of abnormal conditions specified in **(1)** and **(2)** above
However, in the case of ships capable of remote control from bridges and other places, the requirements may be dispensed with for visual alarms on bridges. Furthermore, in cases where such distinction can be readily made by other instruments in engine rooms, the requirements may be also dispensed with.

2 In the case of ships which have steam turbines as main propulsion machinery, automatic opening devices for astern intermediate valves in the case of astern maneuvering conditions are to be provided as parts of those remote control systems specified in **14.3.2-1(1), Part 7 of the Rules**.

3 In cases where the control handles of main propulsion machinery are installed in main control stations located inside the same space where such main propulsion machinery is installed and separated by walls, local control handles fitted beside such main propulsion machinery may be dispensed with.

4 "Failure of remote control systems of main propulsion machinery or controllable pitch propellers" specified in **14.3.2-3, Part 7 of the Rules** means the following:
(1) Loss of the power supply sources (electric, pneumatic or hydraulic power) of remote control systems
(2) Failure of computers in cases where computerized systems are adopted

5 With respect to those requirements specified in **14.3.2-4, Part 7 of the Rules**, even though low pressure alarms for main engine starting air reservoirs are activated before the required number of starts specified in **2.5.3-2, Part 7 of the Rules** has not been completed, engines are to be capable of being started from remote controls station and to complete the required number of starts after activating such alarms.

6 In application of the requirements given in **14.3.2-3(5), Part 7 of the Rules**, in cases where emergency stop devices are set into electrical systems and operated by electrical power, loss of power and discontinuity are to be monitored.

14.3.3 Bridge Control Devices

1 It is recommended that the operating handles or buttons of bridge control devices be linked with engine room telegraphs.

2 In **14.3.3(3), Part 7 of the Rules**, a period of about 5 *seconds* may be needed to assess navigational circumstances.

3 The following may be considered as examples of those "cases where the total failure of main propulsion machinery will occur within a short period of time" given in **14.3.3(4)(b), Part 7 of the Rules**:
(1) Over-speed
(2) Abrupt pressure drops of lubricating oil to main bearings

14.3.4 Safety Measures

The interlocking devices on the remote control systems for main propulsion machinery are to be provided as the "necessary interlocking devices" specified in **14.3.4-1(1)(a), Part 7 of the Rules**, so as not to start main propulsion machinery under the following conditions:
(1) Engaged condition of turning gear
(2) Pressure drops of lubricating oil

14.7 Tests

14.7.1 Shop Tests

1 The wording "automatic or remote control systems of machinery and equipment, considered necessary by the

Society” specified in **14.7.1, Part 7 of the Rules** generally means those electronic control devices used for main propulsion machinery, and the machinery and equipment as given in **Table 7.14.7.1-1** installed in ships intended to be registered as electric motor propulsion ships.

2 The wording “The procedures for these tests are to be deemed appropriate by the Society” specified in **14.7.1(1), Part 7 of the Rules** means those procedures in accordance with **Chapter 1, Part 7 of “Guidance for the Approval and Type Approval of Materials and Equipment for Marine Use.”**

Table 7.14.7.1-1 Automatic equipment and devices subject to Environmental Tests

Automatic equipment	Monitoring and alarm devices for machinery Remote control devices for main propulsion machinery Control devices for boilers Control devices for electric generating sets
Automatic devices	Sensors (temperature, pressure, number of revolution, etc.) Indicators (electrical types only) Annunciators Control equipment Computers Sequencers Power supply units (containing electronic components)

Chapter 15 BARGES

15.2 Internal Combustion Engines

15.2.2 Safety Devices

1 Internal combustion engine to drive a generator and having a maximum continuous output of not less than 220 *kW*, is to be provided with a overspeed protective device so adjusted the engine speed from being exceeded by more than 15% of the maximum continuous revolutions. This overspeed protective device and its driving gear are to be independent from the governor specified in **5.4.1, Part 8 of the Rules**.

2 Internal combustion engine having a cylinder diameter of not less than 230 *mm* is to be provided with relief valves or warning devices specified in **2.4.2, Part 7 of the Rules**. Internal combustion engine having a cylinder diameter of not less than 200 *mm* is to be provided with relief valves at the crankcases specified in **2.4.3, Part 7 of the Rules**.

15.4 Auxiliaries and Piping Arrangement

15.4.1 Pressure Pipes and Pipe Connections

Strength of the pipes subjected to the internal pressure is to be in accordance with the requirements in **10.2.2-1, Part 7 of the Rules**. Direct connection of pipe lengths and connection of pipes with flanges are to be in accordance with the requirement in **10.4.2** and **10.4.3, Part 7 of the Rules**.

15.4.7 Bilge Systems

1 The capacity of the power bilge pumps specified in **15.4.7-3, Part 7 of the Rules** is not to be less than Q obtained from the following formula, even where one of the pumps becomes out of use.

$$Q = 5.75d^2 \times 10^{-3} \quad (m^3/h)$$

$$d = 1.68\sqrt{L(B+D)} + 25 \quad (mm)$$

Where:

L, B and D : The length, breadth and depth of the barge, respectively (m)

2 The diameter of the bucket cylinder of the manual bilge pump is not to be less than d' obtained from the following formula.

$$d' = lBD/142 + 100 \quad (mm)$$

Where:

d' : The diameter of the bucket cylinder (mm)

l : Length of the compartment to be drained by the manual pump (m)

Other symbols are the same as in **-1**.

15.6 Tank Barges

15.6.1 General

Tank barges with double bottoms

In cases where tank barges with double bottoms use the spaces underneath their cargo oil tanks for purposes other than holding cargo oil, the requirements specified in **Chapter15, Part 7 of the Rules** as well as the following requirements specified in this**15.6.1** are to be complied with:

(1) Air pipes and sounding pipes provided in double bottoms may pass through cargo oil tanks. In this case, all pipe joints in such cargo oil tanks are to be welded joints of sufficient thickness according to the requirements of **Table 7.10.6, Part 7 of the Rules**. Furthermore, consideration is to be given to piping arrangements for the expansion and contraction of the pipes.

(2) Valve operating rods are not to pass through any part subjected at all times to liquid head, such as the inner

bottom plates of cargo tanks.

(3) Notwithstanding the requirements of **15.6.8, Part 7 of the Rules**, ballast pipes are not to pass through any spaces within cargo oil tanks.

15.6.3 Arrangement of Cargo Oil Piping Systems

1 "All cargo oil tanks and cargo piping systems" in **15.6.3-7, Part 7 of the Rules** includes the following tanks and cargo oil piping systems specified in following **(1)** to **(4)**:

(1) Cargo oil pipes, vent pipes, tank washing pipes, etc.;

(2) Cargo tanks which are electrically separated from the hull of the ship (*e.g.*, independent cargo oil tanks);

(3) Pipe connections arranged for the removal (*e.g.*, spool pieces); and

(4) Wafer-style valves with non-conductive (*e.g.*, PTFE) gaskets or seals.

2 For the purpose of the requirements in **15.6.3-7, Part 7 of the Rules**, earthing is to conform to the requirements of **2.1.4, Part 8 of the Rules** and the resistance between cargo oil tanks/cargo piping systems (cargo oil pipes, vent pipes, tank washing pipelines, etc.) and the hull is to be not greater than 1 $M\Omega$.

15.6.4 Alternative Use of Tanks

1 Cargo oil tanks also used as segregated ballast tanks

In cases where tanks alternate between being used as cargo oil tanks and segregated ballast tanks, the related cargo oil pipes, ballast pipes and vent pipes are to be arranged, as shown in **Fig. 7.15.6.4-1**, so that they can be switched for each respective case.

Furthermore, for other piping systems, the requirements for the piping systems in cargo oil tanks are to be complied with.

2 Cargo oil tanks also used as fuel oil tanks

In cases where tanks alternate between being used as cargo oil tanks and fuel oil tanks, all related cargo oil pipes, fuel oil pipes and vent pipes are to be arranged, as shown in **Fig. 7.15.6.4-2**, so that they can be switched for each respective case.

Furthermore, for other piping systems, the requirements for the piping systems in cargo oil tanks are to be complied with.

Fig. 7.15.6.4-1 Example of Piping Arrangements for Tanks Alternatively Used as Cargo Oil Tanks and Segregated Ballast Tanks

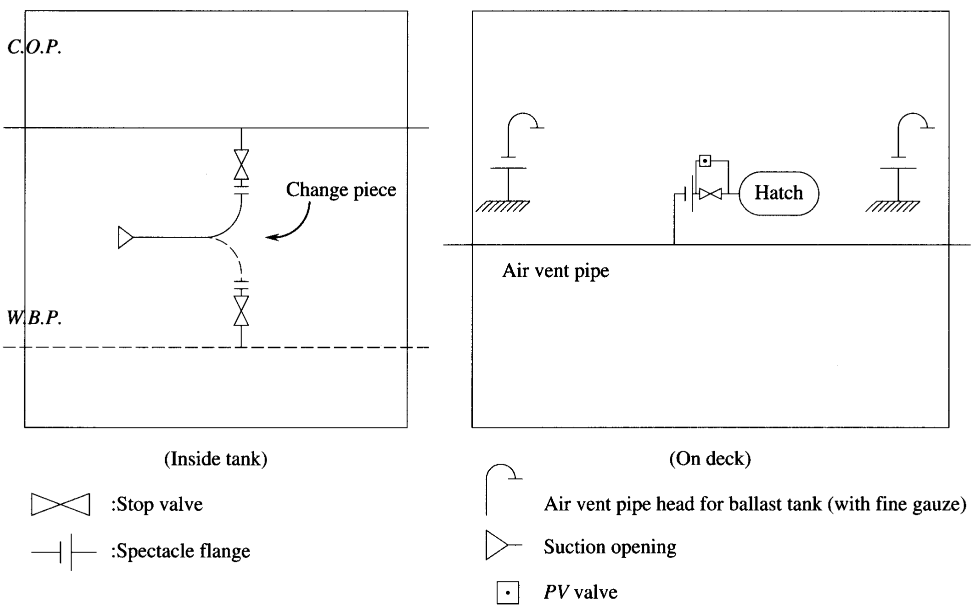
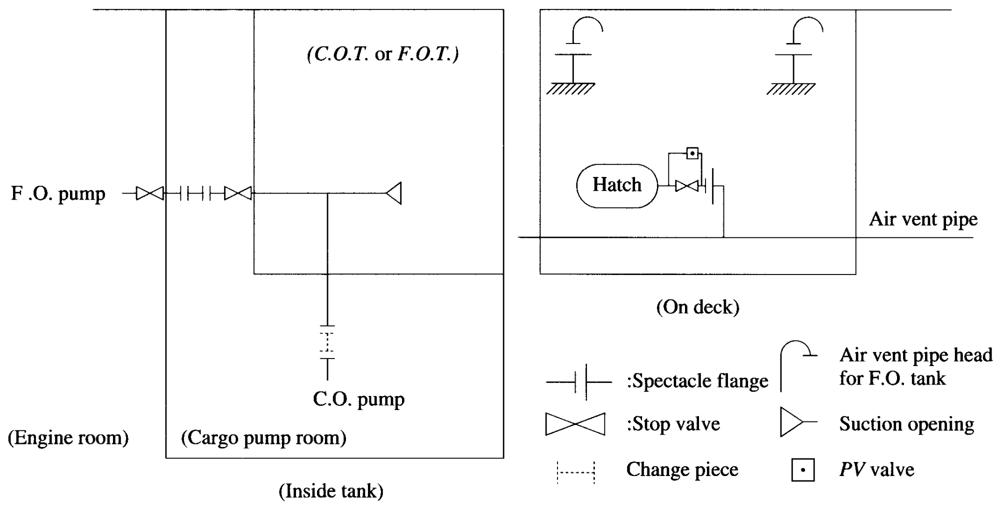


Fig. 7.15.6.4-2 Example of Piping Arrangements for Tanks Alternatively Used as Cargo Oil Tanks and Fuel Oil Tanks



15.6.5 Separation of Cargo Oil Pumps and Cargo Oil Pipes

Piping systems to be connected to cargo oil piping are to be dealt with under the following requirements:

(1) Pumps and pipes in any piping systems connected to cargo oil pipes are to be dealt with in the same manner as those in cargo oil piping systems. However, for those piping systems specified in **15.6.3-4**, **15.6.10-6**, and **15.6.14-2**, **Part 7 of the Rules** and item **(2)** below, this requirement may be dispensed with. Piping systems connected to cargo oil piping means those connected to cargo oil pipes, and those piping systems having openings thereto. Accordingly, hydraulic oil pipes for controlling cargo oil piping systems, for example, are not regarded as a piping system connected to the cargo oil piping.

(2) In cases where cargo oil piping systems are connected to the following piping systems:

(a) Tank vent pipes

The requirements in **35.2.7-7** and **-8**, **Part R of the Rules for the Survey and Construction of Steel Ships** are to be complied with. In addition, ventilating fans, except for inert gas blowers, are to be installed within hazardous area.

(b) Pressure gauge pipes for cargo oil piping systems (including pumps)

Pressure gauges to which cargo oil is directly led are to be installed in pump rooms or on weather decks. However, in cases where stop valves are provided at joints between pressure gauge piping systems and cargo oil piping systems, and in cases where bulkhead valves are provided at locations where such pipes penetrate bulkhead between engine rooms and pump rooms, pressure gauges may be installed in engine rooms.

(c) Pipes for measuring oil content

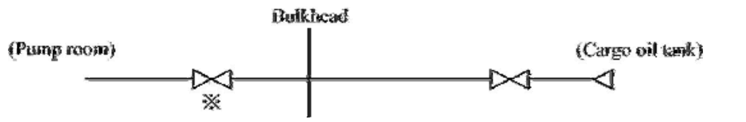
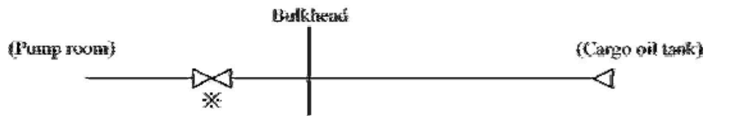
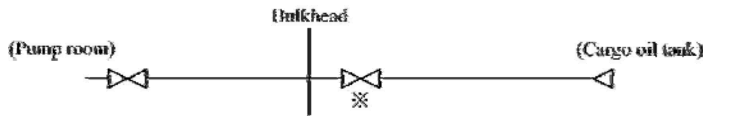
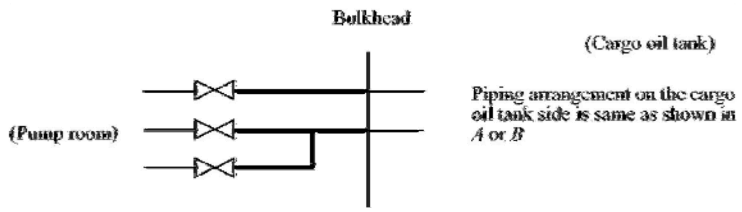
Sampling pipes for measuring oil content may be led to spaces other than hazardous area, in cases where such pipes have nominal diameters of 25*A* or less and in cases where two or more stop valves are provided between cargo oil piping and the penetration of the casing of non-hazardous area.

15.6.6 Bulkhead Valves of Cargo Oil Piping Systems

1 The arrangement and type of bulkhead valves are to be as given in **Table 7.15.6.6-1**.

2 Those piping systems, according to **15.6.5(1)**, that are not being used for transferring cargo fuel oil, in cases where the requirements for cargo fuel oil piping are being applied, may be fitted with remote control devices, specified in **15.6.6-2, Part 7 of the Rules**, that are used only for closing. (*e.g.*, slop tanks or oil concentration detecting cocks fitted to the walls of pump rooms)

Table 7.15.6.6-1 Arrangement and Type of Bulkhead Valves

Arrangement *A*		In cases where stop valve is provided at the end of opening in the cargo oil tank: No specific requirements are imposed on type and material of bulkhead valve.
Arrangement *B*		In cases where no stop valve is provided at the end of opening in the cargo oil tank: The bulkhead valve is to be of steel castings and be operable from a control position on deck.
Arrangement *C*		In cases where bulkhead valve is provided in the cargo oil tank: The valve on the tank side is to be operable from a control position on deck.
Arrangement *D*		In cases where bulkhead valve is not provided close to the bulkhead: If those indicated with bold lines in the figure are of cast steel pipes having thickness of 13.5 *mm* or more or of heavy gauge steel pipes of 16 *mm* or more, the requirements for bulkhead valves as shown in Arrangement *A* or *B* may be accepted.

Note:
※ This valve is to be installed as close to the bulkhead as practicable

15.6.8 Piping in Cargo Oil Tanks

1 Ballast pipes

In cases where ballast pipes passing through cargo oil tanks are led to ballast tanks located afore of collision bulkheads, the requirements in **15.6.14-1(2)** are to be complied with.

2 Pipes for measuring instruments and remote control equipment

Steel pipes for measuring instruments and remote control equipment provided in cargo oil tanks are to have minimum thickness of Schedule 80, except in cases where such pipes have openings inside cargo oil tanks.

3 Scupper pipes and sanitary pipes

All pipe joints of scupper pipes and sanitary pipes passing through cargo oil tanks are to be welded joints. In addition, scupper pipes or sanitary pipes in spaces containing sources of ignition such as accommodation space are not to pass through cargo oil tanks.

4 Overboard discharge pipes (bilge or ballast pipes)

(1) Overboard discharge pipes passing through cargo oil tanks are to be dealt with under the following requirements **(a)** to **(d)**:

(a) Overboard discharge pipes are not to pass through the cargo oil tanks other than those having a relatively small capacity (*e.g.*, slop tanks, etc.).

(b) Such pipes in cargo oil tanks are to be short in length and all pipe joints in cargo oil tanks are to be welded joints. In cases where cast steel pipes are used, pipe thickness may be 15 *mm* or more.

(c) Internal surfaces of pipes are to be coated with paints having good corrosion resistance properties, except in cases where cast steel pipes specified in **(b)** above or steel pipes of an adequate thickness that make allowances for corrosion are used.

(d) No valves are to be provided in cargo oil tanks.

(2) Notwithstanding **(1)** above, in the case of tankers other than double hull tankers, overboard discharge pipes passing through cargo oil tanks are to be dealt with under the following requirements in **(a)** to **(e)**:
   - (a) Overboard discharge pipes are not to pass through the cargo oil tanks other than those having a relatively small capacity (*e.g.*, slop tanks, etc.).
   - (b) All pipe joints in cargo oil tanks are to be welded joints. In cases where cast steel pipes are used, pipe thickness may be 15 *mm* or more.
   - (c) Bent pipes are to be provided adequately to absorb any expansion and contraction of the pipe line.
   - (d) Internal surfaces of pipes are to be coated with paints having good corrosion resistance properties, except in cases where cast steel pipes specified in **(b)** above or steel pipes of an adequate thickness that make allowances for corrosion are used.
   - (e) No valves are to be provided in cargo oil tanks.

15.6.9 Sounding Devices of Cargo Oil Tanks

1 The sounding device of cargo oil tanks is to be of the construction capable of measuring the ullage without opening the tank hatch cover. In cases where ullage hatches are provided, hatch closing devices are to be in accordance with the requirements of **3.5.4-4, Part 9 of the Rules**.

2 In cases where sounding pipes are provided, any open ends are to be led to the weather deck and to be provided with pipe heads having sluice valves or cocks which are fitted with automatic closing devices. However, for those sounding pipes with pipe diameters of 50 *mm* or less, screw-down type plugs and sluice valves or cocks which are not fitted automatic closing devices may be accepted.

3 In cases where level indicating devices are provided for those sounding devices specified in **15.6.9, Part 7 of the Rules**, such devices are to be of a type approved by the Society. However, when a device conforms to other standards approved by the Society or when it is provided with a certificate recognized by the Society, these requirements do not apply.

15.6.13 Bilge Piping Systems, etc. for Cargo Oil Pump Rooms and Cofferdams adjacent to Cargo Oil Tanks

The open ends of sounding pipes may be provided in pump rooms. However, in cases where any open ends are lower than the bulkhead deck, the requirements in **3.2.2(3)(e)(i), Part 9 of the Rules** are to be complied with.

15.6.14 Ballast Tanks adjacent to Cargo Oil Tanks

1 Ballast piping systems of the forward ballast tanks, etc. (**15.6.14-1, Part 7 of the Rules**)

Ballast piping systems, etc. serving ballast tanks whose forward end is located afore of collision bulkheads and are adjacent to cargo oil tanks (hereinafter referred to as “forward ballast tanks”) are to be in accordance with the following requirements in addition those in **15.6.14-2** to **15.6.14-4, Part 7 of the Rules**. However, ballast piping systems, in cases where they are as specified in the following **(2)** or **(3)** and serve ballast tanks which are not adjacent to cargo oil tanks, but whose forward end is located afore of collision bulkheads, are considered to be piping systems of forward ballast tanks and, therefore, are to be in accordance with the requirements for forward ballast tanks.

(1) Arrangements are to be made so that any ballast water in forward ballast tanks, except for those cases specified in the following **(2)** or **(3)**, can be ballasted/deballasted by pumps located in the forward part of the cargo tanks.

(2) In cases where ballast pipes of forward ballast tank are led to ballast pumps by passing through cargo oil tanks, except in cases where prohibited by **15.6.8, Part 7 of the Rules** or **15.6.1**, the following requirements are to be complied with:
   - (a) Flange joints with a nominal pressure less than 1 *MPa* are not to be used for pipe joints.
   - (b) Stop valves are to be provided afore of collision bulkheads in addition to those bulkhead valves specified in **11.2.5-2, Part 7 of the Rules**.
   - (c) Ballast pumps are to be provided in cargo oil pump rooms or other subdivisions that are without sources of ignition.
   - (d) The requirements of **(a)** to **(e)** in the following **(3)** are to be complied with.

(3) In cases where ballast pipes of forward ballast tanks are led to other ballast piping systems serving ballast tanks which are adjacent to cargo oil tanks, the following requirements are to be complied with:
   - (a) In applying the requirements specified in **Part 8 of the Rules**, forward ballast tanks are to be considered to be hazardous areas as specified in **4.2.1(2)(c), Part 8 of the Rules**.

