20-900

RULES FOR THE SURVEY AND CONSTRUCTION OF GOVERNMENTAL AND NAVAL SHIPS

Rules for the Survey and Construction of Governmental and Naval Ships

ESTABLISHMENT

Rule No.3 30 March 2020
Resolved by Technical Committee on 22 January 2020

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RULES

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ESTABLISHMENT OF THE RULES FOR THE SURVEY AND CONSTRUCTION OF GOVERNMENTAL AND NAVAL SHIPS

"Rules for the Survey and Construction of Governmental and Naval Ships" has been established as follows:

RULES FOR THE SURVEY AND CONSTRUCTION OF GOVERNMENTAL AND NAVAL SHIPS

(See attached)

EFFECTIVE DATE AND APPLICATION

1. The effective date of the establishment is 30 March 2020.

RULES FOR THE SURVEY AND CONSTRUCTION OF GOVERNMENTAL AND NAVAL SHIPS

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Part 1 GENERAL RULES

Chapter 1 GENERAL

1.1 Application of the Rule

1.1.1 Application

1 The requirements of the Rules apply to the surveys, structures, installations, materials, equipment, etc. of governmental and naval ships (as defined in **2.2.1(1)** in this Part) for which the length of the freeboard is 24 *m* or greater which are to be registered in accordance with the requirements of **Chapter 2 of the Regulations for the Classification and Registry of Ships** (hereinafter referred to in this Rules as "the ship") in cases where an application for classification services during construction is submitted by the shipowner. In such cases, the ship is to be examined and surveyed by Society surveyors in accordance with the Rules. If the ship is deemed to be in compliance with the requirements of the Rules, the ship is assigned a class and registered in the Classification Register in accordance with **the Regulations for the Classification and Registry of Ships**. Any public disclosure of either the classification registry or details of registration, however, is to be determined on a case-by-case basis based upon an agreement between the shipowner and the Society.

2 When an application for the examination and survey of the structures, equipment, and machinery of ships in accordance with the Rules is submitted by the shipowner instead of an application for classification service registration, the Society is to carry out the examinations and surveys applied for by the shipowner in accordance with this Rules

3 The Rules apply to ships for which the main hull is constructed in steel, aluminium alloy or fibre reinforced plastic (hereinafter referred to as "*FRP*") as well as to ships for which the hull form is mainly of a monohull displacement type.

4 For ships applying the Rules, the use of materials containing the following substances is prohibited.

(1) Asbestos
(2) Polychlorinated biphenyl (*PCB*)
(3) Ozone depleting substances, such as certain freons and certain halons, etc. that are covered under the Montreal Protocol on Substances

1.1.2 Equivalency

Hull constructions, equipment, installations, arrangements or dimensions thereto not specified in the requirements of the Rules or for which the requirements of the Rules cannot be applied may be accepted by the Society, provided that the Society is satisfied that they either are equivalent to those required in the Rules or are otherwise confirmed through examination or testing, etc. to conform to the requirements of the Rules.

1.1.3 Materials, Manufacturing Processes, Hull Constructions, Installations, Machinery, etc. Based on New Advanced Technology or Novel Design Theory

Materials, manufacturing processes, hull constructions, installations, machinery, etc. based on new advanced technology or new design theory may be approved at the discretion of the Society. That is to say, the Society may modify or add to the requirements for examinations and surveys as deemed necessary to accommodate the applicable technology or theory in consideration of any documents and data submitted or when the results of any testing to verify the applicable technology or theory conform to the requirements of the Rules are considered to be satisfactory.

1.1.4 Regulations of Flag Administrations

Hull constructions, equipment, installations, arrangements, etc. of ships are also to take into account the national laws and regulations of their respective flag administrations in addition to complying with the requirements of the Rules.

1.1.5 Treatment with the International Conventions

When applying requirements of the Rules, consideration is to be given to the most recent versions of international conventions, etc. with respect to any requirements either based upon or which reference said international conventions, etc.

1.2 Class Notations

1.2.1 General

1 The Society will issue a certification of verification or statement of facts for ships surveyed in accordance with the requirement of **1.1.1-2** provided that the structures, installations, materials, equipment, surveys, etc. of the ship comply with the requirements of the Rules.

2 For ships which are registered in the Classification Register in accordance with requirement **1.1.1-1** as well as for ships complying with special requirements or which are restricted service ships, appropriate class notations are affixed to their Classification Characters in accordance with the provisions of **Chapter 2 of the Regulations for the Classification and Registry of Ships** in cases where any of the following **(1)** to **(11)** are applicable in accordance with the requirements of this Rules. In such cases, the applicable class notations are affixed to the Classification Characters in the following order.