(b) Vent pipe openings provided for forward ballast tanks are to be located on open decks at an appropriate distance of not less than 3 *m* away from any sources of ignition. In addition, the area around such vent pipe openings is defined as a hazardous area in accordance with **4.2.1(2)(i), Part 8 of the Rules** and **4.2.1(3)(a), Part 8 of the Rules**.

(c) Means are to be provided, on open decks, to allow measurement of the concentration of flammable gases within forward ballast tanks. In this case, such means may be a combination of portable detecting instruments specified in **3.5.8(2)(a), Part 9 of the Rules** and sampling pipes. Such sampling pipes may be those sounding pipes specified in the following **(d)** in cases where deemed appropriate by the Society.

(d) Sounding pipes provided for forward ballast tanks are to be led to open decks.

(e) Access into forward ballast tanks is to be direct from open deck. However, indirect access from open decks into the forward ballast tanks through enclosed spaces may be acceptable provided that the following **(i)** or **(ii)** is satisfied.

(i) In cases where enclosed spaces are separated from the cargo oil tanks, access into forward ballast tanks are to be a gas tight bolted manhole located in such enclosed spaces. In this case, a warning sign is to be provided at the manhole stating that the forward ballast 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.

(ii) In cases where enclosed spaces have common boundaries with the cargo tanks, such enclosed spaces are to satisfy the relevant requirements of hazardous areas and are, in addition, to be well ventilated.

2 Ballast piping systems for ballast tanks adjacent to cargo oil tanks (**15.6.14-2, Part 7 of the Rules**)

Ballast piping systems for ballast tanks adjacent to cargo oil tanks is to be dealt with under the following requirements:

(1) In cases where both those ballast tanks adjacent to forward cargo oil tanks and those ballast tanks not adjacent thereto are provided afore of forward cargo oil tanks, ballast pipes for those tanks may be led to the same ballast/deballast pumps located afore of forward cargo oil tanks, except in cases where such pipes pass through cargo oil tanks.

(2) In cases where ballast tanks adjacent to cargo oil tanks are intended to be deballasted by cargo oil pumps in an emergency, spool pieces and screw-down non-return valves are to be provided on each ballast pipe at joints with cargo oil pipes. Furthermore, a warning notice is to be posted stating that spool pieces are to be removed except for in times of emergency.

3 Air vent pipes of ballast tanks adjacent to cargo oil tanks (**15.6.14-4, Part 7 of the Rules**)

The wording "wire gauze to prevent any passage of flame" specified in **15.6.14-4, Part 7 of the Rules** means wire gauze meeting the following requirements:

(1) To be made of corrosion resisting material.

(2) To comprise either dual wire gauze with a mesh size finer than $850 \mu m$ spaced at a distance of 25.4 ± 12.7 *mm*, a single wire gauze with a mesh size finer than $500 \mu m$, or others of equivalent performance thereto.

4 Open ends of sounding pipes for ballast tanks adjacent to cargo oil tanks (**15.6.14-5, Part 7 of the Rules**)

The requirements of **15.6.13** also apply to the open ends of sounding pipes for ballast tanks adjacent to cargo oil tanks.

15.6.15 Fuel Oil Tanks adjacent to Cargo Oil Tanks

The requirements of **15.6.13** also apply to the open ends of sounding pipes for fuel oil tanks adjacent to cargo oil tanks.

15.6.16 Pump Arrangements of Forward Compartments

In applying the requirements specified in **15.6.16, Part 7 of the Rules**, pipes conveying liquid and bilge suction pipes for tanks or void spaces at forward positions of ships are to comply with the following requirements in cases where these pipes do not passing through cargo oil tanks:

(1) Pipes for tanks or void spaces adjacent to forward ends of cargo oil tanks may be led to aft pump rooms. Fuel oil transfer pipes may be led to pumps located in engine rooms.

(2) Pipes for tanks or void spaces not adjacent to cargo oil tanks may be led to pumps located in engine rooms or pumps to which neither cargo oil pipes nor dangerous ballast pipes provided in aft pump rooms are led.

Part 8 ELECTRICAL INSTALLATIONS

Chapter 1 GENERAL

1.1 General

1.1.1 Scope

1 Electrical equipment for ships operating by remote control and automatic control are to comply with the requirements given in **Part 8 of the Rules** as well as with the requirements given in **Part 7 of the Rules**.

2 The requirements given in **Part 8 of the Rules** do not apply to the following electrical equipment except in those cases where explosion-protected construction is necessary:

(1) Radiotelegraph or radiotelephone equipment provided in accordance with international law or the laws of the flag state

(2) Navigational aids provided in accordance with international law or the laws of the flag state (those prescribed in Regulations 19 and 20, Chapter V, the Annex to *SOLAS* Convention)

3 Home electrical appliances to be brought on board ships such as television sets, radio sets, table lamps, electric heaters, etc., are not included in any of the electrical installations specified in **Part 8 of the Rules**.

4 Cables, circuit breakers and fuses connected to the electrical equipment stipulated in requirements given in **-2** and **-3** above are to comply with the relevant requirements given in **Part 8 of the Rules**.

1.1.6 Drawings and Data

The wording "lists of any electrical equipment installed in such hazardous areas" specified in **1.1.6-2(2), Part 8 of the Rules** means such lists are to include the following information:

(1) The installation arrangement, kind of construction, type (including the certificate number and the name of any testing institution), manufacturer name, quantity and usage of any explosion-protected electrical equipment

(2) Relevant documents related to how conditions impact such things as ventilation ratios, pressurizations or air-locks of each type of hazardous areas in order to confirm the effectiveness of such equipment (in cases where applicable)

1.1.7 Ambient Conditions

In the case of electrical installations, except those used for automatic and remote control systems, which are installed in enclosed spaces having air conditioning units and are able to be initially set to work safely within a 45 *°C* ambient temperature, the upper limit of those ambient temperatures specified in **Table 8.1.1, Part 8 of the Rules** may be reduced to any value not less than 35 *°C* subject to the following requirements:

(1) Reduced ambient temperatures are to be controlled by at least two air conditioning units (including refrigerating units, hereinafter referred to as the same) which can work at 45 *°C* ambient temperature. In the event of the loss of any one air conditioning unit, all remaining units are to be capable of maintaining such reduced ambient temperatures.

(2) If the temperature rise over the upper limit of these reduced ambient temperatures, audible and visual alarms are to be activated at continually manned spaces, *e.g.*, navigation bridges or machinery control rooms.

1.2 Testing

1.2.1 Shop Tests

1 The wording "tests for any equipment with small capacities as specified in **(4)** and **(5)** are to be conducted as deemed appropriate by the Society" specified in **1.2.1-1, Part 8 of the Rules** means those shop tests for electrical motors whose capacities at continuous ratings are less than 100 *kW* and controlgears of those motors may be substituted for by manufacturer tests. In such cases, submission or presentation of test records may be required by the

Society.

2 Those “motors for essential services” specified in **1.2.1-1(4), Part 8 of the Rules** means those driving auxiliary machinery corresponding to auxiliary machinery essential for main propulsion, auxiliary machinery for manouevring and the safety, and auxiliary machinery for cargo handling specified in **Table 7.1.1.5-1, Part 7**.

3 The wording “subject to Society approval” in **1.2.1-3, Part 8 of the Rules** means compliance with the requirements given in **the Rules for Approval of Manufacturers and Service Suppliers**. Equipment and cables approved are made public on **the List of Approved Materials and Equipment**.

4 The wording “to be subjected to type tests” in **1.2.1-4, Part 8 of the Rules** means **Part 8 of the Guidance for the Approval and Type Approval of Materials and Equipment for Marine Use**. Equipment and cables approved are made public on **the List of Approved Materials and Equipment**.

5 Cables requiring type approval are as follows:

(1) Cables used for power feeding systems and power distribution circuits for power, lighting and internal communications and used for control circuits

(2) Flexible cords used for feeding power systems and power distribution circuits and control circuits

(3) Multicore vinyl insulated cables for 150 V electronic equipment

6 Type tests may be carried out for flexible cords, vinyl sheathed cords, insulated cables for switchboards and control equipment, coaxial cables, etc., other than those specified in **-5** above in cases where a request is made by the manufacturer.

7 In the electrical appliances and cables specified in **1.2.1-4, Part 8 of the Rules** in cases where it is inadequate to deal with them under the requirements for type tests (*e.g.* those used only for specific ships or purposes with little possibility of continued use, or items for which the acquisition of individual test/inspection certificates is desired), tests and inspection on individual product items may be accepted by application in place of type tests.

Chapter 2 ELECTRICAL INSTALLATIONS AND SYSTEM DESIGN

2.1 General

2.1.2 Voltage and Frequency

1 In **2.1.2-3, Part 8 of the Rules**, voltage fluctuations in main busbars are to be designed after taking into account any voltage drop in power cables so that any electrical equipment supplied by such switchboards are capable of operating satisfactorily without any problems.

2 In **2.1.2-3, Part 8 of the Rules**, the steady state voltages and frequencies of *a.c.* motors are to be considered to change simultaneously, and any fluctuations in such events in terms of the sum of the absolute value of respective ratios of these fluctuations are to be within 10%. Furthermore, any limits placed on the fluctuations of voltages and frequencies are to be set as the maximum amplitude of each.

3 The wording "specially approved by Society" given in **2.1.2-4, Part 8 of the Rules** means to satisfy any of the following:

(1) In supply systems connected with semiconductor converters where the safe operation of other electric devices connected to such supply systems is maintained by the adoption of suitable methods for decreasing harmonic content effects, and Total Harmonic Distortion (THD) values do not exceed 8%.

(2) In electric propulsion ships, where the supply systems connected with propulsion semiconductor converters are closed circuits independent from other internal supply systems, and Total Harmonic Distortion (THD) values do not exceed 10%.

Fig. 8.2.1.2-1 Application example of 2.1.2-3(1)

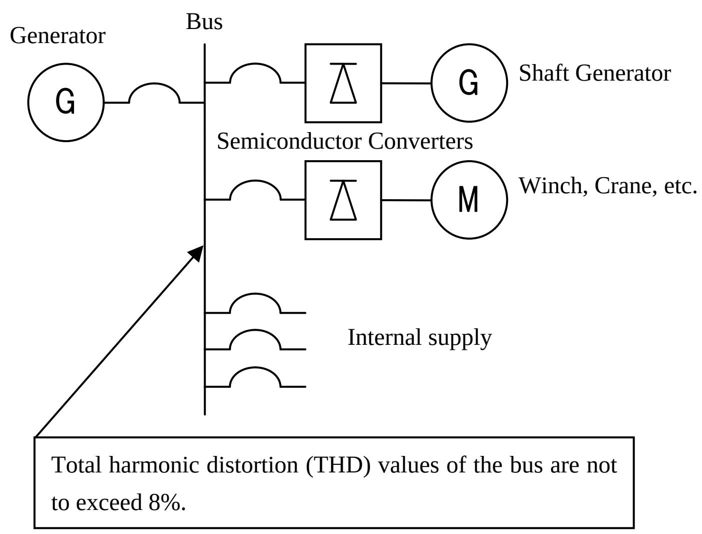
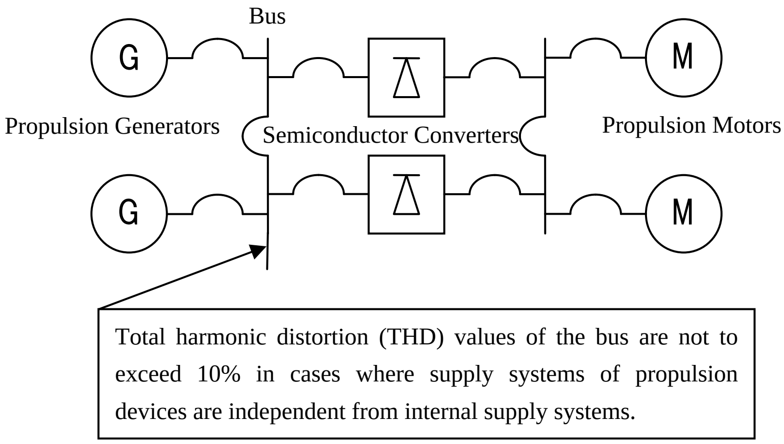


Fig. 8.2.1.2-2 Application example of 2.1.2-3(2)



2.1.3 Construction, Materials, Installations, etc.

1 Electrical equipment is to be constructed so as to allow accessibility to all parts requiring inspection, overhauling and repairs.

2 Rotating, reciprocating, high temperature parts and live parts of electrical equipment are to be arranged with suitable protections, so that operators or other personnel working in the vicinity of such parts are kept free from injury.

3 Power source switches of electrical equipment are to be arranged so that such equipment is not charged through control circuits and/or pilot lamps when such switches are in their "off" positions.

4 The protective enclosures of electrical equipment are to comply with the following requirements:

(1) Degree and marking of the protection of such enclosures

The degree of protection of such enclosures is to be as given in **Table 8.2.1.3-1**. Protection types are to be expressed by the combination of the following letters and numerals.

- (a) Code letters "IP"
- (b) The first characteristic numeral shows the degree of protection against any access to hazardous parts and any ingress of solid foreign objects.
- (c) The second characteristic numeral shows the degree of protection against any ingress of water with harmful effects.
- (d) An additional letter (optional) shows the degree of protection against any access to hazardous parts.
- (e) A supplementary letter (optional) shows any supplementary information.

(2) Construction and test methods of degree of protection

Construction and testing methods of degrees of protection are to be as given in **Table 8.2.1.3-2**, **Table 8.2.1.3-3**, **Table 8.2.1.3-4** and **Table 8.2.1.3-5**. Manufacturers are to carry out tests for the first product and confirm the availability of degree of protection shown on equipment. Surveyors may require tests for such products when deemed necessary.

(3) Application of electrical equipment

The requirements given in **Table 8.2.1.3-6** are to be taken into consideration for the applications of electrical equipment with regard to their degree of protection.

5 In cases where electrical equipment and cables are not carrying currents which exceed rated values, a magnetic compass is not considered to be affected by external magnetic fields as long as the changes in the values of the magnetic compass are within ± 0.5 *degrees*. In addition, it is not necessary to consider transitional conditions resulting from establishing and breaking a circuit except in cases where the circuits are of a type frequently switched on and off.

6 Electrical installations in paint lockers and adjacent areas are to be in accordance with **Table 8.2.1.3-7**.

7 Electrical installations recognized as suitable for installation in acetylene stores are to be safe type explosion-protected electrical equipment which complies with the requirements specified in **2.16, Part 8 of the Rules**.

In addition, the equipment is to certified as both Gas and Vapour Group *II*C, and Temperature Class *T*2 or higher. Finally, all cables associated with the equipment are to treated as part of the equipment.

Table 8.2.1.3-1 Degrees of Protection and Markings

Code letters	First characteristic numeral	Second characteristic numeral	Additional letter (optional)	Supplementary letter (optional)
	Against any access to hazardous parts and any ingress of solid foreign objects	Against any ingress of water with harmful effects	Against any access to hazardous parts	Supplementary information
IP	0 1 2 3 4 5 6	0 1 2 3 4 5 6 7 8	A B C D	H M S W

Note:

In cases where it is not necessary to indicate either the first characteristic numeral or the second characteristic numeral, the degree of protection may be represented by the letter *X*.

Examples:

IP*X*8 Degree of protection only against the ingress of water with harmful effects

IP5*X* Degree of protection only against the access to hazardous parts and ingress of solid foreign objects

Table 8.2.1.3-2 Degree of Protections against Access to Hazardous Parts and Ingress of Solid Foreign Objects shown by the First Characteristic Numeral

First characteristic numeral	Construction of protection	Testing methods and criteria
0	Non protected	-
1	Protected against access to hazardous parts with the back of a hand and protected against solid foreign objects of 50*mm* ϕ and greater	The sphere of 50 (+0.05, -0) *mm* is not to fully penetrate with 50*N*±10 % of test force and adequate clearance form hazardous parts is to be kept.
2	Protected against access to hazardous parts with a finger and protected against solid foreign objects of 12.5*mm* ϕ and greater	The jointed test finger of 12*mm* ϕ , 80*mm* length, may penetrate up to its 80*mm* length with test force of 10 *N* ± 10%, but adequate clearance from hazardous parts is to be kept. In addition, the sphere of 12.5 (+0.05, -0) *mm* ϕ is not to fully penetrate with 30*N* ±10% of test force.
3	Protected against access to hazardous parts with a tool and protected against solid foreign objects of 2.5*mm* ϕ and greater	The test rod of 2.5 (+0.05, -0) *mm* is not to penetrate with 3*N*±10% of test force and adequate clearance form hazardous parts is to be kept.
4	Protected against access to hazardous parts with a wire and protected against solid foreign objects of 1.0*mm* ϕ and greater	The test rod of 1.0 (+0.05, -0) *mm* is not to penetrate with 1*N*±10% of test force and adequate clearance form hazardous parts is to be kept.
5	Protected against access to hazardous parts with a wire and dust-protected	(1) Testing methods and criteria against the first characteristic numeral 4 are to be complied with. (2) The enclosure where the normal working cycle of the equipment causes reductions in air pressure within the enclosure below that of the surrounding air, *e.g.*, due to thermal cycling effects (hereinafter referred to as *Category* 1 enclosure) is to comply with the following **(a)** and **(b)**. At the end of the test, talcum powder is not to be accumulated in a quantity or location such that it could interfere with the correct operation of the equipment or impair safety. (a) The test is to be made using a dust chamber. The powder circulation pump circulates and floats the talcum powder continuously in the test chamber. The talcum powder used is to be capable of passing through a square-meshed sieve the nominal wire diameter of which is 50 μm and the nominal width between wires 75 μm . The amount of talcum powder is to be 2kg/m^2 of the test chamber. It is not to be used for more than 20 tests. The enclosure under test is to be supported inside the chamber by fixing or hanging. The pressure inside the enclosure is to be maintained below the surrounding atmospheric by a vacuum pump. The depression of the pressure is not to exceed 2*kPa*. (b) If an extraction rate of 40 to 60 *vol./hour* is obtained the duration of the test is to be 2 *hours*. If, with a maximum depression of 2*kPa*, the extraction rate is less than 40 *vol./hour*, the test is to be continued until 80*vol.* have been drawn through, or a period of 8 *hours* has elapsed. (3) Enclosures where no pressure difference relative to the surrounding air is present (hereinafter referred to as *Category* 2 enclosures) is to comply with the above **(2)** tests in condition that the enclosure under the test is supported in its normal operating position, but is not connected to a vacuum pump. The test is to be continued for a period of 8 *hours*. At the end of the test, talcum powder is not to be accumulated in a quantity or location such that it could interfere with the correct operation of the equipment or impair safety.
6	Protected against access to hazardous parts with a wire and dust-tight	(1) Testing methods and criteria against the first characteristic numeral 4 are to be complied with. (2) The above **(2)** tests against the first characteristic numeral 5 is to be carried out and deposit of dust is not to be observed inside the enclosure at the end of the test.

Note: The detailed test methods and criteria are based on *IEC* 60529.

Table 8.2.1.3-3 Degree of Protection against Ingress of Water with Harmful Effects

Second characteristic numeral	Construction of protection	Testing methods and criteria
0	Non-protected	-
1	Protected against vertically falling water drops	The enclosure under test is to be placed in its normal operating position and 200*mm* below the drip box. A flow of water drops of which flow rate is 1 (+0.5, -0) *mm*/*min*. are to be produced for 10*min*. At the end of the test, a water is not to be accumulated in a quantity or location such that it could interfere with the correct operation of the equipment or impair safety.
2	Protected against vertically falling water drops when enclosure tilted up to 15 *degrees*	The enclosure under test is to be placed in its normal operating position and 200*mm* below the drip box. A flow of water drops of which flow rate is 3 (+0.5, -0) *mm*/*min.* are to be produced for 2.5*min*. in each of four fixed positions. These positions are to be 15 *degrees* on either side of the vertical. At the end of the test, a water is not to be accumulated in a quantity or location such that it could interfere with the correct operation of the equipment or impair safety.
3	Protected against spraying water	The enclosure under test is to be placed in its normal operating position. A uniform flow of water drops are to be produced over the whole area between vertical and 60 *degrees* on either side of the vertical at the distance of 300*mm* to 500*mm* from the enclosure. The delivery rate of water flow is to be 10 (+0.5, -0.5) *l*/*min*. The pressure to achieve this delivery rate is to be the range of 50*kPa* to 150*kPa.* The test duration is to be 1*min.*/m^2 of the calculated surface area of the enclosure (excluding any mounting surface), with a minimum of 5*min*. At the end of the test, a water is not to be accumulated in a quantity or location such that it could interfere with the correct operation of the equipment or impair safety.
4	Protected against splashing water	The enclosure under test is to be placed in its normal operating position. A uniform flow of water drops are to be produced over the whole area between vertical and 180 *degrees* on either side of the vertical at the distance of 300*mm* to 500*mm* from the enclosure. The delivery rate of water flow is 10 (+0.5, -0.5) *l*/*min.* The pressure to achieve this delivery rate is to be the range of 50*kPa* to 150*kPa.* The test duration is to be 1*min.*/m^2 of the calculated surface area of the enclosure (excluding any mounting surface), with a minimum of 5*min*. At the end of the test, a water is not to be accumulated in a quantity or location such that it could interfere with the correct operation of the equipment or impair safety.
5	Protected against water jet	The enclosure under test is to be placed in its normal operating position. A stream of water from a standard nozzle of which internal diameter is 6.3*mm* is to be sprayed to the enclosure from all directions. The distance between the nozzle and the enclosure is to be 2.5*m*. The delivery rate is (12.5*l*±0.5%) /*min*. Core of the substantial stream is to be a circle of approximately 40*mm* diameter at 2.5*m* distance from nozzle. Test duration per square metre of enclosure surface area likely to be sprayed is to be 1*min*. Minimum test duration is to be 3*min*. At the end of the test, a water is not to be accumulated in a quantity or location such that it could interfere with the correct operation of the equipment or impair safety.
6	Protected against powerful jet	The enclosure under test is to be placed in its normal operating position. A stream of water from a standard nozzle of which internal diameter is 12.5*mm* is to be sprayed to the enclosure from all directions. The distance between the nozzle and the enclosure is to be 2.5*m* to 3*m*. The delivery rate is to be (100*l*±0.5%) /*min*. Core of the substantial stream is to be a circle of approximately 120*mm* diameter at 2.5*m* distance from nozzle. Test duration per square metre of enclosure surface area likely to be sprayed is to be 1*min*. Minimum test duration is to be 3*min*. At the end of the test, no water is to be entered into the enclosure.
7	Protected against the effects of temporary immersion in water	The highest point of enclosures is to be located deeper than 150*mm* below the surface of water, and also the lowest point of the enclosure is to be located deeper than 1,000*mm* below the surface of water. The duration of the test is to be 30*min*. The water temperature is not to differ from that of the equipment by more than 5 °*C* . However, it may be waived where the equipment is energized and/or its parts in motion. At the end of the test, no water is to be entered into the enclosure.
8	Protected against the effects of continuous immersion in water	The test conditions are to be subject to agreement between manufacturer and user, but they are to be more severe than the conditions for the second characteristic numeral 7 and they are to take account of the condition that the enclosure will be continuously immersed in actual use. At the end of the test, no water is to be entered into the enclosure.