NS* ((1)), ((2), (3)), ((4)), ((5)), ((6)), ((7)), ((8)), ((9)), ((10)), ((11))

(1) Purposes of ships specified in **1.2.2**
(2) Restricted services specified in **1.2.3**
(3) Materials used for hulls specified in **1.2.4**
(4) Characteristics of ships specified in **1.2.5**
(5) Ice strengthening hull construction specified in **1.2.6**
(6) Detailed structural analysis specified in **1.2.7**
(7) Construction and systems for marine pollution prevention specified in **1.2.8**
(8) Measures for noise and vibration in accommodation spaces, etc. specified in **1.2.9**
(9) Safety equipment and navigational equipment specified in **1.2.10**
(10) Survey schemes specified in **1.2.11**
(11) Special items specified in **1.2.12**

1.2.2 Purposes of ships

1 Ships are classed into four (4) types as follows corresponding to their purpose, and an approximate class notation is affixed to their Classification Characters.

(1) Governmental & Naval Ship Type *A* (abbreviated as "*GNS-A*")
Where the ship operates together with other ships as part of a fleet, *GNS-A* ships are ships having the ability to escort other ships through the deployment, operation and control of helicopters and other ships as well as the ability to support other ships. Where the ship operates alone, *GNS-A* ships are ships having the ability to deal with various dangerous situations.

(2) Governmental & Naval Ship Type *B* (abbreviated as "*GNS-B*")
GNS-B ships are ships operating in high threat sea areas for the purpose of transporting crew and other personnel, helicopters, fuel or necessary goods for operations on land or for supplemental operations such as guarding or patrolling around *GNS-A* ships as the support of operations of *GNS-A* ships.

(3) Governmental & Naval Ship Type *C* (abbreviated as "*GNS-C*")
GNS-C ships are ships operating in low threat sea areas for the purpose of transporting crew and other personnel, helicopters, fuel or necessary goods for operations on land, for guarding or patrolling low threat sea areas except for coastal waters, for training crews or for carrying out oceanographic surveys

(4) Governmental & Naval Ship Type *D* (abbreviated as "*GNS-D*")
GNS-D ships are ships other than those specified in **(1)** through **(3)** above that operate in coastal waters without threats for guarding, patrolling or conducting specific tasks.

2 For ships having facilities for transporting helicopter or other supporting goods, or for ships whose purposes are designated by applicants in applications for classification, an appropriate symbol is affixed to the end of the class notation specified in **-1.** (*e.g.*: "*Governmental & Naval Ship Type C- Helicopter Carrier*" (abbreviated as "*GNS-C – HC*")

1.2.3 Restricted Service Ships

For ships classed as being engaged in restricted service, an appropriate class notation as specified below is affixed to their Classification Characters.

(1) For ships engaged in service restricted only to coastal areas which are within 20 *nautical miles* from the nearest shore or to other areas deemed equivalent thereto by the Society, the class notation "*Coasting Service*" (abbreviated as "*CS*") is, in principle, affixed.

(2) For ships engaged in service restricted only to calm water areas which are sheltered from the open sea by land or to other areas deemed equivalent thereto by the Society, the class notation "*Smooth Water Service*" (abbreviated as "*SWS*") is, in principle, affixed.

(3) For ships other than those specified in **(1)** and **(2)** which also apply the Rules which are intended to be engaged in a restricted service deemed necessary by the Society, a class notation deemed appropriate by the Society may be affixed.

1.2.4 Structural Materials for Main Hulls

1 For ships whose main hulls are made of structural materials other than steel, one of the following **(1)** to **(3)** class notations is affixed to the Classification Characters.

(1) Main hulls made of aluminium alloys: "*Aluminum Alloy*" (abbreviated as "*AL*")

(2) Main hulls made of fibre reinforced plastics: "*Fibre Reinforced Plastics*" (abbreviated as "*FRP*")

(3) Main hulls made of materials other than those specified in **(1)** and **(2)**: a class notation deemed appropriate by the Society.

2 For ships having ballast water tanks painted in compliance with the provisions in **Part 3** "*Performance Standard for Protective Coating*" (abbreviated as "*PSPC*") is affixed to the Classification Characters.

3 For ships made of steel and provided with corrosion control systems that comply with the requirement of the Rules, the class notation "*Corrosion Control*" (abbreviated as "*CoC*")" is affixed to the Classification Characters.

1.2.5 Characteristics of Ships

1 A "high speed ship" is defined as a ship capable of a maximum design speed of ship (V) equal to or exceeding the value obtained by the following formula and a class notation "*High Speed Ship* (abbreviated as "*HSS*")" is affixed to the Classification Characters.

$V = 3.7 \times \nabla^{0.1667}$ (*m/sec*)

where:

∇ is a moulded displacement in m^3 at the designed maximum load draught defined in **2.3.11**.

For such ships, the class notation "*High Speed Ship* " (abbreviated as "*HSS*") is affixed to the Classification Characters.