Note: The detailed test methods and criteria are based on *IEC* 60529.

Table 8.2.1.3-4 Degree of Protection against Access to Hazardous Parts shown by the Additional Letters

Additional letter	Construction of enclosure	Test methods and criteria
A	Protected against access with the back of the hand	The access probe, sphere of 50*mm* ϕ, is to have adequate clearance form hazardous parts with 50*N*±10% of test force.
B	Protected against access with a finger	The jointed test finger of 12*mm* ϕ, 80*mm* length, is to have adequate clearance form hazardous parts with 10*N*±10% of test force.
C	Protected against access with a tool	The access probe of 2.5*mm* ϕ, 100*mm* length, is to have adequate clearance form hazardous parts with 3*N*±10% of test force.
D	Protected against access with a wire	The access probe of 1.0*mm* ϕ, 100*mm* length, is to have adequate clearance form hazardous parts with 1*N*±10% of test force.

Note: The detailed test methods and criteria are based on *IEC* 60529.

Table 8.2.1.3-5 Supplementary Information shown by the Supplementary Letters

Supplementary letter	Significance
H	High-voltage apparatus
M	Tested for harmful effects due to the ingress of water when the movable parts of the equipment, *e.g.* the rotor of the rotating machine, are in motion
S	Tested for harmful effects due to the ingress of water when the movable parts of the equipment, *e.g.* the rotor of the rotating machine, are stationary
W	Suitable for use under specified weather conditions and provided with additional protective features or processes

Table 8.2.1.3-6 Application of Degree of Protection

Degree of protection	Conditions in area of installation	Examples of areas of installation
Explosion-protected electrical equipment	Danger of explosion	Dangerous areas for ships carrying special cargoes, ammonia plant rooms, battery rooms, lamp rooms, paint lockers, store rooms of welding gas bottles, holds regarded as dangerous areas as well as pipe tunnels for oils with flash point of 60 $^{\circ}C$ or below (Note 1)
IP20	Danger of touching live parts	Accommodation spaces, control rooms and monitoring rooms in dry conditions
IP22	Danger of dripping liquid and/or moderate mechanical damage	Navigation bridges, above the floors of engine rooms and boiler rooms, steering gear rooms, refrigerating machine rooms (excluding ammonia plants), emergency machinery rooms, provision stores as well as general stores/lockers (Note 2)
IP34	Danger of spraying liquid and/or increased mechanical damage	Bath rooms and shower rooms, below the floors of engine rooms and boiler rooms, enclosed F.O. purifier rooms as well as enclosed L.O. purifier rooms (Note 3)
IP44		Ballast pump rooms, refrigerating rooms, galleys and laundries (Note 4)
IP55	Danger of spurting liquid and/or serious mechanical damage Presence of cargo dust and/or aggressive fumes	Shaft tunnels or pipe tunnels in double bottoms, general cargo holds, and open decks (Note 5)
IP56	Danger of liquids in massive quantities	Open decks hit by rough seas (Note 6)
IPX8	In water	Bilge wells

Notes:

1 Receptacles are not to be installed in those areas listed in this column.

2 (a) In the case of wiring accessories (switches, receptacles, junction boxes, etc., hereinafter referred to the same) installed in those areas listed in this column excluding navigation bridges, provision stores and general stores/lockers, the degree of protection is to be IP44.

(b) In the case of electrical equipment installed on navigation bridges, which are located in a way to preclude any dripping liquids emanating from ventilation ducts or in the vicinity of the windows, or not located in the vicinity of any wing doors being exposed to water or rain, the degree of protection may be IP20.

3 (a) In the case of wiring accessories installed in those areas listed in this column, the degree of protection is to be IP55.

(b) In the case of switchboards, control devices, motors, controlgears for motors, heating appliances installed in those areas listed in this column, the degree of protection is to be IP44.

(c) Receptacles are not to be installed below the floors of engine rooms and boiler rooms, enclosed F.O. purifier rooms and enclosed L.O. purifier rooms unless a lid is attached to such receptacles which is located in a way to preclude splashing water, fuel oil, or lubricating oil from the equipment.

4 In the case of lighting fittings installed in ballast pump rooms, refrigeration rooms, galleys, laundries, the degree of protection may be IP34.

5 In the case of wiring accessories installed in the shaft tunnels of double bottoms or pipe tunnels, the degree of protection is to be IP56.

6 In the case of lighting fittings installed on open decks exposed to rough seas, the degree of protection may be IP55.

Table 8.2.1.3-7 Electrical Installations Permitted in Paint Lockers and Their Adjacent Areas

<table>
<tr><th colspan="2">Areas</th><th>Permitted electrical installations</th></tr>
<tr><td>(a)</td><td>Paint lockers</td><td rowspan="2">(1) Certified safe type equipment specified below at least with respect to gasses and vapours of group IIB and of temperature class T3 as well as their associated cables
-intrinsic safety type (Exi)
-flameproof type (Exd)
-pressurized type (Exp)
-increased safety type (Exe)
(2) Through run cables
(3) Non-sparking type ventilation fans complying with 3.5.5-1, Part 9</td></tr>
<tr><td>(b)</td><td>Inlet and exhaust ventilation ducts</td></tr>
<tr><td>(c)</td><td>Areas on open decks within 1m of inlet and exhaust ventilation openings</td><td rowspan="2">(1) Electrical installations permitted for those areas specified in (a) and (b)
(2) Electrical equipment with a type of protection ‘n’ as well as their associated cables
(3) Electrical equipment of those types which ensure the absence of sparks or arcs and which no parts of such equipment haves operating temperatures which can cause the ignition of gases or vapours of those flammable liquids being stored as well as their associated cables
(4) Electrical equipment with simplified pressurized enclosures or vapour proof enclosures (minimum degree of protection is IP55) and which no parts of such equipment have operating temperatures which can cause the ignition of gases or vapours of those flammable liquids being stored as well as their associated cables</td></tr>
<tr><td>(d)</td><td>Areas on open decks within 3m of exhaust mechanical ventilation openings</td></tr>
<tr><td>(e)</td><td>Enclosed spaces having direct openings into paint lockers</td><td>These spaces may be considered as non-hazardous, provided that:
(1) Doors to paint lockers are gastight doors with self-closing devices;
(2) Paint lockers are provided with independent natural ventilation systems which are deemed appropriate by the Society; and,
(3) Warning notices are fitted adjacent to paint locker entrances stating that such lockers contain flammable liquids.</td></tr>
</table>

2.1.4 Earthing

1 The following exposed metal parts may not be earthed:

(1) Non-current-carrying metal parts of electrical equipment which are unlikely to be touched by people during times when such equipment is being used.

(2) Lamp caps

(3) Shades, reflectors and guards, supported on lampholders or luminaires constructed of, or shrouded in, non-conducting materials.

(4) Metal parts or screws separated by insulators from current-carrying parts or from earthed non-current-carrying parts which are not charged or earthed under normal service conditions.

(5) Bearing housing insulated to prevent any circulation of currents in bearings.

(6) Clips of fluorescent lighting tubes

(7) Equipment power supplied at safety voltages

(8) Cable clips

2 Earthing may be made under the requirements specified below:

(1) All earthing connections are to be made through copper or other corrosion resistant materials and are to be securely installed to hull structures. All earthing conductors are to be protected in cases where necessary against any mechanical damage and galvanic corrosion.

(2) In cases where metal frames or enclosures of electrical equipment are directly fitted to hull structures, and those surfaces in contact are clean and free from any rust, scale and paint as well as bolted firmly, no earthing conductors may be provided.

(3) Lead cable sheaths are not to be used as the sole earthing means under any circumstances.

(4) Nominal cross-sectional areas of all copper earthing conductors are to be as given in **Table 8.2.1.4-1**. In cases where earthing conductors other than copper are used, their conductance is to be of more than that of those copper conductors given in this table.

(5) Connections between earthing conductors and hull structures are to be made in accessible positions, and to be secured by screws made of brass or some other corrosion-resistant-materials that have a diameter not less than 4*mm* and which are to be used for this purpose only. In any case, contact faces are to have glossy metal surfaces when these screws are tightened.

3 In power distribution systems, in cases where one line of the system is earthed and normally a non-current carrying line, earthing connections are to be as specified in **-2** above. However, the upper limit value of $64mm^2$ of those cross-sectional areas of earthing conductors given in **Table 8.2.1.4-1** does not apply.

4 Non-current-carrying metal parts of portable electrical appliances are to be earthed through plugs and receptacles by mean of earthing conductors provided in flexible cables or cords.

Table 8.2.1.4-1 Sizes of Earthing Conductors

Types of earthing conductors		Cross-sectional areas of current-carrying conductors	Minimum cross-sectional areas of copper earthing conductors
Earthing conductors in flexible cables or flexible cords		Up to and including $16mm^2$	100% cross-sectional area of current-carrying conductors
		Exceeding $16mm^2$	50% cross-sectional area of current-carrying conductors (at least $16mm^2$)
Earthing conductors incorporated in fixed cables	Insulated earthing conductors	Up to and including 16 mm^2	100% cross-sectional area of current-carrying conductors (at least $1.5mm^2$)
		Exceeding $16mm^2$	50% cross-sectional area of current-carrying conductors (at least $16mm^2$)
	Bare earthing wires in direct contact with lead sheaths	1 - $2.5mm^2$	$1mm^2$
		4 - $6mm^2$	$1.5mm^2$
Separate earthing conductors		Up to and including $3mm^2$	100% cross-sectional area of current-carrying conductors (at least $1.5mm^2$ for stranded earthing connections or $3mm^2$ for unstranded earthing connections)
		Exceeding $3mm^2$ Up to and including $125mm^2$	50% cross-sectional area of current-carrying conductors (at least $3mm^2$)
		Exceeding $125mm^2$	$64mm^2$

2.2 System Design (General)

2.2.2 Insulation Monitoring Systems

1 The term "distribution system" generally means the following circuits:

(1) Primary distribution circuits directly connected to generator circuits

(2) Secondary distribution circuits connected via insulated transformers with those primary distribution circuits specified in **(1)** above. However, unless otherwise specified, secondary circuits exclusively for specifically designated equipment (*e.g.* Suez Canal search lights, heaters and lighting circuits provided in cranes, etc.) may be excluded.

(3) Lighting circuits supplied from accumulator batteries or busbars of feeder panels to which such circuits are connected.

2 Alarm set values of insulation monitoring systems are to have insulation resistance values, as a standard, corresponding to 1/10 of that of the electric circuit in normal condition for which monitoring is to be made.

3 In cases where insulation monitoring systems are used in common with earthing lamp, they are to be interlocked against each other.

2.2.5 Lighting Circuits

For lighting circuits which satisfy the following conditions, the wording “not exceed 80% of the ratings of protective devices” in **2.2.5-2, Part 8 of the Rules** can be interpreted to mean “not exceed the ratings of protective devices”.

(1) Such circuits are not used in accommodation areas

(2) Electrical apparatus with unspecified load currents (such as receptacles, etc.) are not connected.

(3) The ratings or appropriate settings of protection devices are decided based upon maximum load currents of connected lighting points

2.2.6 Circuits for Shore Connections

In cases where portable phase sequence indicators or polarity detectors are provided on board ship, those detectors in shore connection boxes may be omitted.

2.2.7 Disconnecting Switches of Circuits

In cases where those switches specified in **2.2.7-2, Part 8 of the Rules** are provided on board ship in dispersed manner, their wiring connection diagrams are to be displayed in monitoring rooms or other adequate spaces.

2.2.8 Remote Stopping of Ventilating Fans and Pumps

“Consideration against the fuse element failure” specified in **2.2.8-2, Part 8 of the Rules** is satisfied if no volt alarms, electrical source indicators, or the like are provided at normally attended positions.

2.3 System Design (Protection)

2.3.3 Protection against Short-circuits

1 In cases where the determination of the cascade breaking capacities of breakers necessary for employing for short-circuit protection is intended in accordance with **2.3.3-3, Part 8 of the Rules**, test methods and criteria are to be as specified below:

(1) Test methods

Back-up circuit breakers or fuses are to be connected in series with circuit breakers on load sides, and short-circuit tests under an operating duty of 1 time “*O* - 2 *minutes** - *CO*” for those circuit breaker on load sides are to be carried out.

Note: In cases where thermal trip reset times and fuse replacement times exceed 2 *minutes*, those times asterisked are the ones deemed appropriate by the Society.

(2) Criteria after tests

Circuit breakers on load sides are to satisfy the following requirements:

(a) No short-circuit is to be caused if back-up circuit breakers are reclosed with power supplies connected, and no voltages are to be applied on terminals of circuit breakers on load sides.

(b) Circuit breakers can be safely and easily replaced with spares.

(c) No damage is to be caused on cases proper and covers.

(d) Making and breaking of circuits are to be possible.

(e) High voltage tests are to be carried out at voltages twice rated voltages, and to prove that it resists such voltages.

(f) Insulation resistances are to be $0.5M\Omega$ or more.

2 In calculating short-circuit currents, the contribution of generators which are interlocked and are not to connected simultaneously to the bus may not be included in such short-circuit currents. (For example, in cases where 4 of 6 generators are connected simultaneously to a bus, the contribution of those 4 generators is to be included in short-circuit currents.) In the case of generators which are connected to a bus simultaneously only when switching such as harbour use generators, the contribution of such generators are to be included in short-circuit currents.

2.3.5 Protection of Generators

Adjusting values of trip currents for the overcurrent tripping devices with time delays of generators are to be selected in such a manner that such generators can be protected safely from any overcurrents according to the thermal capacities of the generators and the tripping characteristics of the overcurrent tripping devices with time delays. Furthermore, in selecting the type and adjusting values for those overcurrent tripping devices with long time delays and short time delays of short-circuit protection, consideration is to be given as to their coordination.

2.3.6 Protection of Feeder Circuits

In applying **2.3.6-2, Part 8 of the Rules**, in cases where fuses are used as short-circuit and overload protection devices of circuits which are supplied power at voltages not exceeding 50*V d.c.* or 50*V a.c.* root mean square between conductors, switches on the power source sides of these fuses may be dispensed with.

2.4 Rotating Machines

2.4.2 Characteristics of Governors

1 The wording "to be deemed appropriate by the society" in **2.4.2-1(1), Part 8 of the Rules** means as follows:

(1) In cases where momentary variations are 10% or less of the rated speed when the maximum load on board is suddenly thrown off and the speed is returned to within 1% of the final steady speed in not more than 5 *seconds*, momentary variations in excess of 10% of rated speeds may be acceptable in cases where rated loads of such generators are suddenly thrown off.

(2) The momentary variations given in **(1)** above, in cases where rated loads of generator are suddenly thrown off are to be less than any adjusted values of the intervention of overspeed devices as required by **2.4.1-1, Part 7 of the Rules**.

2 For prime movers with mean effective pressures of 1.35*MPa* or more to which the application of those methods of throwing on rated loads of generators specified in **2.4.2-1(2), Part 8 of the Rules** are impossible, the following three or four steps throwing on method in accordance with the formulae below is to be used notwithstanding the above requirements:

Total throw-on loads at the 1st step (%) = 80/*BMEP*

Total throw-on loads at the 2nd step (%) = 135/*BMEP*

Total throw-on loads at the 3rd step (%) = 180/*BMEP*

Total throw-on loads at the 4th step (%) = 100

BMEP: Brake mean effective pressure (*MPa*)

However, in cases where the above throwing on method apply, manufacturers or shipyards are requested to submit throw-on power calculation sheets to the Society for approval which demonstrate that the throw-on loads and base loads at each step of the operation do not exceed those values determined by the formulae above under any circumstances.

(1) At times of power restoration after blackout

(2) At times of sequential starting

(3) At times of starting with large start-up loads

(4) At times of instantaneous load transfers in cases where one set of generators fails (during parallel running)

2.4.3 Limits of Temperature Rise

1 Temperature rise of bearings

(1) Temperature rise of bearings are not exceed 35*K* in cases where temperatures are measured on surfaces, 40*K* in cases where temperatures are measured by temperature elements embedded in metal, or 50*K* in cases where temperatures are measured on surfaces using heat resisting lubricants; for example, lithium soap based greases.

(2) In cases where heat resisting insulation of Thermal class F or higher is used in rotating machines and it is difficult to apply those requirements specified in **(1)** above, documents relating to the heat resistance of bearings and lubricants are to be submitted to the Society for approval.

2 In the case of rotating machines with forced cooling air coolers, temperatures of windings are to be measured by embedded temperature detectors or resistance methods.

2.4.4 Modification of Limits of Temperature Rise

In dealing with the wording "in those cases where deemed appropriate by the Society" referred to in **2.4.4-2, Part 8 of the Rules**, limits of temperature rise may be modified as follows:

(1) In cases where forced cooling is provided and temperatures of cooling water at inlets of air coolers are not higher than 32$^\circ C$, limits of temperature rise may be set 13*K* higher than those limits specified in **Table 8.2.2, Part 8 of the Rules**.

(2) In cases where forced cooling is provided and temperatures of cooling water at inlets of air coolers are higher than $32^{\circ}C$, limits of temperature rise may be determined by the Society in each case.

2.4.5 Overload Capability

In excess torque tests for special types of motors, overload scaling may be determined as follows unless otherwise specified:

Single-phase motors: 133% of rated torque for 15 *seconds*

Motors for deck machinery: 150% of rated torque for 15 *seconds*

2.4.6 Short-circuit Scaling

The wording "to be capable of withstanding the mechanical and thermal effects" referred to in **2.4.6-1, Part 8 of the Rules** means as follows:

(1) In the event of short-circuit at rated operating conditions, *a.c.* generators are to keep their mechanical strength, and their conductors and insulating materials are not to be burned for a period of at least 1 *second*.

(2) In the event of short-circuit at rated operating conditions, *d.c.* generators are to keep their mechanical strength and electrical functions after separation of fault circuits.

2.4.11 Shafts of Rotating Machine

1 In cases where the method of weld flanges on shafts of generators is adopted in order to form shaft couplings for the first time, plans for welding procedure qualification tests including test items on fatigue strength and the data covering the working process standards are to be submitted in advance for Society approval.

2 In cases where welding ribs or other similar things on shafts of generators are provided, the following are to be submitted in advance for Society approval:

(1) Calculation sheets on standard design stresses and strength on ribs or other torque members intended to be welded onto shafts.

(2) Details of welding quality control systems and working process standards.

(3) Test records, including any results of macro-section, micro-section and hardness surveys on welded parts of any specimens welded in accordance with those working process standards referred to in **(2)** above.

3 In cases where spiders or other main torque members of welded structures are provided, those requirements specified in **-2** above are to be applied.

4 Welding on the shafts of motors are to comply with the following:

(1) In cases where motors are rated as 100*kW* or more and are to drive auxiliary machinery intended for essential services, those requirements specified in **-1** and **-2** above are to be applied.

(2) In cases where motors are rated up to 100*kW* then

  (a) those requirements specified in **(1)** above are to be applied in cases where weld flanges on shafts are provided.

  (b) working process standards for welding are to be submitted to the Society in cases where welding ribs or other similar things on the shafts are provided.

2.4.15 Shop Tests

1 The wording "generator or motor which is produced in series having identical type with their unit" referred to in **2.4.15-1, Part 8 of the Rules** means those generators or motors which are of the same capacity, voltage, current, rotational speed, principal dimensions, cooling method, insulation thermal class and manufactured according to the same process at the same plant. The wording "small capacity" means up to 100*kW* of continuous rating capacity.

2 The wording "separately specified procedures" referred to in **2.4.15-8, Part 8 of the Rules** means as follows:

(1) Synchronous machines

  (a) Zero power-factor tests

  Zero power-factor tests, tests with almost zero power-factor currents on rotating machines operated as generators or motors without loads at rated voltages and frequencies, can be applied to synchronous phase advancers without modification. In cases where such tests are applied to synchronous generators or motors and the *kVA* is not adequate for rated outputs due to low intensities of field currents, such field currents are to be high enough and test results are to be modified in accordance with the following:

  i) The temperature rise of armature winding t_O and armature core t_{CO} are measured through another temperature test at rated voltage without loads (on armature open circuit).

ii) Other symbols used in **iii)** are as follows:

t' : temperature rises of windings during zero power-factor tests at voltage V' and current I'

t'_C : temperature rises of cores during zero power-factor tests at voltage V' and current I'

t'_f : temperature rises of field windings during zero power-factor tests at field current I'_f

iii) Temperature rises at rated states are calculated using the following equations in cases where V, I and I_f represent rated voltage, current and field current respectively.

Armature windings:

$$T = t_O + (t' - t_O) \times \left(\frac{I}{I'}\right)^2$$

Armature cores:

$$T_C = t_{CO} + (t'_C - t_{CO}) \times \left(\frac{I}{I'}\right)^2$$

Field windings:

$$T_f = t'_f \times \left(\frac{I_f}{I'_f}\right)^2$$

(Testing voltage V' is to be as close to the rated voltage as practicable but be at least higher than 90% of it)

(b) Presumption method of temperature rises

i) In the case of temperature rises of the armature cores of rotating machines operated at rated outputs, temperature rises of the armature cores of rotating machines operated without loads at voltages which are 110% of their rated voltages are substituted. In the case of temperature rises of the armature windings of rotating machines operated at rated outputs, temperature rises of the armature windings of rotating machines operated at voltages which are 125% of their rated current with all terminals shorted are substituted.

ii) In the case of temperature rises of the armature cores/windings of rotating machines operated at rated outputs, the sum of the temperature rises of armature cores/windings of rotating machines operated at rated voltages without loads and operated at rated currents with all terminals shorted are substituted.

iii) In the case of temperature rises of armature cores/windings of rotating machines operated at rated outputs, temperature rises of armature cores/windings of rotating machines which are operated at rated rotational speeds and carrying *d.c.* or single phase circulating currents, equivalent to their rated currents, on circularly connected armature windings with openings to make terminal voltages, by excitation, be equivalent to their rated voltages are substituted. Field currents are modified by zero power-factor tests.

(2) Induction machines

(a) Primary side superposed load method

Induction machines connected as shown in **Fig. 8.2.4.15-1** are operated without loads and voltages and frequencies of low voltages superposed on those voltages impressed by main sources of electric power are adjusted. Generally, primary currents are equalized to total load currents (current based method) but for induction machines of special squirrel-cage, two poles and high outputs, inputs are equalized to the loss at rated loads calculated by the circle diagram method (loss based method).

(b) Secondary side superposed load method

Induction machines connected as shown in **Fig. 8.2.4.15-2** are operated without loads and voltages and frequencies of those low voltages superposed on secondary sides are adjusted to make primary sides carry almost total load currents.

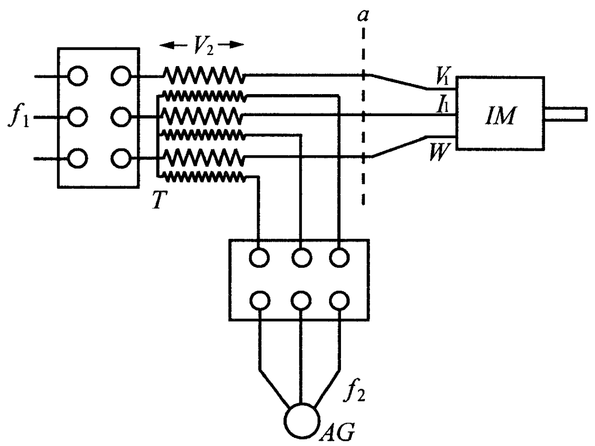
3 Temperature tests on duty type rating three-phase induction motors may be in accordance with “Methods for determining temperature rises of three-phase induction motors at periodic duty rating” (Standard of The Japan Electrical Manufacturers' Association; *JEM* 1385).

4 In those commutation tests specified in **2.4.15-4, Part 8 of the Rules**, any sparks arising between commutator segments and brushes in *d.c*. machines are categorized into eight types as shown in **Fig. 8.2.4.15-3**, and categories 5 through 8 are deemed to be harmful.

5 Notwithstanding -4 above, sparks which cause any scorching or damage to the commutator surfaces or which wear out or break up brushes during temperature tests and overload tests are deemed to be harmful.

6 Through operation at rated or lower outputs, sparks are recommended to be of categories 1 or 2.

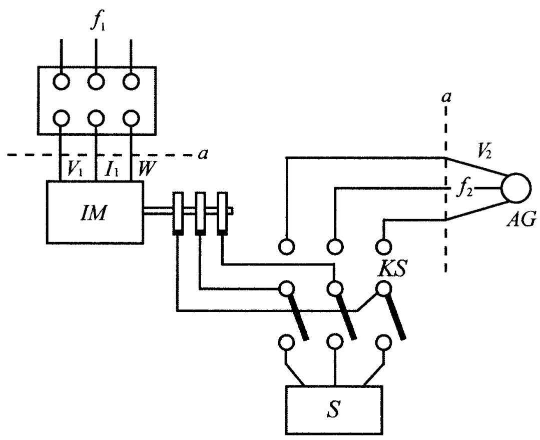
Fig. 8.2.4.15-1 Test Circuits of Primary Side Superposed Load Methods



IM : rotating machine to be tested
T : D.C. transformer inserted in series
a : connecting points of a voltmeter, ammeter and wattmeter
AG : generator for an auxiliary source of electrical power
V_1 : terminal voltage (rated voltage)
f_1 : frequency of the source of electrical power (rated frequency)
I_1 : primary current to the induction machine
V_2 : superposed voltage
f_2 : superposed frequency
W : input

(note) 1. Auxiliary and main source of the electrical powers are to have the same phase sequence direction.
2. Superposed voltage V_2 is to be low enough comparing to V_1; to be as low as the impedance voltage of the rotating machine to be tested.

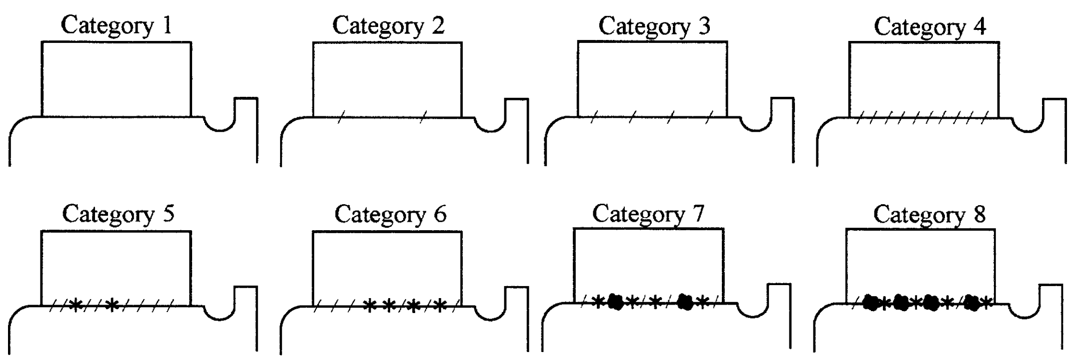
Fig. 8.2.4.15-2 Test Circuits of Secondary Side Superposed Load Methods



IM : rotating machine to be tested
a : connecting points of a voltmeter, ammeter and wattmeter
AG : generator for an auxiliary source of electrical power
V_1 : terminal voltage (rated voltage)
f_1 : frequency of the source of electrical power (rated frequency)
I_1 : primary current to the induction machine
V_2 : superposed voltage
f_2 : superposed frequency
W : input
S : starting resister
KS : switch

(note) 1. Phase rotation of auxiliary source of electrical power shall be chosen so that the rotative direction of a rotor is to be the same in case of operation by auxiliary and main source of electrical power.
2. Superposing frequency f_2 is to be lower than a half of f_1 and is recommended to be as low as practicable.

Fig. 8.2.4.15-3 Category of Sparks



Intensity of sparks: /… small ∗… medium ●… large

2.5 Switchboards, Section Boards and Distribution Boards

2.5.1 Location

In cases where the laying of steam pipes, water pipes, oil pipes, etc. in the proximity of switchboards is unavoidable, the flanges of such pipes are to be of welded joints or means are to be provided so that no detrimental effects are exerted on switchboards if any leakage occurs.

2.5.2 Safety Precautions of Operators

The width of the space provided in front of switchboards as specified in **2.5.2-5, Part 8 of the Rules** is to be a standard of 0.9*m* or more. Furthermore, in cases where switchboards are constructed so that necessary operation and maintenance can be performed at their front, passageways at the rear of such switchboards may be omitted.

2.5.4 Busbars

1 Busbars, contact faces of busbars and linking conductors are to be protected against any corrosion or oxidization by means of silver plating, tin plating or dippling in solder baths, etc.

2 Current ratings of busbars may generally be determined by **Table 8.2.5.4-1**.

3 The wording "in cases where deemed appropriate by the Society" in **2.5.4-4, Part 8 of the Rules** refers to cases where documents which show that there are no adverse effects on any of the following **(1)** to **(5)** are submitted to and approved by the Society in cases where the temperature rises of any busbars, connecting conductors and their connections that are carrying full-load currents exceed 45*K* at an ambient temperature of 45 $^{\circ}C$.

(1) Mechanical strength of the conducting material

(2) Possible effect on adjacent equipment

(3) Permissible temperature limits of the insulating materials in contact with the conductor

(4) Effect of the temperature of the conductor on the apparatus connected to busbars

(5) For plug-in contacts, the nature and surface treatment of the contact material

Table 8.2.5.4-1 Current Rating of Busbars

Type			Current rating
For generators	In cases where only one generator is feeding power to the busbars.		100% or more of the rated current of the generator.
	In cases where two or more generators are feeding power at their full capacities to the busbars.	Subdivided busbar arrangement (distribution systems consisting of multiple busbars)	For each busbar (including spare circuits), ((100% of the large capacity rated currents (*e.g.* bow thrusters, etc.)) + (75% of the sum of the rated currents of the rest of the feeding circuits)) or more
		Single busbar arrangement (distribution system consisting of a single busbar)	((100% of the rated current of one generator of the largest capacity) + (80% of the sum of the rated currents of generators)) or more
For power feeding	In the case of general power feeding circuits.		75% or more of the sum of the rated currents of the feeding circuits (including spare circuits). However, there is no need of exceeding the capacity of the generator busbars.
	In cases where feeding circuits have only one load circuit, or where power is fed to groups of motors under continuous service.		The total load current or more.

2.9 Cables

2.9.3 Choice of Protective Coverings

1 The term "metallic sheath" represents lead alloy metals, stainless steel and copper sheaths. In cases where the use of ordinary steel or light metal alloy sheaths is intended, adequate protection against corrosion is to be provided.

2 The term "hygroscopic insulation" specified in **2.9.3(2), Part 8 of the Rules** means mineral insulation.

2.9.6 Voltage Drop

1 Voltage drop calculations are to be carried out by using the following formulae as standards:

(1) In the case of *d.c.* circuits

$$\textit{Voltage drop}\ (\%) = \frac{R_{20} \times K \times 2L \times I \times 100}{V}$$

(2) In the case of *a.c.* circuits

Single phase *a.c.* circuits *Voltage drop* (%) = $\left(\frac{R_{20} \times K \times 2L \times I \times 100}{V}\right) \times \delta$

Three phase *a.c.* circuits *Voltage drop* (%) = $\left(\frac{R_{20} \times K \times 2L \times I \times 100}{V}\right) \times \frac{1.73}{2} \times \delta$

L : length of cable for single passage (m)
I : maximum load current (A)
V : circuit voltage (V)
R_{20} : *d.c.* resistance at $20^{\circ}C$ (Ω / m)
K : temperature factor at the maximum allowable temperature of conductor
70 ℃: 1.20
75 ℃: 1.22
90 ℃: 1.28
95 ℃: 1.30
δ : factor of voltage drop (*See* **Table 8.2.9.6-1**)

2 In the circuits of electric motors, voltage drop is to be calculated by taking into account the starting currents of those electric motors with the largest capacity. Furthermore, in the circuits of generators, approximately 115% of rated currents are to be regarded as maximum loads, so it is recommended that voltage drops are to be controlled to 1% or less as far as practicable. Also, voltage drop in the circuits of accumulator batteries, shore connections, etc. is to be controlled to 2% or less as far as practicable.

Table 8.2.9.6-1 Factor (δ) of *a.c.* Voltage Drops in Rubber Insulated Cables

Nominal sectional area of conductor (mm^2)	Power factor (%)							Inductance (mH/km)
	100	95	90	85	80	75	70	
1.5	1.00	0.95	0.90	0.85	0.81	0.76	0.71	0.370
2.5	1.00	0.95	0.91	0.86	0.81	0.76	0.71	0.341
4	1.00	0.96	0.91	0.86	0.81	0.76	0.71	0.317
6	1.00	0.96	0.91	0.86	0.82	0.77	0.72	0.299
10	1.00	0.96	0.92	0.87	0.83	0.78	0.73	0.279
16	1.00	0.97	0.93	0.89	0.84	0.79	0.75	0.263
25	1.00	0.98	0.95	0.90	0.86	0.82	0.77	0.259
35	1.00	0.99	0.96	0.92	0.88	0.84	0.80	0.250
50	1.00	1.01	0.98	0.95	0.91	0.87	0.83	0.248
70	1.00	1.03	1.02	0.99	0.96	0.93	0.89	0.240
95	1.00	1.07	1.06	1.04	1.02	0.99	0.96	0.240
120	1.01	1.10	1.11	1.10	1.08	1.06	1.03	0.235
150	1.01	1.13	1.15	1.15	1.14	1.12	1.10	0.235
185	1.02	1.18	1.21	1.23	1.23	1.22	1.20	0.234
240	1.04	1.26	1.32	1.35	1.36	1.37	1.36	0.230
300	1.05	1.35	1.43	1.48	1.51	1.53	1.53	0.229

2.9.11 Cables in Hazardous Areas

1 Hazardous areas generally mean the battery rooms, paint lockers and flammable gas bottle rooms such as acetylene gas bottle storage rooms.

2 Protections for cables to be installed in those hazardous areas specified in **-1** above are to comply with the following requirements:

(1) Cables are, as a rule, to be metal armoured ones.
(2) Protection for preventing any mechanical damage to cables is to be provided as necessary.

2.9.12 Earthing of Metal Coverings

Earthing of metal coverings of cables may comply with the requirements as specified below:

(1) Cable sheaths and armour may be earthed with earthing glands designed so as to allow effective earthing. Glands are to be installed in such a manner that they are securely fixed to earthed metal structures with good electrical contacts.
(2) Conduits may be earthed by being screwed into metal enclosures, or by nuts on both sides of the walls of such metallic enclosures, provided any surfaces in contact are clean and free from rust, scale or paint and that such enclosures are securely earthed. Connections are to be painted immediately after assembly in order to inhibit corrosion.
(3) Cable sheaths, armour and conduits may be earthed by means of clamps or clips of corrosion resistant materials making effective contact with sheaths or armour and earth metals in lieu of those procedures specified in **(1)** and **(2)** above.
(4) All contacts of metal conduits, ducts and metal sheaths of cables used for earth continuity are to be soundly made and, in cases where necessary, are to be protected against corrosion.

2.9.13 Supports and Fixing of Cables

1 "Cable supports" is a general term for casings (pipes, ducts, etc.), trays, hangers and so on.

2 The wording "to be made of flame-retardant material" in **2.9.13-3(3)(a), Part 8 of the Rules** means those clips which have passed flame-retardant tests in accordance with the standard *UL*94 (categories V-0, V-1, V-2) or the equivalent thereto.

3 The wording "arranged so as to prevent any cables from becoming slack" in **2.9.13-3(3)(b), Part 8 of the Rules** means reinforcement by metallic cable clips arranged at intervals of 1 to 2*m* in consideration the outside diameter of the cable.

4 The wording "any tests otherwise specified by the Society" referred to in **2.9.13-3(4)(a), Part 8 of the Rules** are those tests specified in **3.4.2, Part 7 of the Guidance for the Approval and Type Approval of Materials and Equipment for Marine Use**.

5 The wording "those tests" referred to in **2.9.13-3(4)(f), Part 8 of the Rules** are those safe working load tests specified in **3.4.2(3), Part 7 of the Guidance for the Approval and Type Approval of Materials and Equipment for Marine Use**.

2.9.14 Penetration of Bulkheads and Decks

In verifying the watertightness and gas-tightness at cable penetrations, the construction and characteristics of materials of the cables are to be considered.

2.9.17 Cables in Refrigerated Spaces

1 In cases where non-metal sheaths are used for cables installed in refrigerated spaces, materials which are not aged at the lowest temperatures such refrigerated spaces are to be selected and cables are to be installed in such a manner that they are not subjected to any mechanical damage.

2 *PVC* sheathed cables to be installed in refrigerated spaces below -10$^\circ C$ are to pass low temperature tests which use a testing temperature of the lowest temperatures of such refrigerated spaces plus an additional -5$^\circ C$. In cases where numbers in the ones-columns of such testing temperatures are greater than 0 but less than or equal to 5, such numbers are to be rounded up to 5. In cases where numbers in the ones-columns of such testing temperatures are greater but less than or equal to 10, such numbers are to be rounded up to 10.

3 Polychloroprene rubber sheathed cables or chlorosulphonated polyethylene sheathed cables to be installed in refrigerated spaces below -30$^\circ C$ are to pass those low temperature tests which apply to *PVC* sheated cables.

2.9.19 Terminals, Joints and Branches of Cables

1 The wording "in cases where deemed appropriate by the Society" in **2.9.19-1, Part 8 of the Rules** refers to cases where a cable connection is installed by splicing which consists of a conductor connector, replacement insulation, replacement cable sheath, and, where applicable, replacement armour and shielding, and establishes electrical continuity in conductors, armour, or screens, under the following conditions:
(1) In cases where cables are installed in structural sub-assemblies
(2) In cases where circuits are extended or shortened in a ship which will undergo remodeling
(3) In cases where a damaged section of cables is replaced
(4) Splicing is not to be used for propulsion cables and cables in hazardous locations. However, with respect to

cables in hazardous locations, cases where Society approval is obtained are excluded
(5) Other cases deemed appropriate by the Society

2 In **-1** above, splicing is to comply with the following **(1)** to **(7)**:

(1) The conductors are to be connected using a compression type butt connector. In such cases, a one-cycle compression tool and proper dies are to be used. Long barrel butt connectors with conductor stops are to be used for conductor sizes of $6mm^2$ or larger.

(2) The splices for multi conductor cables are to be staggered in such a way that the connectors for each conductor are not contiguous to the connector of an adjacent conductor. In addition, no more than is necessary to ensure a proper connection of the cable insulation is to be removed.

(3) Replacement insulation that has the same or a greater thickness than that of the cable insulation and the same or better thermal and electrical properties of the cables.

(4) For screened cables, replacement screenings are to be provided and such screenings are to be secured by a method that does not exert more pressure than necessary to establish adequate electrical contact. Screened cables are to have at least a $13mm$ overlap between any replacement shielding material and the original screening material.

(5) Replacement cable sheath materials are to have physical properties that are the same as, or equivalent to, the cable sheath. Replacement cable sheaths are to be centered over the splices and to overlap the existing cable sheaths by at least $51mm$. Replacement cable sheaths are to be installed so that a watertight seal with the existing cable sheaths is created.

(6) The electrical continuity of any cable armour is to be re-established by a jumper of wire or braid, or replacement armour of the same metal.

(7) For cables with a sheath over the armour, a replacement covering is to be used.

3 The wording "to retain the original electrical, mechanical and flame-retardant properties of the cable" in **2.9.19-5, Part 8 of the Rules** means that connections and branching of cables are to be made within enclosures with no possibility of any outward spreading of fire by internal short-circuits or other causes. In addition, the type of enclosure is to be selected from those meeting the requirement given in **2.1.3-4** according to installation location.

2.10 Transformers for Power and Lighting

2.10.4 Modification of the Limits of Temperature Rise

The wording "in those cases where deemed appropriate by the Society" in **2.10.4-2, Part 8 of the Rules** means that limits of temperature rise may be modified as follows:

(1) In cases where forced cooling is provided and the temperatures of cooling water at the inlets of air coolers are not higher than $32^{\circ}C$, limits of temperature rise may be set $13K$ higher than those limits specified in **Table 8.2.15, Part 8 of the Rules**.

(2) In cases where forced cooling is provided and the temperatures of cooling water at the inlets of coolers are higher than $32^{\circ}C$, limits of temperature rise may be determined by the Society on a case by case basis.

2.11 Accumulator Batteries

2.11.1 General

1 Accumulator batteries of adequate discharge rates are to be selected according to their application.

2 In cases where alkali batteries are installed, specifications including construction, performance, method of installation, etc. are to be submitted for Society approval at each time of installation.

2.11.3 Location

1 Accumulator batteries are not to be located in high temperature or low temperature areas, or any areas exposed to steam, water or oil vapours.

2 The term "large batteries" in **2.11.3-2, Part 8 of the Rules** means those accumulator batteries connected to battery charging facilities with outputs of $2kW$ or more. Outputs of such battery charging facilities are to be the product of the rated currents of semiconductor converters and the nominal voltage of battery groups. Deck boxes may be naturally ventilated. Natural ventilation by means of ducts of ample dimensions, terminating at least $1.25m$ above in goose-necks, mushroom-heads or their equivalent will be sufficient. Holes for air inlets are to be provided on at least two opposite sides of these boxes.

3 Accumulator batteries connected to battery charging facilities with capacities in the range of 0.2 to 2*kW* are to be placed in battery boxes installed within battery compartments or on the upper deck or upward. In cases where such batteries are unable to be installed in such areas, the following requirements are to be complied with:

(1) Batteries are to be placed in storage boxes or on shelves provided at adequate areas;

(2) Batteries are to be placed in open states within machinery spaces; or,

(3) Batteries are to be placed in compartments with good air ventilation.

4 Accumulator batteries connected to battery charging facilities with capacities of 0.2*kW* or less may be placed in open states at adequate areas or may be placed in battery boxes.

2.11.5 Ventilation

1 In cases where accumulator batteries are arranged in two tiers or more, all shelves are to have not less than 50*mm* in space, front and back, for the circulation of air.

2 The capacity of exhaust ventilation of battery compartments is to be greater than or equal to the value obtained by the following formula:

Exhaust capacity $Q = 110 \times I \times n$ (*litre* /*h*)

I: maximum charging current at end (in cases where no specific limitations are imposed, charging currents in a period of 10 *hours* is to be regarded as the standard)

n: number of batteries

3 It is recommended that ventilation systems for those compartments containing accumulator batteries connected to battery charging facilities with outputs of 2*kW* or more be mechanical exhaust-ventilation types.

4 The ventilation fan which is “are to be constructed and to be made of such materials so as to render any sparking impossible in the event of impellers touching fan casings” specified in **2.11.5-3, Part 8 of the Rules** means those non-sparking type ventilation fans complying with the requirements given in **3.5.4-3, Part 9 of the Rules**.