2 For ships intended to operate in areas with low air temperature such as the Arctic Ocean or the Antarctic Ocean using steels suitable to the design temperature (T_D), the class notation "*Design Temperature Category*: *TD-xx* (abbreviated as "*TD-xx*") is affixed to the Classification Characters.

1.2.6 Ships Intended to Operate in Ice Covered Areas

For ships intended to operate in ice covered areas such as polar waters that comply with the requirements of **Part I of the Rules for the Survey and Construction of Steel Ships**, a class notation specifying the polar class or ice class is affixed in accordance with the requirements of that aforementioned **Part I of the Rules for the Survey and Construction of Steel Ships**.

1.2.7 Application of Structural Strength Assessment Methods

For ships whose scantlings and structural details are approved by applying direct strength analysis methods and fatigue strength analysis methods deemed appropriate by the Society, a class notation indicating the type of method is affixed to the Classification Characters in accordance with the following **(1)** to **(6)**.

(1) Where the scantlings are determined by direct strength analysis based upon the requirements of the Rules with consideration given to any diminution of plate thickness caused by corrosion while the ship is in service, and where yield strength assessments and buckling strength assessments are carried out by strength analysis using scantling values from which amounts of diminution deemed appropriate by the Society are subtracted: "*PrimeShip-Direct Strength Assessment*" (abbreviated as "*PS-DA*").

(2) Where the fatigue strength assessments for structural details deemed necessary by the Society are carried out in accordance with the requirements of the Rules: "*PrimeShip-Fatigue Assessment*" (abbreviated as "*PS-FA*").

(3) Where scantlings and detailed structures are determined by direct load analysis based upon the requirements of this Rules, direct strength analysis and fatigue strength assessments with consideration of the diminution of plate thickness caused by corrosion while the ship is in service, and where yield strength assessments, buckling strength assessments and fatigue strength analysis are carried out comprehensively by strength analysis using scantling values from which amounts of diminution deemed appropriate by the Society are subtracted: "*PrimeShip-Total Assessment*" (abbreviated as "*PS-TA*").

(4) Where hull girder ultimate strength assessments are carried out based upon the requirements of the Rules: "*PrimeShip-Hull Girder Ultimate Strength Assessment*" (abbreviated as "*PS-USA*").

(5) Where residual strength assessments of hull girders are carried out based upon the requirements of the Rules: "*PrimeShip-Hull Girder Residual Strength Assessment*" (abbreviated as "*PS-RSA*").

(6) Where vibration and whipping analyses and assessments by modeling the hull as a beam are carried out based upon the requirements of the Rules: "*PrimeShip-Whipping Assessment*" (abbreviated as "*PS-WA*").

1.2.8 Systems Related to Marine Pollution Prevention

Class notation in accordance with the following **(1)** to **(9)** is affixed to the Classification Characters of ships complying with the requirements of the Rules or complying with requirements referenced by the Rules with respect to measures related to the prevention of marine and air pollution.

(1) Where ships employ measures for the prevention of marine pollution by oil in accordance with the requirements in **Part 11**: "**MARPOL ANNEX I**".

(2) Where ships employ measures for the prevention of marine pollution by discharges of noxious liquid substances in accordance with the requirements in **Part 11**: "**MARPOL ANNEX II**".

(3) Where ships employ measures for the prevention of marine pollution by sewage in accordance with the requirements in **Part 11**: "**MARPOL ANNEX IV**".

(4) Where ships employ measures for the prevention of marine pollution by garbage in accordance with the requirements in **Part 11**: "**MARPOL ANNEX V**".

(5) Where ships employ measures for the prevention of air pollution in accordance with the requirements in **Part 11**: "**MARPOL ANNEX VI**".

(a) Nitrogen oxides: "*Nitrogen Oxides Emission-Tier III*" (abbreviated as "*NOx-III*").
For ships using selective catalytic reduction systems, exhaust gas recirculation systems, dual fuel engines or gas-only engines to satisfy the maximum allowable *NOx* emission limits, a class notation corresponding to the concerned systems or engines is suffixed to the end of the class notation.

(b) Sulphur oxide and particulate matter: "*Sulphur Oxide*" (abbreviated as "*SOx*").

(c) Volatile organic compounds: "*Volatile Organic Compounds*" (abbreviated as "*VOC*").

(d) Ships installed incinerator onboard: "*Incinerator*".

(e) Carbon dioxide: "*Energy Efficiency Design Index*" (abbreviated as "*EEDI*").

(f) For ships installed with an onboard exhaust gas cleaning system: "*Exhaust Gas Cleaning System*" (abbreviated as "*EGCS*").

(6) Where ships provided with systems to limit or prevent the attachment of unwanted organisms to their outer shells comply with the requirements of the Rules: "*Anti-Fouling System*" (abbreviated as "*AFS*").