2.11.6 Electrical Installations

Explosion-protected electrical equipment grouped into Explosion Class *d*3 and Ignition Group *G*1 as specified in Technical Recommendation issued by, National Institute of Industrial Safety Independent Administrative Institution in Japan, may be treated as equivalent to those grouped into Apparatus Group *II*C and Temperature Class *T*1 as specified in *IEC* 60079.

2.12 Semiconductor Converters for Power

2.12.1 General

The wording “standards are to be deemed appropriate by the Society” given in **2.12.1-2, Part 8 of the Rules** means the current standards of *IEC* 60146.

2.12.4 Shop Tests

1 Regarding the temperature rise tests for semiconductor element connections mentioned in **2.12.4-2, Part 8 of the Rules**, measurements of the temperature rise of individual element parts such as cooling fins, cases and coolant parts, etc. may be accepted. However, such temperature rise tests may be preformed on the aforementioned element parts only in cases where manufactures specify in advance that the temperature rise of semiconductor element connections will not exceed their maximum allowable temperature if the temperature rise of their parts is within allowable limits.

2 With respect to **2.12.4-3, Part 8 of the Rules**, tests which may inadvertently inflict serious damage on the protective devices of semiconductor elements may be omitted in cases where the proper operation of semiconductor element protective fuses, etc. can be confirmed.

2.15 Heating and Cooking Equipment

2.15.1 Construction

1 Protection guards of heating elements are to be of robust construction and be so fitted that they cannot be brought into contact with any current-carrying parts of such electric heating equipment. Openings of such protection guards are to be small enough not to allow standard test fingers to come in contact with heating elements.

2 Live parts of cooking appliances are to be protected so that the cooking utensils cannot be brought into contact with them.

3 Heating elements dipped in liquids for service are to be protected with corrosion resistant metal sheaths.

4 In cases where heating elements are used in baths, they are to be arranged so as not to cause any electric shocks while taking bath. Furthermore, their operating switches are to be of the multi-pole linked type and also indicator lamps and warning signs are to be provided.

5 Portable cooking heaters are to be of such shape or so weighted that they cannot be easily overturned.

2.16 Explosion-protected Electrical Equipment

2.16.1 General

The wording "the standard deemed appropriate by the Society" in **2.16.1, Part 8 of the Rules** means *IEC* 60079.

Chapter 3 DESIGN OF INSTALLATIONS

3.2 Sources of Electrical Power and Lighting Systems

3.2.1 Main Sources of Electrical Power

1 Generators driven by main propulsion machinery (hereinafter referred to as “shaft driven generator systems”) are to comply with the following requirements **(1)** to **(6)** if they are provided as the main sources of electrical power specified in **3.2.1-1, Part 8 of the Rules**:

(1) Voltage and frequency fluctuations of shaft driven generator systems are to be maintained within those specified limits given in **Table 8.3.2.1-1** under all weather conditions during sailing and maneuvering as well as when vessels are stopped and are in crash astern conditions.

(2) Shaft driven generator systems are to be equipped with devices to start main machinery independently of other generators belonging to the same main generator set.

(3) In those ships which have bridge control devices for main propulsion machinery, running indicators of shaft driven generator systems are to be provided on navigating bridges.

(4) In cases where main sources of electrical power are such that operation of generating sets is to be changed over to those generating sets not depending upon propulsion plants according to ship speed (*e.g.* ahead, stop, astern), such changeovers need to be made both automatically along with the control of propulsion plants and by remote operation from those positions where such propulsion plants are being controlled. In such cases power supplies are not to be interrupted by such changeovers.

(5) Shaft driven generator systems are to be capable of providing sufficient short circuit currents to trip generator circuit-breakers taking into account any selective tripping of protective devices for distribution systems on board.

(6) Protection is to be arranged in order to safeguard shaft driven generator systems in case of a short circuit in main busbars. Shaft driven generator systems are to be suitable for further use after fault clearances of the short circuit.

2 Shaft driven systems are to comply with the following requirements **(1)** to **(4)** if they are provided on board ships in addition to main sources of electrical power required by **3.2.1-1, Part 8 of the Rules**.

(1) Voltage and frequency fluctuations of shaft driven generator systems are to be maintained within those specified limits given in **Table 8.3.2.1-1** under their operating ranges which are to be previously arranged.

(2) In the event of any shaft driven generator systems being stopped and their frequency exceeding those limit given in **(1)** above, automatic changeovers to other main generating sets are to be carried out within a period of 45 *seconds*.

(3) In those ships which have bridge control devices for their main propulsion machinery, the following requirements are to be complied with:

  (a) Measures which allow the continued operation of those installations for the prevention of blackouts specified in **3.2.1-3** to be provided, or such systems to allow the operation of such measures without fail are to be established.

  (b) Those operating ranges which have been previously arranged are to be shown on navigation bridges, and devices to indicate the condition of shaft driven generating systems are to be established.

(4) Shaft driven generator systems are to be capable of providing sufficient short circuit currents to trip generator circuit-breakers taking into account any selective tripping of protective devices for distribution systems on board.

Table 8.3.2.1-1 Voltage and Frequency Fluctuations for Shaft driven Generator Systems

Type of fluctuations	Fluctuations	
	Permanent	Transient
Voltage	± 2.5%	-15%, 20% (± 3% within 1.5 *sec*)
Frequency	± 5%	± 10%(within 5 *sec*)

3.2.2 Lighting Systems

The passageways, stairways and exits specified in **3.2.2-2(2), Part 8 of the Rules** include those passageways, stairways and exits that lead to launching stations of life rafts and the outboard sides in the vicinity illuminated by the lighting specified in **3.2.2-2(1), Part 8 of the Rules**.

3.2.3 Reserve Sources of Electrical Power

The feeding time for the equipment specified in **3.2.3, Part 8 of the Rules** may be appropriately shortened in consideration of operating conditions, etc. provided that the Society deems such modifications acceptable.

Chapter 4 ADDITIONAL REQUIREMENTS FOR ELECTRIC PROPULSION PLANTS

4.1 General

4.1.1 Scope

In **4.1.1-1, Part 8 of the Rules**, the exclusion of thrusters intended as auxiliary steering devices, booster and take-home devices may be acceptable.

4.2 Propulsion Electrical Equipment

4.2.1 General

The wording "designed considering the harmonic content effects" specified in **4.2.1-2, Part 8 of the Rules** means that designs in which the Total Harmonic Distortion (THD) on circuits connected to propulsion electric equipment satisfies the requirement given in **2.1.2-4, Part 8 of the Rules**.

4.2.2 General Requirements for Propulsion Motors

1 The wording "current carrying components" specified in **4.2.2-1(5), Part 8 of the Rules** means, for example, cables, feeder circuits, and slip-rings.

2 The wording "restricted service" specified in **4.2.2-5, Part 8 of the Rules** means, for example, the opening of emergency air inlets fitted in the body of propulsion motors by the crew, etc. in order to maintain minimum cooling performance as well as the manoeuvring condition of operating such motors under low output.

4.2.3 Construction and Arrangement of Propulsion Rotating Machines

The wording "thermometers for measuring cooling air temperatures" specified in **4.2.3-4, Part 8 of the Rules** means that it is measure exhaust side temperatures. Furthermore, the Society may accept the use of thermo-sensors fitted in the stator windings of propulsion rotators as a substitute means.

4.2.5 Propulsion Semiconductor Convertors

1 The wording "means for monitoring effective forced cooling" specified in **4.2.5-3, Part 8 of the Rules** means, for example, those thermometers measuring cooling air temperatures.

2 The wording "sensors failure" specified in **4.2.5-5, Part 8 of the Rules** means line open faults, short-circuit, etc.

4.2.6 Propulsion Transformers

In cases where specified in **4.2.6-6, Part 8 of the Rules**, the use of protection devices fitted in propulsion convertors may be acceptable.

4.3 Composition of Electrical Equipment for Propulsion and Electrical Power Supply Circuits

4.3.1 Composition of Electrical Equipment for Propulsion and Auxiliary Machinery for Propulsion

1 The wording "obtaining a navigable speed for the ship" specified in the main sentence of **4.3.1-1, Part 8 of the Rules** means the speed given in **1.3.1-1, Part 7**.

2 The wording "lubricating systems" specified in **4.3.1-1(4), Part 8 of the Rules** means lubricating oil pumps.

3 In cases where specified in **4.3.1-1(4), Part 8 of the Rules**, the installation of only one propulsion motor onboard ship may be acceptable on the condition that the following requirements are satisfied:

(1) Synchronous motors and induction motors are to be provided with two stator winding systems which can be disconnected from their respective propulsion convertor. Furthermore, such convertors are to be designed for at least 50% nominal power of the propulsion drive system

(2) Permanent-magnet excited motors are to be provided with two stator winding systems which can be disconnected from their respective propulsion convertor.

(3) Propulsion motors are to be provided with means for substitution (emergency opening air flap etc.) in addition to those temperature monitoring systems required in **4.2.3-3** and **-4, Part 8 of the Rules**. However, in cases where two cooling systems are installed, this requirement does not apply.

Chapter 5 BARGES

5.1 General

5.1.3 System Voltage

Where the electric power of which voltage exceeds the value specified in **5.1.3-1, Part 8 of the Rules** is intended to be used data of construction, installation, testing method, etc. for the electrical equipment and cables are to be submitted to the Society.

5.1.5 Limits of Temperature Rise

The ambient temperature for the electrical equipment fitted on the barges navigating only outside the tropical zone is as follows;

For all equipment located in all spaces: 40 *°C*

5.2 Earthing

5.2.3 Exception in Application

In general, the earthing of the following may not be required;

(1) Lamp cap
(2) Shades, reflectors and guards supported on lamp holders or luminaries constructed of, or shrouded in, non-conducting material.
(3) Bolts, metal penetrations and moulded metal parts isolated by insulations from live parts and earthed metal parts.
(4) Housings of bearings insulated to prevent a circulating current
(5) Clips of fluorescent lighting tube
(6) Cable clips

5.3 Protective Devices of Electrical Equipment

5.3.1 General

"The requirements equivalent thereto" prescribed in **5.3.1-2, Part 8 of the Rules** means *JIS*, *IEC* or other national or authorized standards. However, in this case fuses are to be of enclosed type (tube type or plug type).

5.4 Source of Electrical Power

5.4.1 Generator

Characteristics of the speed governors for the prime movers to drive generators are to comply with the requirement in **2.4.2-1, Part 8 of the Rules**.

5.4.2 Switchboards

Switchboards used for the source of electrical power in which two or more generators are provided but not arranged to operate in parallel may be provided with only one ammeter, voltmeter and wattmeter (where the alternating current) which can be used in common for each generators.

5.4.5 Accumulator Batteries

In the case of unmanned barge provided with means of turning off the navigation lights in the day time, the capacity of the storage batteries is to be determined based on the assumption that the duration of the supply of the electrical power to the navigation light is 12 *hours* in a day.

5.5 Cables

5.5.2 Installation of Cables

1 Where cables are installed with loops for expansion, the internal radius of the loops is at least not to be less than 12 *times* the external diameter of the cables.

2 When installing cables, the minimum inside radius of bend is to be in accordance with the following:

(1) 6*d* for rubber and *PVC* insulated cables with metallic covering (*d* = overall diameter of cable);

(2) 4*d* for rubber and *PVC* insulated cables without metallic covering (*d* = overall diameter of cable); and

(3) 4*d* for mineral insulated cables (*d* = Overall diameter of cable)

3 Where cables with different maximum-rated conductor temperatures are bunched together, the current rating of the cables is to be determined based on the lowest temperature-rated cables in the group.

5.5.3 Mechanical Protection of Cables

The protection pipes and casings for cables in cargo holds are to be of metallic. Where non-metallic pipes or casings are used, details of materials, strength, installation method, etc. are to be submitted to the Society for approval.

5.5.5 Securing of Cables

The distance between cable clips or supports is not be more than the value given in **Table 8.5.5.5-1**.

Table 8.5.5.5-1 Distance between cable supports

Installation method of cables	Distance between supports(*mm*)
In case of horizontal runs by clips	300
In case of vertical runs by clips	400
In case of horizontal runs by supports	900(1)

Note:

Where cables are installed on the weather deck, the distance between supports is to be 300 *mm*

5.7 Control Gears

5.7.1 Starters

Electromagnetic contactors for starters complying with *JIS*, *IEC* or such national or authorized standards may be used, not only those complying with the requirement in **2.6, Part 8 of the Rules**.

5.9 Tank Barges

5.9.3 Hazardous Areas

1 The wording “those requirements otherwise specified by the Society” in **5.9.3-2**, **Part 8 of the Rules** means the categorization technique specified in **5.9.4** in *IEC* 60092-502 (1999). This technique categorizes those hazardous areas adjacent to any spaces (standard hazardous areas) in which flammable or explosive gas atmospheres are present or likely to occur after taking into account the effectiveness of any sources of release and ventilation. (Refer to **Fig. 8.5.9.3-1**)

2 The wording “those requirements otherwise specified by the Society” in **5.9.3-3**, **Part 8 of the Rules** means the following requirements:

(1) Enclosed spaces with openings or doors, other than those with bolted, gastight or watertight openings which are kept closed under seagoing conditions, to Zone 1 or 2 areas are to be categorized the same as those hazardous areas in which such openings or doors are located. However, those cases specified in **(2)** to **(4)** below are excluded.

(2) Enclosed spaces which have doors to adjacent Zone 1 areas may be categorized as Zone 2 areas provided that such spaces comply with all of the following requirements:

(a) Doors are to be gastight self-closing type doors and notice placards which indicate that such doors are to be kept closed are to be provided.

(b) Mechanical ventilation devices complying with all of the following requirements are to be provided so that any air inside such spaces flows into Zone 1 areas in cases where such doors are opened.

i) This ensures that there is no accumulation of any gases or vapours in such ventilated spaces and secures the safety of the crew's working environment.

ii) Audible and visual alarms are to be activated in continually manned spaces, e.g. navigation bridges or machinery control rooms, in cases where ventilation device failures have occurred.

iii) Any ducts used for the ventilation of hazardous areas are to be separate from those used for the ventilation of non-hazardous areas.

(3) Those enclosed spaces specified in **(a)** and **(b)** below which have openings into adjacent Zone 1 areas may be categorized as non-hazardous areas.

(a) Doors are to be doubly protected gas-tight doors forming air-locks with both self-closing devices and without holding back arrangements. Notice placards which indicate that such doors are to be kept closed are to be provided.

(b) Mechanical ventilation devices complying with all of the following requirements are to be provided so that spaces are pressurized against hazardous areas.

i) A minimum overpressure of 25 *Pa* with respect to such adjacent hazardous spaces is to be maintained at all points inside such spaces and its associated ducts at which leaks are liable to occur when all doors and windows are closed.

ii) In cases where spaces are not suitably pressurized as in **i)** above, *e.g.* during initial start-up or after shut-down conditions, no electrical installations other than those permitted by **5.9.4, Part 8 of the Rules** (hereinafter referred to as "permitted electrical installations") are to be turned on unless internal atmospheres are ensured as being non-hazardous (any concentration of explosive gases or vapours in such spaces is below 30% of lower explosive limits) or prior purging of a sufficient duration of time which allows internal atmospheres to be considered as non-hazardous is performed.

iii) Monitoring devices are to be provided to ensure the satisfactory functioning of pressurization of such spaces. In cases where flow-monitoring devices are used, it is to be verified that either required pressurization levels are maintained with any doors or other openings open, or that alarms are activated if any door or other opening has not been closed.

iv) In cases where those pressurization levels required by **i)** above are not maintained, alarms are to be activated in any continually manned spaces, *e.g.* navigation bridges or machinery control rooms, and permitted electrical installations are to be automatically switched off. However, important electrical equipment for tank barges safety or personnel safety are to be permitted and set to avoid any automatic switch-off.

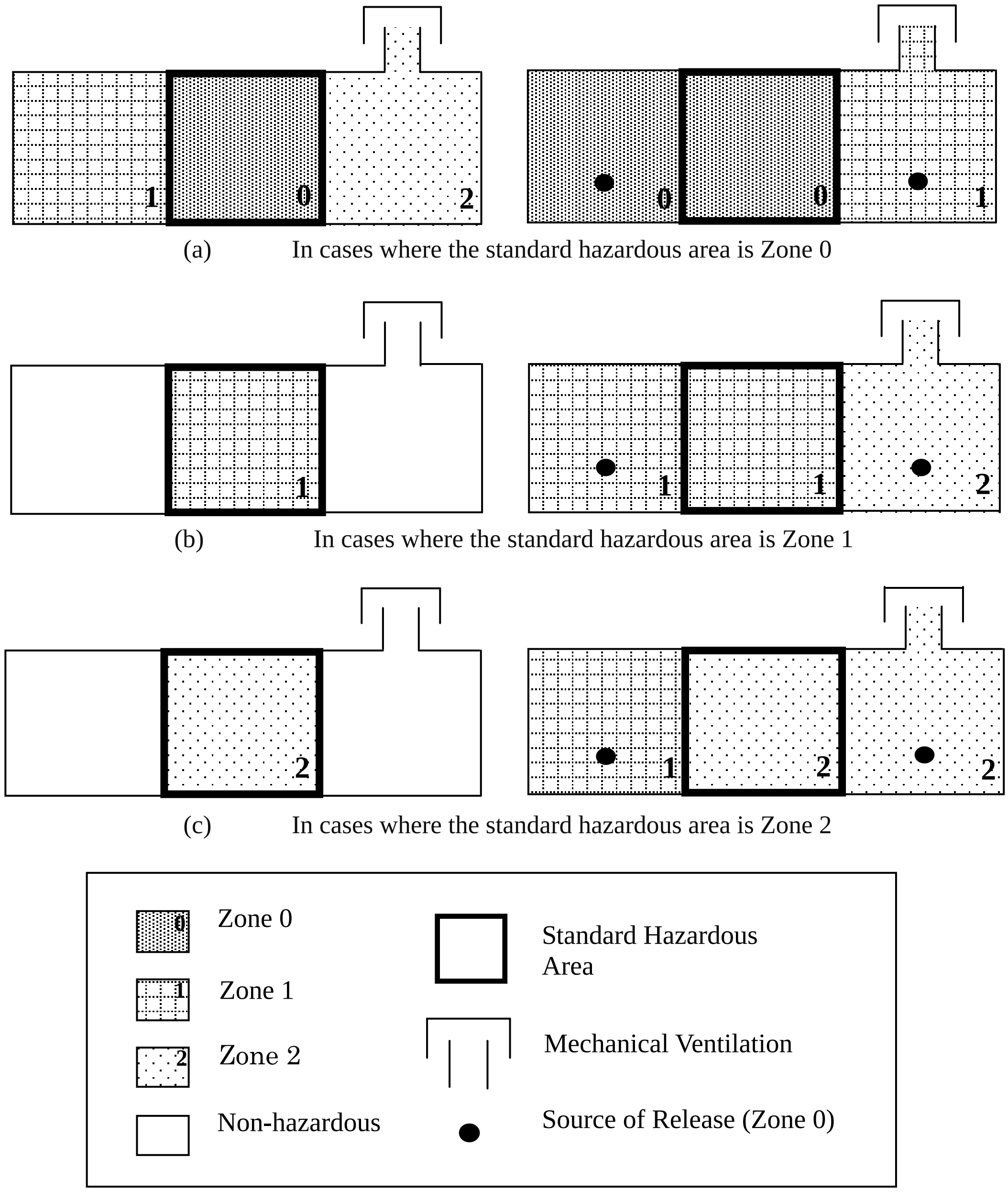
v) Any ducts used for the ventilation of hazardous areas are to be separate from those used for the ventilation of non-hazardous areas.

(4) Enclosed spaces which have doors into adjacent Zone 2 areas may be categorized as non-hazardous areas provided that such spaces comply with all of the following requirements:

(a) Doors are to be gastight self-closing type doors, opening into such spaces inside and notice placards which indicate that such doors are to be kept closed are to be provided.

(b) Mechanical ventilation devices complying with those requirements given in **(2)(b)i)** to **iii)** above are to be provided so that any air inside such spaces flows into Zone 2 areas in cases where such doors are opened.

Fig.8.5.9.3-1 Hazardous Areas Adjacent to Standard Hazardous Areas



5.9.4 Electrical Installations in Hazardous Areas

1 Hull fittings complying with those requirements given in **5.9.4-1(2)(e), Part 8 of the Rules** are to be totally enclosed gastight types or to be housed in gastight enclosures. In addition, they are not to be located adjacent to any cargo tanks. Any of their associated cables connecting to upper decks are to be installed in heavy gauge galvanized steel pipes and their connection joints are to be gastight types.

2 The wording "other electrical equipment deemed appropriate by the Society" in **5.9.4-1(3)(b), Part 8 of the Rules** means one of the following:

(1) Electrical equipment of type "n" protection in accordance with *IEC* 60079-15(2001)

(2) Electrical equipment of a gas enclosed type which is certified by an appropriate authority

(3) Electrical equipment of a type which ensures the absence of any sparks or arcs as well as no surface parts having temperatures which during normal operation may cause the ignition of any gases or vapours from cargoes

3 The wording "it is to be confirmed that such equipment is safe to use in explosive gas atmospheres" in **5.9.4-2, Part 8 of the Rules** means the following:

In the case of tank barges which carry only crude or product oil, explosion-protected electrical equipment complying with the requirements given in **2.16, Part 8 of the Rules** and grouped into Apparatus Group *II*A, Temperature Class *T*3 as specified in *IEC* 60079-0 or Explosion Class *d*1, Ignition Group *G*3 as specified in the Technical Recommendation issued by the National Institute of Industrial Safety, Independent Administrative Institution in Japan and approved by the Society in accordance with those requirements given in **1.2.1-4, Part 8 of the Rules** or their equivalent thereto, or any types of equipment which may not cause the ignition of any gases or vapours from cargoes

4 In the case of small tank barges, in cases where parts of fore castle decks are contained within any hazardous areas on open decks over all cargo tanks to the full breadth of the tank barge plus 3 *m* fore and aft on open decks, up to a height of 2.4 *m* above deck, electrical equipment having enclosures with a degree of protection at least IP55 other than explosion-protected types may be installed in such areas subject to the following requirements **(1)** and **(2)** instead of those requirements given in **5.9.4-2, Part 8 of the Rules**.

(1) Steel type gas barrier walls without any openings are to be provided on forecastle decks.

(2) The height of gas barrier walls is to be 2.4 *m* or more from open decks and the breadth is to be the full breadth of the forecastle deck at those gas barrier walls specified in **(1)** above.

5 In applying **5.9.4-4, Part 8 of the Rules**, "Society approval" includes the drop test specified in *IEC* 60079-0.

6 In applying **5.9.4-5, Part 8 of the Rules**, "corrosion is to be expected" means, for example, those cables installed on open decks.

5.9.7 Maintenance for Explosion-protected Electrical Equipment

The wording "maintenance deemed appropriate by the Society" in **5.9.7, Part 8 of the Rules** means the following:

(1) Maintenance carried out by those procedures given in **Annex 5.9.7**

(2) Any repairs or overhaul of equipment (if necessary)

(3) Confirmation of explosion-protected performance in cases where any modifications, additions or adjustments to equipment are carried out

5.10 Tank Barges Carrying Liquid Cargoes Having Flashpoint Not Exceeding 60 °*C*

5.10.1 Classification of Hazardous Areas

Examples of those hazardous areas specified in **5.10.1, Part 8 of the Rules** are shown in **Fig. 8.5.10.1(1)** to **Fig. 8.5.10.1(3)**.

Fig.8.5.10.1(1) Example of Zone 0

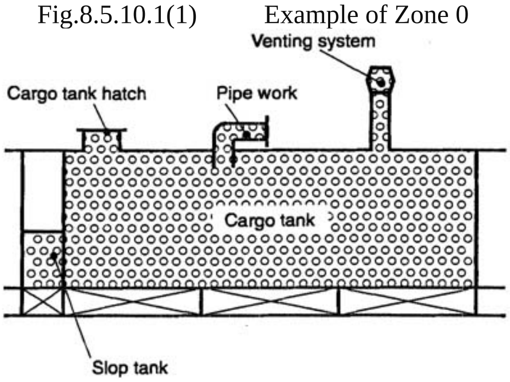


Fig.8.5.10.1(2) Example of Zone 1

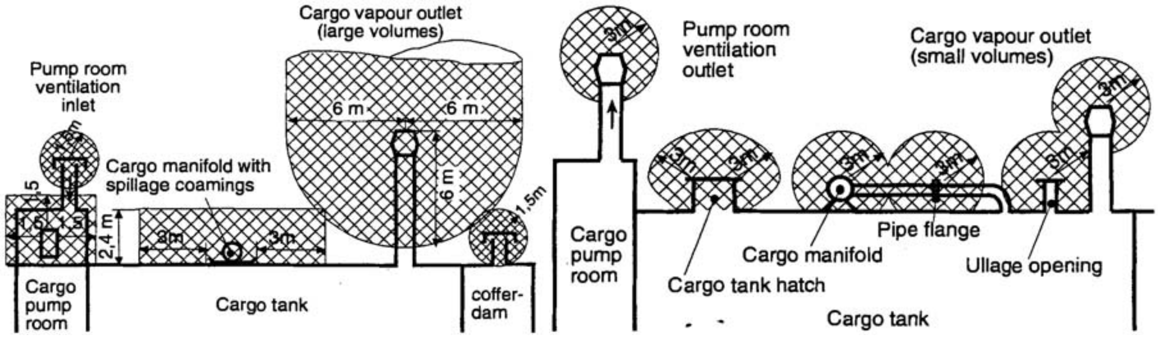
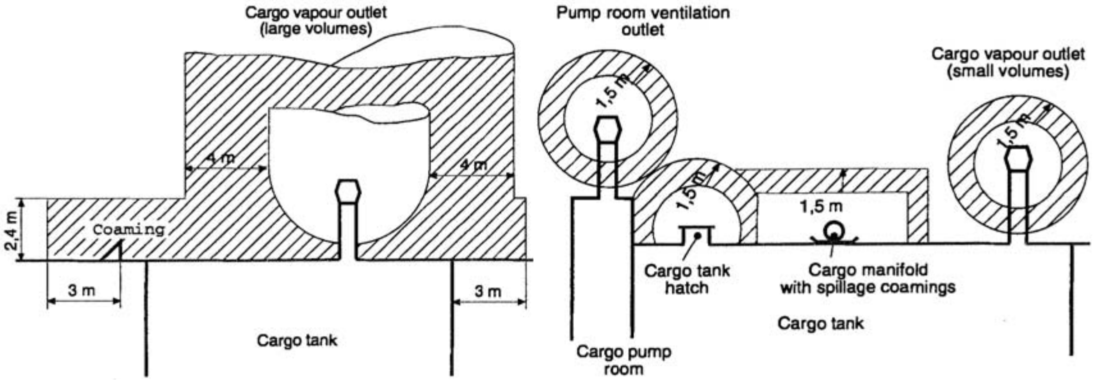


Fig.8.5.10.1(3) Example of Zone 2



5.11 Tests

5.11.1 Tests at the Manufacturer's Work

The voltage regulation of generators and transformers is to be in accordance with the requirements specified in **2.4.13-4**, **2.4.14-2** and **2.10.4, Part 8 of the Rules**.

Part 9 FIRE PROTECTION, DETECTION AND EXTINCTION

Chapter 1 GENERAL

1.5 Modification of Requirements

1.5.1 General

In applying **1.5.1, Part 9 of the Rules**, the request stating rational reasons taking into account environmental conditions of area of operation, etc. is to be submitted to the Society.

Chapter 2 DEFINITIONS

2.1 General

2.1.1 General Rules

In respect of fire protection materials specified in **Part 9 of the Rules**, the wording “approved by the Society in accordance with the Fire Test Procedures Code” means those complying with the test standards specified in **Chapter 1, Part 4 of GUIDANCE FOR THE APPROVAL AND TYPE APPROVAL OF MATERIALS AND EQUIPMENT FOR MARINE USE** and approved by the Society.

2.2 Definitions

2.2.1 Accommodation Spaces

The Following devices **(1)** and **(2)** may be provided in “pantries containing no cooking appliances” specified in **2.2.1, Part 9 of the Rules**.

(1) Toasters, microwave ovens, induction heaters and similar appliances each of them with a maximum power of 5 *kW*. However, coffee machines, dish washers and water boilers with no exposed hot surfaces may be provided in these pantries regardless of their power; and

(2) Electrically heated cooking plates and hot plates for keeping food warm each of them with a maximum power of 2 *kW* and a surface temperature not above 150*°C*.

2.2.4 Cargo Spaces

With respect to the provisions of **2.2.4, Part 9 of the Rules**, trunks lead to cargo spaces need not be regarded as “cargo spaces”, provided that the trunks are separated from the cargo spaces by effective closing devices and are, in the opinion of the Society, not having similar risk as cargo spaces.

2.2.6 Control Stations

1 The wording “main navigational equipment” specified in the provisions of **2.2.6, Part 9 of the Rules**, includes the steering stand, the compass, radar equipment.

2 The steering gear room provided with the emergency steering position is not regarded as “control station” specified in **2.2.6, Part 9 of the Rules**.

3 With respect to the provisions of **2.2.6, Part 9 of the Rules**, spaces where major components of a fixed fire-extinguishing system are provided need not be considered as a control station, except where in **Part 9 of the Rules** relevant to fixed fire-extinguishing systems there are no specific requirements for the centralization within a control station of such major components.

2.2.13 Machinery Spaces of Category *A*

Incinerators specified in **2.2.13, Part 9 of the Rules** is those with a maximum combustion capacity over 34.5 *kW*.

2.2.16 Public Spaces

Electrical equipment specified in **2.2.1** may be provided in “dining rooms” specified in **2.2.16, Part 9 of the Rules**.

2.2.18 Service Spaces

The Following devices **(1)** and **(2)** may be provided in “pantries containing cooking appliances” specified in **2.2.18, Part 9 of the Rules**. However, spaces containing any electrically heated cooking plate or hot plate for keeping food warm with a power of more than 5 *kW* are to be regarded as galleys.

(1) Toasters, microwave ovens, induction heaters and similar appliances each of them with a power of more than 5 *kW*. However, coffee machines, dish washers and water boilers may be provided in these pantries regardless of their power; and

(2) Electrically heated cooking plates and hot plates for keeping food warm each of them with a maximum power of 5 *kW*.

Chapter 3 PROBABILITY OF IGNITION

3.2 Arrangements for Oil Fuel, Lubrication Oil and Other Flammable Oils

3.2.1 Limitations in the Use of Oils as Fuel

1 The wording "other requirements when deemed appropriate by the Society" referred to in **3.2.1(3)(e), Part 9 of the Rules** means those as follows:

(1) Filling pipes and sounding pipes of fuel oil tanks are to be of permanently fixed ones led above the weather deck. Sounding rod is to be of non-ferrous metal material.

(2) Sounding device is to be so located that tank sounding can readily be taken at a place near the filling connection.

(3) The fuel oil is not to be heated to a temperature of 38*°C* or more.

(4) Oil drip trays for fuel oil tanks and fuel oil strainers are to be covered with a wire gauze and the leaked oil collected in the oil trays is to be led to an exclusive drain tank having no opening to the engine room.

2 The wording "considered appropriate by the Society" in **3.2.1(5), Part 9 of the Rules** means that fuel oil service tanks, settling tanks or other tanks provided in fuel oil supply systems which satisfy the following conditions:

(1) The length of the vent pipes from such tanks and/or cooling devices are sufficient for cooling the vapours to below 60*°C*, or the outlet of the vent pipes are located at least 3 *m* away from a source of ignition.

(2) The open-end device of vent pipes are fitted with flame screens.

(3) There are no openings from the vapour space of the fuel oil tanks into machinery spaces (bolted manholes with gaskets are acceptable).

(4) Enclosed spaces are not located right above the fuel oil tanks, except for well-ventilated cofferdams.

3.2.2 Arrangements for Oil Fuel

1 With respect to the requirements specified in **3.2.2(2), Part 9 of the Rules**, the compartments in which fuel oil burning systems, fuel oil settling and service tanks, fuel oil purifiers, etc. are located are to be specially well ventilated.

2 The wording "forepeak tanks" specified in **3.2.2(3)(a), Part 9 of the Rules** means tanks positioned forward the collision bulkhead except portable tanks.

3 With respect to the requirements specified in **3.2.2(3)(b), Part 9 of the Rules**, in case where "free standing oil fuel tanks" are provided in machinery spaces of category *A* due to unavoidable reasons, the capacity of such tanks is not to exceed that to run the main propulsion machinery continuously for 15 *hours*.

4 As for the enough distance specified in **3.2.2(3)(c), Part 9 of the Rules**, the horizontal distance between the tank of flammable oil and the rear face of boilers, thermal oil heaters or incinerators is to be 610 *mm* or more, and that between the tanks and the other portions of boilers is to be 460 *mm* or more. However, the distance between the tank and the cylindrical part of boiler drums or between the tank and the corner of water-tube boiler casings may be reduced to 230 *mm*.

5 With respect to the requirements of **3.2.2(3)(d), Part 9 of the Rules**, pneumatic remote shut-down devices (of the type that needs compressed air only at the time of closing) of main suction valves of fuel oil tanks are to comply with the following requirements:

(1) 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.

(2) The capacity of air bottle is to be sufficient for closing all the main suction valves of fuel oil tanks at least twice.

(3) The air bottle is to be provided with a pressure indicating device at a position which can be easily seen from the position to operate.

(4) Air pipes from the air bottle to the main suction valve's actuators are not to be provided with any valve except for air outlet valves and blow-off valves for these pipes.

(5) Air pipes from the air bottle to the main suction valve's actuators are to be of steel or copper.

(6) Air charging pipes to the air bottle are to be provided with non-return valves.

6 In case where air bottles specified in **-5** above are used commonly for remote shut-down of the fuel tank valves for the emergency generator, remote opening of the water suction valve of the emergency fire pump, remote shut-down of dampers for the ventilating fans for machinery spaces, etc., the following requirements are to be complied with:

(1) The capacity of the air bottle is to be capable of operating simultaneously shut-down of fuel oil tank valves, opening of water suction valves of emergency fire pupms, closing of dampers of ventilation systems for engine rooms, etc. at least twice.

(2) The air piping for the remote shut-down of fuel oil tank main suction valve is to be arranged separately from pipings for other purposes, and the air outlet valve from the air bottle is to be fitted with a name tag for clear identification of the intended service.

(3) The air piping system for remote shut-down of the fuel oil tank main suction valves for the emergency generator is to comply with **(2)** above and to be independent from the other air piping system for remote shut-down.

7 With respect to the requirements specified in **3.2.2(3)(d), Part 9 of the Rules**, the oil fuel pipes, which, if damaged, would allow oil to escape from a storage, settling or daily service tank means that a valve or a cock of such pipes from the tanks is normally open.

8 The wording "ones approved by the Society" in **3.2.2(3)(e)ii), Part 9 of the Rules** means the oil level gauges approved in accordance with the requirements of **Chapter 4, Part 7 of the Guidance for the Approval and Type Approval of Materials and Equipment for Marine Use** and the wording "the standard deemed approved by the Society" means the *JIS F 7215* "Flat glass oil-level gauges" or equivalent.

9 With respect to the requirements to prevent overpressure specified in **3.2.2(4), Part 9 of the Rules**, where pressure relief valves are provided on the delivery side of the fuel oil pumps, arrangements are to made so that the discharged oil is led to the suction side of the pump. However, for centrifugal pumps discharge pressure of which does not exceed design pressure of piping systems, relief valves need not be provided.

10 If flexible hoses are used as a jacketed piping system required in **3.2.2(5)(b), Part 9 of the Rules**, these are to be of an approved type.

11 The wording "appropriate designs, constructions and arrangements for minimizing the fire risk" specified in **3.2.2(5)(b), Part 9 of the Rules** means that the diesel engine meets all the following conditions:

(1) to be installed in a space other than machinery spaces of category *A*;

(2) to be of a single cylinder engine so as to automatically stop by a spillage from the high pressure oil fuel pipe; and

(3) to have a suitable shield for the high pressure oil fuel pipe or whole of the engine so as to prevent oil spray or oil leakage onto ignition sources.

12 The wording "other suitably protected to avoid oil spray or oil leakage onto the sources of ignition" specified in **3.2.2(5)(c), Part 9 of the Rules** means the following preventive measures which are subject to approval by the Society upon submission of those drawings or documents.

(1) Anti-splashing tape

(2) Metal flange cover designed in accordance with *IMO MSC/Circ.*647

(3) Other appropriate preventive measures against oil spray

13 With respect to the requirements in **3.2.2(5)(c), Part 9 of the Rules**, it is considered unnecessary to provide protective means for the following arrangements as the danger caused by an oil spray or an oil leakage is considered relatively low.

(1) Pipings of flammable oil located below the floor plates of engine rooms.

(2) Effective insulation in way of the joints of flammable oil.

14 The means of isolating specified in **3.2.2(5)(e), Part 9 of the Rules** are to be provided at the position in the engine room where is capable of operating safely and ascertaining the fire condition in case of fire of the engine or equipment situated near the engine. With respect to return pipings from engines, non-return valves may be acceptable as the means of isolating.

15 With respect to the requirements in **3.2.2(6)(a), Part 9 of the Rules** where the insulation for hot surfaces is of oil absorbent material or may permit the penetration of oil, the insulation is to be encased in sheathing of steel or equivalent material, except those installed in a place having no fire risk.

3.2.3 Arrangements for Lubricating Oil

With respect to the provisions of **3.2.3, Part 9 of the Rules**, air pipes from unheated lubricating oil tanks may terminate in the machinery space, provided that the open ends are so situated that issuing oil cannot come into contact with sources of ignition such as electrical equipment or heated surface.

3.2.4 Arrangements for Other Flammable Oils

1 The wording “having no danger of fire caused by the spillage” in the provisions of **3.2.4-1, Part 9 of the Rules** means that the hydraulic valves and the cylinders are provided in the space, such as tanks or cofferdams, having no ignition sources, or in the space, such as weather deck, having low risk of contact with ignition sources and where oil spillage may be detected easily.

2 With respect to the provisions of **3.2.4-1, Part 9 of the Rules**, air pipes may be in accordance with the provisions of **3.2.3**.

3.3 Arrangements for Gases for Domestic Purpose

3.3.1 Arrangements for Gaseous Fuel for Domestic Purpose

1 With respect to the requirements of **3.3.1, Part 9 of the Rules**, gas bottles, pipes, valves and pipe fittings of the gaseous fuel systems are to comply with an international or national standard deemed appropriate by the Administration or the Society, notwithstanding the provisions of **Part 7 of the Rules**.

2 Gas bottles are to be protected appropriately according to characters of used gases. In general, gas bottles are to be stored in areas not exposed to direct sunlight and also safe against waves, high temperature and fires, and secured so that the safety against ship motions and vibrations are ensured.

3 With respect to the requirements of **3.3.1, Part 9 of the Rules**, a portion of open deck, recessed into deck structure, machinery casing, deck house, etc., used for the exclusive storage of gas bottles is to comply with the following requirements.

(1) Such a recess is to have an unobstructed opening, except for small appurtenant structures, such as opening corner radii, small sills, pillars, etc. The opening may be provided with grating walls and door.

(2) The depth of such a recess is not to be greater than 1 *m*, where the depth means the maximum horizontal distance between the recessed wall and the wall of deck structure, machinery casing, deck house, etc.

4 A storage space 3 sides of which are closed is to be regarded as a recessed space and comply with the requirements of **-3** above.

5 With respect to the requirements of **3.3.1, Part 9 of the Rules**, where gas bottles are stored in a space other than open decks, including those complying with the provisions in **-3** above, such a space is to be provided with appropriate mechanical ventilation. Electrical installations provided within storage spaces other than open decks or 3*m* of ventilation outlets for the spaces are to comply with the requirements of **2.1.3-7, Part 8 of the Rules**.

3.3.2 Arrangements for Gas Welding Equipment

1 With respect to the requirements of **3.3.2, Part 9 of the Rules**, gas welding equipment using acetylene and oxygen are to conform to the following provisions.

2 Gas bottles, pipes, valves and pipe fittings of the gas welding equipment are to comply with an international or national standard deemed appropriate by the Administration or the Society, notwithstanding the provisions of **Part 7 of the Rules**. Other gas welding equipment is to be to the satisfaction of the Society.

3 Locations of gas bottles are to be as specified below:

(1) Gas bottles are to be stored in areas not exposed to direct sunlight and also safe against waves, high temperature and fire. Appropriate consideration is to be given so that in general the temperature of the bottles will not be higher than 40*°C*.

(2) Gas bottles are to be secured so that the safety against ship motions and vibrations is ensured, and they are to stand upright. Further, means are to be provided so that the bottles can be transferred quickly in case of fire.

(3) Acetylene bottles and oxygen bottles are to be stored apart as far as practicable.

4 With respect to the provisions of **3.3.2, Part 9 of the Rules**, a portion of open deck, recessed into deck structure, machinery casing, deck house, etc., used for the exclusive storage of gas bottles is to comply with the following requirements.

(1) The deck area of such a recess is not to be excessive large.

(2) Such a recess is to have an unobstructed opening, except for small appurtenant structures, such as opening corner radii, small sills, pillars, etc. The opening may be provided with grating walls and door.

(3) The depth of such a recess is not to be greater than the width of the recess, where the depth means the maximum horizontal distance between the recessed wall and the wall of deck structure, machinery casing, deck house, etc.

5 A storage space of which 3 sides are closed is to be regarded as a recessed space and comply with the requirements of **-4** above.

6 With respect to the provisions of **3.3.2, Part 9 of the Rules**, where gas bottles are stored in a space other than open decks, including those complying with the provisions in **-4** above, such a space is to be provided with appropriate mechanical ventilation. Electrical installations provided within storage spaces other than open decks or 3 *m* of ventilation outlets for the spaces are to comply with the requirements of **2.1.3-7, Part 8 of the Rules**.

7 Storage spaces exclusively used for oxygen bottles need not to comply with the provisions of **-4(3)** above.

8 Piping between the gas bottles and working area is to comply with the following provisions:

(1) Steel pipes with corrosion protection are to be used for acetylene gas piping, and steel or copper pipes are to be used for oxygen gas piping. Use of flexible joints made of non-metal material ensleeved in metal sheath in part of the piping may be accepted.

(2) No cast iron is to be used as material for valves and pipe fittings of piping arrangement. Further, copper or copper alloy with a copper content exceeding 62% is not to be used as the material of valves and pipe fittings in the acetylene gas piping.

(3) The procedures of piping arrangement are to be as specified below.

(a) Acetylene gas piping and oxygen gas piping are not to be led through the control stations, accommodation spaces, service spaces of high fire risk, machinery spaces and cargo spaces and other enclosed spaces where any installation which is susceptible to fire is installed.

(b) On acetylene gas piping and oxygen gas piping, stop valves are to be fitted at adequate location of the penetrations through the casing of storage room and working area.

(c) Joints between pipes and pipe fittings are to be welded joint or flange joint as far as practicable.

(d) For clear distinction of the acetylene gas piping system and oxygen gas piping system, the piping systems are to be provided with adequate means of identification.

(4) In case where rubber pipes are used between gas bottles and working area, the rubber pipes are to be of the ones complying with the requirements of any recognized standard deemed adequate by the Society according to the type of gas involved.

(5) After completion of shipboard installation, piping systems are to be subjected to air-tightness test at a pressure of 1.25 *times* or more of the maximum working pressure of the pressure regulator.

3.4 Miscellaneous Items of Ignition Sources and Ignitability

3.4.2 Waste Receptacles

With respect to the requirements of **3.4.2, Part 9 of the Rules**, receptacles constructed of combustible materials may be allowed for the use in galleys, pantries, bars, garbage handling or storage spaces and incinerator rooms provided they are intended purely for the carriage of wet waste, glass bottles and metal cans and are suitably marked.

3.5 Special Requirements for Tank Barges

3.5.4 Cargo Tank Venting

1 When a tank barge to which **1.1.5, Part 1 of the Rules** applies equipped with controlled tank venting systems complying with **8.2.2, Part S of the Rules for the Survey and Construction of Steel Ships** carries crude oil, oil or other similar liquid cargoes with a vapour pressure less than 0.28 *MPa* absolute at 37.8*°C*, the mentioned ship may be regarded as a ship complying with the requirements in **3.5.4-2, Part 9 of the Rules**.

2 "A clear visual indication of the operational status of the valves" specified in **3.5.4-3(2), Part 9 of the Rules** may be achieved by, for example, a distinguishable valve handle position or a placard showing OPEN /CLOSE condition put up near the valve.

3 The design, arrangement, etc. of devices to prevent the passage of flame (including high velocity devices specified in **3.5.4-5(1)(d), Part 9 of the Rules**) specified in **3.5.4-4, Part 9 of the Rules** are to comply with the following requirements.

(1) Terms used in this Chapter are defined as follows.

(a) A device to prevent the passage of flame is a device to prevent the passage of flame through the venting system into the cargo tanks, and includes a flame screen, a flame arrester, a detonation flame arrester and a high velocity device. Such devices are to be of approved type in accordance with the provisions of **Chapter 7, Part 6 of Guidance for the Approval and Type Approval of Materials and Equipment for Marine Use**.

(b) A flame screen is a device to prevent the passage of flame utilizing wire mesh to prevent the passage of unconfined flames.

(c) A flame arrester is a device to prevent the passage of flame utilizing flame arresting element which is based on the principle of quenching.

(d) A detonation flame arrester is a device to prevent the passage of flame generated in association with the detonation in the pipe line.

(e) A high velocity device is a device to prevent the passage of flame consisting of a mechanical valve which adjusts the opening available for flow in accordance with the pressure at the inlet of the valve in such a way that the efflux velocity cannot be less than 30 *m/s*.

(f) Flame speed is the speed at which flame propagates along a pipe or other system.

(g) Flash back is the transmission of flame through a device to prevent the passage of flame.

(2) Devices to prevent the passage of flame (hereinafter referred to as the devices in **3.5.4**) is to be fitted according to the respective types at such a position that the passage of flame through the openings specified in the followings into the cargo tanks can be prevented. Notwithstanding the above, flame arresters and the devices to be fitted in a venting system for cargo tanks protected against a flammable condition by an inert gas system complying with **Chapter 35, Part R of the Rules for the Survey and Construction of Steel Ships**, may be of a type for which an endurance burning test is dispensed with. High velocity devices may be of a type for which a flash back test and an endurance burning test are dispensed with.

(a) A flame screen, a flame arrester, a detonation flame arrester, or a suitable wire gauze complying with the requirements in **7.4.2-2(3)(a)i)** through **ix), Part 6 of GUIDANCE FOR THE APPROVAL AND TYPE APPROVAL OF MATERIALS AND EQUIPMENT FOR MARINE USE** as well as those in **15.6.14-3(1), Part 7** is to be fitted at the following openings:

i) Air suction inlets of *PV* valves for preventing the vacuum in the tanks by thermal variations specified in **7.3.2-1(1), Part 9 of the Rules**

ii) Air suction inlets of devices for preventing the vacuum in the tanks during cargo unloading specified in **7.3.2-1(2), Part 9 of the Rules**

iii) Discharge outlets for cargo tank purging/gas-freeing through which vapour mixtures can be discharged at a velocity of not less than 20 *m/s* in tank barges not provided with an inert gas system, specified in **3.5.7-2(2)(c), Part 9 of the Rules**

(b) A flame screen, a wire gauze specified in preceding **(a)**, a flame arrester, a detonation flame arrester or a high velocity device is to be fitted for the following openings:

i) Openings for release of pressure by thermal variations specified in **7.3.2-1, Part 9 of the Rules**

ii) Vent outputs specified in **3.5.4-5(1)(c), Part 9 of the Rules**, including discharge outlets for cargo tank purging/gas-freeing in tank barges not provided with an inert gas system other than those specified in **(a)iii)** or **(c)**.

(c) A high velocity device is to be fitted for vent outlets for cargo tanks specified in **3.5.4-5(1)(d), Part 9 of the Rules**.

(3) The arrangement and installation of the devices are to be in accordance with the following requirements:

(a) The devices are to be fitted at the outlets to atmosphere unless tested and approved for in-line installation. The devices for in-line installation are not to be fitted at the outlets to atmosphere unless they have been tested and approved for that position.

(b) In case where a detonation flame arrester is installed, the distance between the detonation flame arrester and the end of pipes in which it is fitted is to be such that neither stationary flames nor overheats leading to flash back be generated.

(c) The devices are to be secured in openings so that flames cannot circumvent the devices.

(4) A means is to be provided to prevent the devices from freezing if the operation of the devices is likely hindered by the freezing.

(5) A means is to be provided to enable a personnel to have an access to the devices fitted more than 2 *m* above the deck to facilitate maintenance, repair and inspection.

4 With respect to the provisions of **3.5.4-4, Part 9 of the Rules**, ullage openings need not include cargo tank openings that are fitted with standpipe arrangements used for sampling, monitoring, measuring or etc., with its own manually operated shutoff valves or cocks and diameter of which is not grater than 50 *mm*.

5 The area around the vent outlets specified in **3.5.4-5(1)(c)** and **(d), Part 9 of the Rules** is defined as a hazardous area in accordance with **5.10.1(2)(h)** and **5.10.1(3)(b), Part 8 of the Rules**. In addition, electrical equipment fitted in compliance with the applicable provisions of **5.9.4, Part 8 of the Rules** is not considered as a source of ignition or ignition hazard.

3.5.5 Ventilation

1 With respect to the requirements of **3.5.5-1(1), Part 9 of the Rules**:

(1) For minimizing possible accumulation of the flammable vapours, the ducts are to be arranged, to permit ventilation in the vicinity of the cargo pump-room bilge, above the floor plate or bottom longitudinals. An emergency intake located nearly 2 *m* above the cargo pump-room lower grating is to be arranged for 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. When the lower inlets are closed, at least 15 air changes per hour are to be obtained through the upper inlets.

(2) The ventilation fan of non-sparking construction is to be as follows:

(a) The ventilation fan of non-sparking construction means fans of which materials used for impellers and/or housings are regarded as having a non-sparking property in accordance with **Table 9.3.5.5-1** and of which blade tip clearance is at least 10% of the shaft diameter but need not be more than 13 *mm* (minimum 2 *mm*) except if such materials are ferrous meterials (including austenitic stainless steel). Those specified in this **(a)** also apply to the portable blower fans used outside the cargo pump-room.

(b) Notwithstanding the requirements specified in **(a)** above, fans for which non-sparking property test is carried out in accordance with the procedures approved by the Society in the presence of the Surveyor with satisfactory results may be considered as a non-sparking type. This test may be omitted for fans having test results considered as appropriate by the Society.

(c) Where non-metal materials are used, the anti-electrostatic property is to be verified by a method considered as appropriate by the Society. Fans of which electrical leakage resistance (insulation resistance to earth) is less than $1 \times 10^6\ \Omega$ or electrical conductivity is not less than 1×10^8 *S/m* may be regarded as having an anti-electrostatic property.

(d) Ventilation fans are to be earthed effectively with the hull.

(3) The wording “mesh of suitable size” for wire mesh screens means a mesh not exceeding 13 *mm* × 13 *mm*.

2 The wording “the wire gauze to prevent the passage of flame” specified in **3.5.5-1(2), Part 9 of the Rules** means the one specified in **15.6.14-3(1), Part 7**.

Table 9.3.5.5-1 Materials Used for Ventilation Fans in Cargo Pump-Room

Materials of housing or Materials of lining with a satisfactory thickness		Materials of impellers			
		Non-metallic material with anti-electrostatic property	Ferrous materials (including austenitic stainless steel)	Non-ferrous materials	
					Aluminium alloys or magnesium alloys
Non-metallic material with anti-electrostatic property		○	○	○	○
Ferrous materials (including austenitic stainless steel)		○	(*)	△	×
Non-ferrous materials		○	△	○	○
	Aluminium alloys or magnesium alloys	○	×	○	○

Note:

○ : Combinations considered as having a non-sparking property. (In case of non-metallic materials, the anti-electrostatic property is to be verified in accordance with **3.5.5-1(2)(c)**.)

△ : Combinations to be approved by the Society. (Non-sparking property tests are to be carried out in accordance with **3.5.5-1(2)(b)** except for the combination of beryllium copper alloy and brass which is regarded as having a non-sparking property.)

× : Combinations considered as having a sparking property. This combination can not be used.

(*) : Combinations considered as having a non-sparking property, provided that the impeller tip clearance is at least 13 *mm*.

3.5.6 Inert Gas Systems

1 The wording "means to prevent hydrocarbon gases from the cargo tanks entering the double hull spaces through the system" specified in **3.5.6-3(2), Part 9 of the Rules** means that the branch lines for the supply of inert gas into the double hull spaces are connected to the position between the inert gas regulating valves specified in **35.2.6-3(1), Part R of the Rules for the Survey and Construction of Steel Ships** and the water seal specified in **35.2.6-4(1), Part R of the Rules for the Survey and Construction of Steel Ships** or equivalent measures, and are fitted with the water seal in addition to the water seal required in **35.2.6-4(1), Part R of the Rules for the Survey and Construction of Steel Ships** to prevent hydrocarbon gases from the polluted double hull spaces entering machinery spaces or other safety spaces.

2 The wording "appropriate means" specified in **3.5.6-3(3), Part 9 of the Rules** means the arrangement which consists of portable pipes or flexible hoses and blanking flanges. The pipes or flexible hoses are to be removed and kept on board and all openings of connections of the inert gas main and double hull spaces are to be fitted with blanking flanges except in the event of leakage of oil from cargo tanks entering double hull spaces.

3 The wording "the requirements deemed appropriate by the Society" specified in **3.5.6-4(1), Part 9 of the Rules** means the requirements of the **Annex S11.1.1-2(1)(a), Part S of the Guidance for the Survey and Construction of Steel Ships "Inert Gas Systems using Oil Fired Inert Gas Generators on Ships Carrying Dangerous Chemicals in Bulk"**.

3.5.7 Inerting, Purging and Gas-freeing

For the gas-freeing specified in **3.5.7-1, Part 9 of the Rules**, the systems are to be capable of introducing fresh air into the tanks for increasing the oxygen content to 21% by volume.

3.5.8 Gas Measurement

1 The portable instruments for measuring flammable vapour and oxygen concentrations required in **3.5.8(1), Part 9 of the Rules** may be used as portable instruments required in **3.5.8(2)(a), Part 9 of the Rules** and **35.2.9-4, Part R of the Rules for the Survey and Construction of Steel Ships**.

2 The wording "deemed appropriate by the Society" in **3.5.8(1)** and **(2), Part 9 of the Rules** means to be approved by the Society in accordance with **Chapter 7**, **Part 7** of **"Guidance for the Approval and Type Approval of Materials and Equipment for Marine Use"** or to pass the test of the organization deemed appropriate by the Society.

3.5.11 Protection of Cargo Pump-Rooms

1 With respect to the requirements of **3.5.11(2), Part 9 of the Rules**, a caution plate giving that the lighting is interlocked with ventilation is to be provided nearby switches for the lighting. Where the lighting in cargo pump-rooms can be commonly used as the emergency lighting, this lighting may be accepted for use as emergency lighting and, therefore, interlock devices with ventilation systems may be omitted.

2 The continuous monitoring system for the concentration of hydrocarbon gases required in **3.5.11(3), Part 9 of the Rules** is to be in accordance with the followings:

(1) The system may be of a sampling type provided that the system is dedicated for cargo pump-rooms. In this case, a sampling period is to be as short as possible. Where a gas analysing unit with non-explosion proof measuring equipment is provided for the system, the unit may be located in areas outside cargo areas when mounted on the forward bulkhead provided that the following requirements are observed:

(a) Sampling lines are not to run through gas safe spaces (Gas safe spaces mean spaces in which the entry of hydrocarbon vapour would produce hazards with regard to flammability or toxicity. The same is referred hereinafter.), except where permitted under **(e)**.

(b) The gas sampling pipes are to be provided with devices to prevent the passage of flame. The sample gas is to be led to the atmosphere with outlets provided with devices to prevent the passage of flame and arranged in a safe location on the weather deck.

(c) Flame arresters and flame screens complying with the requirements of **3.5.4-4**. are to be provided for sampling lines and discharge gas lines from gas analysing units, respectively, as the "devices to prevent the passage of flame" specified in **(b)** above.

(d) In respect of the provisions of **(b)** above, the "safe location" for the arrangement of discharge outlets is to be at a horizontal distance not less than 3 *m* from the nearest air intake, discharge outlet or opening to accommodation spaces, service spaces and control stations, or other non-hazardous locations.

(e) Bulkhead penetrations of sample pipes between safe and dangerous areas are to have the same fire integrity as the division. A manual isolating valve is to be fitted in each of the sampling lines at the bulkhead on the gas safe side.

(f) The gas detection equipment including sample piping, sample pumps, solenoids, analysing units etc. is to be located in a reasonably gas tight enclosure (*e.g.* a fully enclosed steel cabinet with a gasketed door). At gas concentrations above 30% *LFL* inside the steel cabinet the entire gas analysing unit is to be automatically shut down.

(g) Where the enclosure cannot be arranged directly on the bulkhead, sample pipes are to be of steel or other equivalent materials and without detachable connections, except for the connection points for isolating valves at the bulkhead and analysing units, and are to be routed on their shortest ways. Copper pipes may be used for sample pipes as equivalent.

(h) A visual and audible alarm is to be provided to notify the shut down of the gas analysing unit specified in the preceding **(f)**. The alarm signal is to be provided in a place where a responsible member of the crew is on duty.

(2) For the system, a flammable gas detecting system suitable for detection of vapours from loaded cargoes may be accepted.

3 The wording "suitable positions in order that potentially dangerous leakages are readily detected" specified in **3.5.11(3), Part 9 of the Rules** means the zone where air circulation is reduced (*e.g.* recessed corners in the pump-room).

4 The wording "as deemed appropriate by the Society" in **3.5.11(3)**, **Part 9 of the Rules** is to be followed as given in **3.5.8-2**.

5 The wording "appropriately located alarms" specified in **3.5.11(4), Part 9 of the Rules** means alarms activating at a level of sufficiently lower than the stuffing box.

6 With respect to the requirements of **3.5.11(4), Part 9 of the Rules**, a bilge high level alarm system being capable of detecting a small bilge in the cargo pump-room and alarming to the cargo control room or the cargo pump control station may be regarded as a bilge level monitoring system.

Chapter 4 FIRE GROWTH POTENTIAL

4.1 Control of Air Supply and Flammable Liquid

4.1.1 Closing Appliances and Stopping Devices of Ventilation

With respect to the requirements of **4.1.1, Part 9 of the Rules**, a warning notice stating, for example "This closing device is to be kept open and only closed in the event of fire or other emergency - Explosive Gas", is to be provided near the closing appliance for the ventilation of a battery room in order to mitigate the possibility of inadvertent closing of the appliance.

4.1.2 Means of Control in Machinery Spaces

1 The means of control outside the space concerned required in **4.1.2, Part 9 of the Rules** may be provided in corridors. In this case, it is not necessary to regard such corridors as a control station.

2 With respect to the requirements of **4.1.2-3, Part 9 of the Rules**, these requirements need not apply to cargo pumps other than those for flammable liquid cargoes. Where submersed pumps are used for cargo pumps, spaces above cargo tanks which they serve are not regarded as a space where the means of control will not be cut off in the event of fire in the cargo tanks.

Chapter 5 DETECTION AND ALARM

5.1 Fixed Fire Detection and Fire Alarm Systems

5.1.1 Installation

1 Requirements of **5.1.1-1, Part 9 of the Rules** apply to machinery spaces of category *A*.

2 The wording “centralized monitoring and control stations on bridge” specified in **5.1.1-1(1)(b), Part 9 of the Rules** means ship wheelhouses in which centralized monitoring and control systems for machinery are installed and from which main propulsion machinery is normally controlled.

3 The wording “centralized control stations” specified in **5.1.1-1(1)(c), Part 9 of the Rules** means those rooms, other than the bridge, in which centralized monitoring and control systems for machinery are installed and from which main propulsion machinery is normally controlled.

Chapter 6 CONTROL OF SMOKE SPREAD

6.1 Release of Smoke

6.1.1 Release of Smoke from Machinery Spaces

1 The arrangements to release smoke from machinery spaces including its control system specified in **6.1.1, Part 9 of the Rules** are to comply with the following requirements **(1)** to **(3)**:

(1) The arrangements to release smoke from machinery spaces are to be skylights, natural ventilation system provided at the crown of machinery spaces, mechanical exhaust ventilating fans and other proper means.

(2) In lieu of the mechanical exhaust ventilating fans given in **(1)** above, reversible mechanical ventilating fans may be accepted. In this case, however, it is to be ensured that the mechanical ventilating fans can be started/stopped at the position specified in **6.1.1-3, Part 9 of the Rules**.

(3) In case where an emergency generator is provided on board the ship, it is preferable that the ventilation system to release smoke can be operated by the emergency power supply.

2 The means of control required in **6.1.1-3, Part 9 of the Rules** may be provided in corridors.

Chapter 7　CONTAINMENT OF FIRE AND STRUCTURAL INTEGRITY

7.1　Protection of Openings in Machinery Spaces Boundaries

7.1.2　Protection of Openings in Machinery Space Boundaries

1　The means of control required in **7.1.2-3, Part 9 of the Rules** may be provided in corridors.

2　The wording "when access to any machinery space of category *A* is provided at a low level" specified in **7.1.2-6, Part 9 of the Rules** means a case where the lower end of the access opening is within 2.5 *m* from the bottom part of machinery spaces category *A*. The wording "light steel fire-screen door" specified in **7.1.2-6, Part 9 of the Rules** means a steel door provided with sufficient thermal insulation effective for shielding fire which is so light as to be operated by a single hand. This door is to be so installed as to have a space to permit passage of one person on the shaft tunnel side.

7.2　Overboard Fittings

7.2.1　Materials of Overboard Fittings

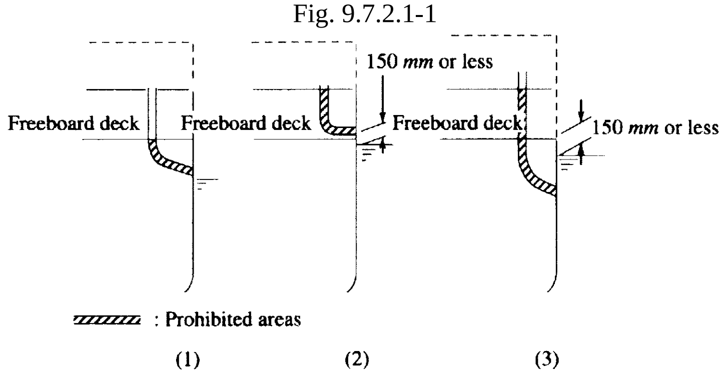
The parts where the use of materials readily rendered ineffective by heat (*PVC*, *FRP*, aluminium alloys, lead, copper and copper alloys) is prohibited for overboard scuppers and sanitary discharges specified in **7.2.1, Part 9 of the Rules** are those in the following **(1)**, **(2)** and **(3)**:

(1) The parts of pipes for scuppers below the freeboard deck and sanitary discharges having open ends on the shell plating below the freeboard deck (*See* **Fig. 9.7.2.1-1(1)**).

(2) In case where scuppers and sanitary discharges have open ends on the shell plating above the freeboard deck with their lower edges located at 150 *mm* or less above the load line, the parts of pipes in the spaces having such openings (*See* **Fig. 9.7.2.1-1(2)**).

(3) In case of **(1)** above, if the distance between the freeboard deck and the load line is 150 *mm* or less, the parts of pipes in the spaces directly above the freeboard deck (*See* **Fig. 9.7.2.1-1(3)**).

Fig. 9.7.2.1-1



7.3　Special Requirements for Tank Barges

7.3.2　Protection of Cargo Tank Structure against Pressure or Vacuum

1　The performance, installation procedures, etc. of pressure/vacuum valves specified in **7.3.2-1(1), Part 9 of the Rules** are to comply with the following requirements. The wording "the procedure deemed appropriate by the Society" means the procedure specified in **Chapter 7, Part 6 of "Guidance for the Approval and Type Approval of Materials and Equipment for Marine Use"**. Approved pressure/vacuum valves are made public on "**List of approved materials and equipment**".

(1) Performance

(a) Pressure/vacuum valves are to be set at a pressure within the ranges from 0.021 *MPa* to 0.014 *MPa* on the pressure side and -0.003 *MPa* to -0.007 *MPa* on the vacuum side. Provided, however, that special reinforcements are made for the scantlings of cargo tanks, the set pressure on the pressure side may be of an appropriate value not exceeding 0.07 *MPa*.

(b) A pressure/vacuum valve installed on a vent branch line of the common venting system is to be such that the discharge outlet is separated from the suction inlet.

(2) Installation Procedure

(a) In case where a pressure/vacuum valve is fitted on a vent branch pipe of the common venting system, the discharge outlet is to be fitted to the vent branch pipe. The suction inlet is not to be fitted to the vent branch pipe to the cargo tanks.

(b) A means is to be provided for easy access to the valves.

(3) Alternative to pressure/vacuum valves

In case where an exclusive automatic pressure valve and an exclusive automatic vacuum valve are provided in combination, such an arrangement may be regarded as that provided with a pressure/vacuum valve. In this case, the exclusive automatic pressure valve and the exclusive automatic vacuum valve are to comply with the requirements for the discharge side or the suction side of the pressure/vacuum valve specified in **(1)** and **(2)** respectively.

2 The area around the air intakes and openings specified in **7.3.2-2(2), Part 9 of the Rules** is defined as a hazardous area in accordance with **5.10.1(2)(g)** and **5.10.1(3)(a), Part 8 of the Rules**. In this case, the “1.5 *m*” in **5.10.1(3)(a), Part 8 of the Rules** is to be read as “2 *m*”. Furthermore, electrical equipment fitted in compliance with the applicable provisions of **5.9.4, Part 8 of the Rules** is not considered as a source of ignition or ignition hazard.

3 The design, arrangement, etc. of high level alarms and level detecting devices of an overflow control system specified in **7.3.2-3(1), Part 9 of the Rules** are to comply with the following requirements. The wording “procedure deemed appropriate by the Society” in **7.3.2-3(1), Part 9 of the Rules** means the procedure specified in **Chapter 7, Part 6 of “Guidance for the Approval and Type Approval of Materials and Equipment for Marine Use”**. Approved high level alarms and level detecting devices are made public on “**List of approved materials and equipment**”.

(1) Performance

(a) Alarms are to be activated in manned spaces.

(b) The alarm system is to be independent of the level sounding system.

(c) The alarm system may operate only when cargo handing is being carried out.

(2) Installation procedures

(a) A means is to be provided for easy access.

(b) In case where the alarm is installed in a position from which cargo handing cannot be stopped, an appropriate means is to be provided to readily pass the alarm to a position from which cargo handling can be stopped.

4 For determining the size of the pressure/vacuum breaking devices specified in **7.3.2-3(3), Part 9 of the Rules**, calculation of pressure losses is to be carried out taking the following parameters into account:

(1) loading/discharging rates;

(2) gas evolution;

(3) pressure loss across devices, taking the resistance coefficient into account;

(4) pressure loss in the vent piping system;

(5) pressure at which the vent opens if a high velocity device is used;

(6) density of the saturated vapour/air mixture; and

(7) to compensate for possible fouling of a flame arrester, 70% of its rated performance is to be used in the pressure drop calculation of the installation.

5 In case where liquid-filled type devices are provided as the pressure/vacuum breaking devices specified in **7.3.2-3(3), Part 9 of the Rules**, a heating system is to be provided if such liquid is likely to freeze.

Chapter 8 FIRE FIGHTING

8.2 Water Supply Systems

8.2.1 Fire Mains and Hydrants

The wording "arrangement of pipes and hydrants to avoid the possibility of freezing" specified in **8.2.1-1, Part 9 of the Rules** means those as follows:

(1) Fire pipes and hydrants at exposed parts are to be provided with suitable insulation.

(2) Scupper valves, etc. are to be provided for draining water for the pipes at exposed parts with piping laid in such a way that no water accumulate in the piping as far as practicable.

8.2.2 Fire Pumps

1 With respect to the requirements of **8.2.2-3, Part 9 of the Rules**, the fire pump is to be connected to a sea chest which is provided with de-icing arrangements.

2 With respect to the requirements of **8.2.2-4, Part 9 of the Rules**, required pump capacity is to be capable of delivering one jet of water which is reachable not less than 12 *m* in distance.

8.2.3 Fire Hoses and Nozzles

1 With regard to "the fire hoses of non-perishable materials approved by the Society" in **8.2.3-1(1), Part 9 of the Rules** and the "approved dual purpose type incorporating a shut off" in **8.2.3-3(4), Part 9 of the Rules**, the wording "approved" means to have passed the inspection by organizations authorized by the Administration or deemed appropriate by the Society.

2 Aluminum alloys may be used for couplings of nozzles and fire hoses specified in **8.2.3, Part 9 of the Rules**.

3 With respect to the requirements of **8.2.3-3, Part 9 of the Rules**, the inside diameters of the tips of nozzles for injecting water to the machinery spaces or exposed areas are to be as given in **Table 9.8.2.3-1** as a standard.

Table 9.8.2.3-1 Inside Diameter of Nozzle Tips

Value of $K\sqrt{Q}$	Inside dia. of nozzle (*mm*)
Less than 16	12
16 and over to 19 exclusive	16
19 and over to 22 exclusive	19
22 and over	19 or 22

Note:

Q : Capacity of the smallest pump (m^3/hr)

K: Values specified in **Table 9.8.2.3-2**

Table 9.8.2.3-2 Values of K

Specified pressure at fire hydrant (*MPa*)	K
0.27	2.85
0.25	2.90

8.3 Portable Fire Extinguishers

8.3.2 Arrangement of Fire Extinguishers

Portable fire extinguishers for accommodation spaces and service spaces required in **8.3.2-1, Part 9 of the Rules** are to be, generally, arranged in accordance with **Table 9.8.3.2-1**.

Table 9.8.3.2-1 Minimum Numbers and Distribution of Portable Fire Extinguishers in the Various Types of Spaces Onboard Ships

Type of space(1)		Minimum number of extinguishers	Class(es) of extinguisher(s) (2)
Accommodation spaces	Public spaces(3)	1 per 250m^2 of deck area or fraction thereof	A
	Corridors	Travel distance to extinguishers should not exceed 25m within each deck	A
	Stairway	0	
	Lavatories, cabins, offices, pantries, containing no cooking appliances	0	
	Hospital	1	A
Service spaces	Laundry drying rooms, pantries containing cooking appliances	1(4)	A or B
	Lockers and store rooms (having a deck area of 4m^2 or more), baggage rooms and workshops(3) (not part of machinery spaces, galleys)	1(4)	B
	Galleys	1 class B and 1 Additional class F or K for galleys with deep fat fryers	B, F or K
	Lockers and store rooms(deck area is less than 4m^2)	0	
	Other spaces in which flammable liquids are stowed	In accordance with **8.6.1, Part 9 of the Rules**	

Notes:

(1) Unless otherwise specified, one of portable fire extinguishers required is to be located at or near entrance and exits in the space. If a space is locked when unmanned, portable fire extinguishers required for that space may be kept inside or outside the space.

(2) The types of portable fire extinguishers are classified below.

(3) It is recommended that the portable fire extinguishers except **(1)** above in public spaces and workshop be located at or near the main entrances and exits.

(4) A portable fire extinguisher required for that small space placed outside or near the entrance to that space may also be considered as part of the requirement for the space in which it is located.

Fire classifications

International Organization for Standardization (ISO standard 3941)	National Fire Protection Association (NFPA 10)
Class *A*: Fire involving solid materials, usually of an organic nature, in which combustion normally takes places with the formation of glowing embers.	Class *A*: Fires in ordinary combustible materials such as wood, cloth, paper, rubber and many plastics.
Class *B*: Fires involving liquids or liquefiable solids	Class *B*: Fires in flammable liquids, oils, greases, tars, oil base paints, lacquers and flammable gases.
Class *C*: Fires involving gases.	Class *C*: Fires, which involve energized electrical equipment where the electrical non-conductivity of the extinguishing medium is of importance. (When electrical equipment is de-energized, extinguishers for class *A* or *B* fires may be used safely.)
Class *D*: Fires involving materials.	Class *D*: Fires in combustible metals such as magnesium, titanium, zirconium, sodium, lithium and potassium.
Class *F*: Fires involving cooking oils.	Class *K*: Fires involving cooking grease, fats and oils.

8.3.3 Spare Charges

With respect to the requirements of **8.3.3, Part 9 of the Rules**, spare charges mean the spares for fire-extinguishing medium and those deemed as necessary for discharging the medium such as compressed air cylinders. Fire extinguishers counted out of the number required in **Part 9 of the Rules** may be considered as spare charges. The spare charges are to be enclosed in receptacles so that no solidification, moisture absorption, degeneration and/or other abnormality would be caused.

8.4 Fixed Fire-extinguishing Systems

8.4.1 General

With respect of the requirements of **8.4.1-5, Part 9 of the Rules**, when commonly served for fixed water-based fire-extinguishing systems, pump systems are to comply with the following **(1)** to **(5)**.

(1) Each fire-extinguishing system is to comply with the performance standards required for each system when the system operates independently.

(2) A failure or damage of any one component in the power and control system is not to result in a reduction of the total pump capacity below that required by any of the areas which the system is required to protect, *e.g.* pump units arranged as 2 x 100%, 3 x 50%, etc. with a dedicated starter cabinet or equivalent arrangements will be accepted. Back-up arrangements are not required for the remote release controls where remote release is required.

(3) Alarms for typical faults and damages in the power and control system are to be provided in a continuously manned control station. Means are to be provided to ensure that the system can be operated manually from positions outside the protected area(s) in case of such faults or damages.

(4) The system is to be arranged to avoid a single failure (including pipe rupture) in one protected area resulting in the system being inoperable in another protected area.

(5) Redundant arrangements for power and water supply are to be located in different compartments.

8.4.3 Storage Rooms of Fire-extinguishing Medium

1 The requirements specified in **(2)**, **(4)**, **(5)** and **(6)** of **8.4.3, Part 9 of the Rules** for storage rooms are applied only to the storage rooms of fixed gas fire-extinguishing systems. For equivalent fixed gas fire-extinguishing systems specified in **25.2.4, Part R of the Rules for the Survey and Construction of Steel Ships**, the requirements of **8.4.3, Part 9 of the Rules** are to be applied to their storage rooms, unless specified otherwise according to the provisions of **R25.2.2-2, Part R of the Guidance for the Survey and Construction of Steel Ships**.

2 With respect to the requirements specified in **8.4.3(5), Part 9 of the Rules**, any space that only permits an access vertically through a hatch provided on an open deck is not deemed to be a space where access from the open deck is provided.

3 With respect to the requirements specified in **8.4.3, Part 9 of the Rules**, where fire-extinguish media protecting the cargo holds is stored in a room located forward the cargo holds, such arrangement is to be in accordance with the provisions of **R25.2.1-8, Part R of the Guidance for the Survey and Construction of Steel Ships**.

8.5 Fire-extinguishing Arrangements in Machinery Spaces

8.5.1 Machinery Spaces containing Oil-fired Boilers or Oil Fuel Units

1 With respect to the requirements specified in **8.5.1, Part 9 of the Rules**, the requirements of fire-extinguishing systems required for machinery spaces containing oil-fired boilers, oil fuel units or internal combustion engines are to be as given in **Table 9.8.5.1-1**. However, for the use of this table, fired inert gas generators, incinerators and waste disposal units, etc. are to be considered as oil-fired boilers.

2 With respect to the requirements specified in **8.5.1-2, Part 9 of the Rules**, in addition to **-1** above, portable fire extinguishers for machinery spaces of category *A* are, in general, to be arranged in accordance with **Table 9.8.5.1-2**.

3 In case where the rate of steam evaporation of boilers converted into *kW*, the following formula may be applied as a standard:

$$F = 2.778 \times 10^{-4} G(i_1 - i_2)$$

F : output (*kW*)

G : actual rate of steam evaporation at designed pressure (*kg/hour*)

i_1 : specific enthalpy of dry saturated steam at designed pressure (*kJ/kg*)

i_2 : specific enthalpy of saturated water at feed water temperature (if unknown, 20°*C*) (*kJ/kg*)

4 The wording “each space in which a part of the oil fuel installation is situated” specified in **8.5.1-2(2), Part 9 of the Rules** means the space in which fuel oil transfer pumps or oil purifiers are provided or the space where an aggregate of valves of the fuel oil transfer line are provided among the spaces provided with the oil fuel installations.

8.5.2 Machinery Spaces containing Internal Combustion Machinery

1 With respect to the requirements of **8.5.2, Part 9 of the Rules**, the provisions of **-1** to **-3** of **8.5.1** of this Guidance are to be applied.

2 For “each such space” specified in **8.5.2, Part 9 of the Rules**, spaces to which persons normally have no access may be excluded.

8.5.3 Machinery Spaces containing Steam Turbines or Enclosed Steam Engines

1 With respect to the requirements of **8.5.3, Part 9 of the Rules**, the provisions of **-1** to **-3** of **8.5.1** and **8.5.2-2** of this Guidance are to be applied.

2 The wording “total output” specified in **8.5.3-1, Part 9 of the Rules** means the total aggregate of the maximum continuous power output of each engine.

3 Types of fire extinguishers not specified in these provisions are to be in accordance with the provisions of **note (2) of Table 9.8.3.2-1.** with respect to their purpose of use on a case-by-case basis.

Table 9.8.5.1-1 Fire Extinguishers in Machinery Space and Boiler Room

<table>
<tr><td colspan="2">Fire-extinguishing arrangements in machinery space of category A</td><td>Fixed fire-extinguishing system</td><td>Portable foam extinguishers</td><td>Additional portable foam extinguishers</td></tr>
<tr><td colspan="2">Reference
Part R of the Rules</td><td>8.5.1-1, Part 9 of the Rules</td><td>8.5.1-2, Part 9 of the Rules</td><td>8.5.2, Part 9 of the Rules</td></tr>
<tr><td rowspan="2">Boiler Room</td><td>Containing oil- fired boilers</td><td>1[y]</td><td>N</td><td>NA</td></tr>
<tr><td>Containing oil-fired boilers and oil fuel units</td><td>1[y]</td><td>N+1</td><td>NA</td></tr>
<tr><td rowspan="4">Engine room</td><td>Containing oil fuel units only</td><td>-</td><td>1</td><td>NA</td></tr>
<tr><td>Containing internal combustion machinery</td><td>-</td><td colspan="2">x</td></tr>
<tr><td>Containing internal combustion machinery and oil fuel units</td><td>-</td><td colspan="2">x</td></tr>
<tr><td>Containing internal combustion machinery, oil fired boilers and oil fuel units</td><td>1[y]</td><td colspan="2">(N+1) or x
whichever is greater</td></tr>
</table>

Notes:

N: Number of firing spaces. “N” means that one extinguisher is to be located in each firing space.

x: Sufficient number, minimum two in each space, so located that no point in the space is more than 10 *m* walking distance from an extinguisher.

y: A foam fire-extinguishing system may be provided in lieu of a fixed fire-extinguishing system.

Table 9.8.5.1-2 Minimum Numbers and Distribution of Portable Fire Extinguishers in the Various Types of Spaces Onboard Ships

Type of space[1]	Minimum number of extinguishers	Class(es) of extinguisher(s) [2]
Central control station for propulsion machinery	1, and 1 additional extinguisher suitable for electrical fires when main switchboards are arranged in central control station	*A* and/or *C*
Vicinity of the main switchboards	2	*C*
Workshops[3]	1	*A* or *B*
Enclosed space with oil-fired inert gas generators, incinerators and waste disposal units	2	*B*
Separately enclosed room with fuel oil purifiers	0	
Periodically unattended Machinery spaces of category *A*	1 at each entrance[4]	*B*

Notes:

(1) Unless otherwise specified, one of portable fire extinguishers required is to be located at or near entrance and exits in the space. If a space is locked when unmanned, portable fire extinguishers required for that space may be kept inside or outside the space.

(2) The types of portable fire extinguishers are to be in accordance with **notes (2) of table 9.8.3.2-1**.

(3) It is recommended that the portable fire extinguishers except **(1)** above in workshop be located at or near the main entrances and exits.

(4) A portable fire extinguisher required for that small space placed outside or near the entrance to that space may also be considered as part of the requirement for the space in which it is located.

Chapter 9 MEANS OF ESCAPE

9.2 Means of Escape from Control Stations, Accommodation and Service Spaces

9.2.1 General Requirements

1 With respect to the requirements specified in **9.2.1-1, Part 9 of the Rules**, means of escape from spaces in which the crew is normally employed but not continuously employed may have only one means of escape. This sole means of escape is to be independent of watertight doors.

2 "Two means of escape" specified in **9.2.1-4, Part 9 of the Rules** are to be those which are separated each other and the escape routes are not common.

9.2.2 Details of Means of Escape

1 With respect to **9.2.2-2, Part 9 of the Rules**, escape routes are to consist of one stairway protected by divisions in combination with a stair or escape hatch capable of being operated from both sides which directly leads to the open deck from the places concerned.

2 Means of escape above the lowest open deck specified in **9.2.2-3, Part 9 of the Rules** are to be in accordance with either of the following requirements:

(1) Escape routes are to consist of two stairways protected by the divisions in combination with doors in outer boundaries on starboard side and portside of the deckhouse at least two levels.

(2) Escape routes are to consist of one stairway protected by the divisions in combination with at least one door in outer boundary of the deckhouse at each level.

3 The continuity of escape routes specified in **9.2.2-5, Part 9 of the Rules** may be accepted even where open decks cannot directly be reached, provided that such areas can be reached through corridors and stairways, etc. in safe ways. Such arrangements as to reach the open decks only by passing through the cabins or using vertical ladders are to be prohibited.

9.3 Means of Escape from Machinery Spaces

9.3.1 Escape from Machinery Spaces of Category *A*

1 With respect to the requirements of **9.3.1, Part 9 of the Rules** to the cases where machinery spaces of category *A* are recessed in toward the stern, one of escape routes required for the machinery space of category *A* is to be provided at the aft of the recess except if the length of the recessed part is 7 *m* or less.

2 With respect to the requirements specified in **9.3.1, Part 9 of the Rules**, doors on escape routes provided in machinery spaces' boundaries facing control stations, accommodation or service spaces are, in general, to comply with the requirements of **9.2.1-5, Part 9 of the Rules**. Details of means of escape except ladders in fire shelters are to be in accordance with **9.2.2-5, Part 9 of the Rules**.

9.3.2 Dispensation from Two Means of Escape

With respect to the requirements of **9.3.2, Part 9 of the Rules**, where the second means of escape is dispensed with, the means of escape is, in principle, to be of an enclosed fire shelter.

9.3.3 Escape from Machinery Spaces other than Those of Category *A*

1 With respect to the requirements of **9.3.3, Part 9 of the Rules**, only one set of means of escape need to be provided for the spaces which are regarded as those having little or no fire risk. In this case, the escape route is not to pass through machinery spaces of category *A* and is to be independent of watertight doors. Where a shaft tunnel is provided, an escape route is to be provided at the aft end of the shaft tunnel.

2 With respect to the requirements specified in **9.3.3, Part 9 of the Rules**, doors on escape routes provided in machinery spaces' boundaries facing control stations, accommodation or service spaces are, in general, to comply with the requirements of **9.2.1.5, Part 9 of the Rules**. Details of means of escape except ladders in fire shelter are to be in accordance with **9.2.2-5, Part 9 of the Rules**.

3 The wording "emergency steering position" specified in **9.3.2-2, Part 9 of the Rules** means all steering positions other than that in the navigation bridge.

Annex 5.9.7 GUIDANCE FOR THE MAINTENANCE FOR EXPLOSION-PROTECTED ELECTRICAL EQUIPMENT

1.1 General

1.1.1 Scope

The requirements in this Guidance apply to the periodical maintenance of explosion-protected electrical equipment installed in tank barges carrying special cargoes.

1.1.2 Definitions

Definitions of the terms used in this Guidance are as follows:

(1) The wording “Connecting Surface” is the name given to connecting parts such as flat connecting parts, threaded parts, faucet joints, coupling parts, shaft penetrating part, etc.
(2) The wording “Container” means components such as boxes for storing electrical equipment, casings, glass globes for lighting, etc. which are of explosion-proof constructions.

1.2 Maintenance

1.2.1 Maintenance Items

The major maintenance items and expected conditions for explosion-protected electrical equipment are as follows. Additional maintenance items are to be required in cases where necessary.

(1) Flameproof type electrical equipment
  (a) There are to be no cracks, fractures or extensive corrosion to any containers
  (b) Container bolts are to be tight and none are to be broken or falling off
  (c) There is to be no corrosion and strain with respect to any connecting surfaces, and flange gap dimensions are to be within proper values
  (d) Cable lead-in parts of the cable entry devices of explosion-proof packing are to be tight and such packing is not to be corroded and worn out
  (e) Thread connecting parts of the cable entry devices using the conduit tube connecting method are to be tight and any compounds used for sealing fittings are to be sufficiently filled and not damaged
  (f) Guards for lighting are not to be damaged and deformed
  (g) There are to be no strains, poor insulation and loose connections to any electrical equipment in containers
(2) Increased safety type electrical equipment
  (a) Any packing used to keep the sealed condition of containers is not to be corroded and worn out
  (b) There are to be no strains, poor insulation and loose connections to any electrical equipment in containers
  (c) In cases where containers are filled with compounds, they are to be sufficiently filled and such compounds are not to be damaged
(3) Intrinsically safe type electrical equipment
  (a) On the inside of intrinsically safe type electrical equipment (*e.g.* power supply units) installed in non-hazardous areas, separation is to be maintained between terminals of intrinsically safe circuits and other circuits
  (b) There are to be no modifications made to any circuits in intrinsically safe type electrical equipment
  (c) Barriers are not to be damaged
  (d) Cable terminals connected to intrinsically safe type electrical equipment (*e.g.* sensors) installed in hazardous areas are to be separated from those terminals of other circuits in junction boxes
(4) Pressurized protected type electrical equipment
  (a) There are to be no cracks, fractures or extensive corrosion to any ducts, pipes and containers
  (b) Protective gas pressures and flows are to be adequate
  (c) Any packing used to keep the sealed condition of containers is not to be corroded and worn out
(5) Encapsulation type electrical equipment

(a) There are to be no strains, poor insulation and loose connections to any electrical equipment in containers
(b) There are to be no cracks, fractures or extensive corrosion to any containers
(c) Containers are to be sufficiently filled with resin and such resin is not to be damaged

(6) Powder filling type electrical equipment
(a) There are to be no strains, poor insulation and loose connections to any electrical equipment in containers
(b) There are to be no cracks, fractures or extensive corrosion to any containers
(c) Ventilating openings on containers are to be in good condition
(d) Containers are to be uniformly filled with powder

(7) Oil immersion type electrical equipment
(a) There is to be no oil leakage from containers or cable lead-in parts
(b) Oil quantity is to be adequate

1.2.2 Regular Maintenance

Regular maintenance is to be carried out at least every year. Among the maintenance items specified in **1.2.1**, those which can be inspected visually are to be examined and it is to be confirmed that no visible unauthorized modifications have been made.

1.2.3 Close Maintenance

Close maintenance is to be carried out at least twice every five years. All of the maintenance items specified in **1.2.1** are to be examined by ladders and inspection tools. Furthermore, it is to be confirmed that the apparatus group and temperature class for which the explosion-protected electrical equipment is designed are correct and that there are no visible unauthorized modifications.