(7) Where ships provided with systems to control and manage ship ballast water so as to satisfy the allowable discharge limits specified in the requirements of the Rules: "*Ballast Water Management System*" (abbreviated as "*BWMS*").

(8) For ships maintaining an inventory of hazardous materials for ship recycling in accordance with the "*Guidelines for the Inventory of Hazardous Materials*" specified separately by the Society: " *Inventory of Hazardous Materials*" (abbreviated as "*IHM*").

(9) For ships adopting specific measures for the environment in accordance with the "*Environmental Guideline*" specified separately by the Society: "*Environmental Awareness*" (abbreviated as "*EA*").

1.2.9 Particular Measures for Noise and Vibration in Accommodation Spaces, etc.

1 Where ships have accommodation spaces, etc. whose noise levels comply with the requirements in **Part 10**, the class notation "*Noise Code*" (abbreviated as "*NC*") is affixed to the Classification Characters.

2 Where ships adopt measures for noise and vibration in accommodation spaces, etc. in compliance with the provisions of the "*Noise and Vibration Guideline*" specified separately by the Society, the class notation "*Noise and Vibration Comfort*" (abbreviated as "*NVC*") is affixed to the Classification Characters.

3 Where ships adopt measures for noise and vibration in machinery room installations in compliance with the provisions of the "*Noise and Vibration Guideline*" specified separately by the Society, the class notation "*Mechanical Vibration Awareness*" (abbreviated as "*MVA*") is affixed to the Classification Characters.

1.2.10 Safety Equipment, Navigational Equipment, etc.

1 Where life-saving appliances comply with the requirements in **Part 10**, the class notation "*Life Saving Appliances*" (abbreviated as "*LSA*") is affixed to the Classification Characters.

2 Where navigational equipment complies with the requirements in **Part 10**, the class notation "*Safety Navigation*" (abbreviated as "*SN*") is affixed to the Classification Characters.

3 Where radio installations comply with the requirements in **Part 10**, the class notation "*Safety*

Radio" (abbreviated as "*SR*") is affixed to the Classification Characters.

4 Where accommodation systems and sanitary systems comply with the requirements in **Chapter 5, Part 10**, the class notation "*Adequate Accommodation Spaces*" (abbreviated as "*AAS*") is affixed to the Classification Characters.

1.2.11 Special Schemes for Ship Maintenance Surveys

Where ships which have been classified on the condition that in-water survey schemes be approved by the Society in accordance with the requirements of **Chapter 6, Part 2**, the class notation "*In-Water Survey*" (abbreviated as "*IWS*") is affixed to the Classification Characters.

1.2.12 Additional Requirements Related to Other Items

1 Where ships using low-flashpoint fuels, defined in **2.4.46**, comply with the requirements of the **Part GF of Rules for the Survey and Construction of Steel Ships**, the class notation "*Low Flash-point Fuel*" (abbreviated as "*LFF*") is affixed to the Classification Characters.

2 Where ships are installed with cargo lifting appliances that comply with the requirements of **Chapter 6, Part 6**, the class notation "*Cargo Handling Gear*" (abbreviated as "*CHG*") is affixed to the Classification Characters.

3 Where ships are installed with additional fire extinguishing systems or fire protection systems that comply with the requirements of **Part 9**, the class notation "*Fire Safety*" (abbreviated as "*FS*"), "*Fire Safety-Alternative Design*" (abbreviated as "*FS-AD*"), "*Fire Safety – Alternative Design(item)*", (abbreviated as "*FS-AD(item)*") or "*Enhanced Fire Safety*" (abbreviated as "*EFS*") is affixed to the Classification Characters.

4 Where ships are installed with systems to control ship roll by fin stabilizers or other anti-rolling systems, the class "*Rolling Control*" (abbreviated as "*RC*") is affixed to the Classification Characters.

5 Where ships are installed with machinery, devices, equipment, etc. which adopt particular measures for noise, vibration and damages, the class notation "*Installation based on Specific Specification*" (abbreviated as "*ISS*") is affixed to the Classification Characters. This class notation, however, is only disclosed to shipowners.

6 Where ships are installed with electrical devices and installations which adopt particular measures regarding electro-magnetic compatibility, the class notation "*Electro-Magnetic Compatibility*" (abbreviated as "*EMC*") is affixed to the Classification Characters. This class notation, however, is only disclosed to shipowners.

7 Where ships are installed with the following helicopter facilities capable of operating helicopters, the class notation indicating the type of operations is affixed to the Classification Characters.

(1) The helicopter facilities defined in **2.4.30**: "*Helicopter Facility*" (abbreviated as "*HF*").

(2) The helidecks defined in **2.4.31**: "*Helideck* " (abbreviated as "*HD*").

8 Where ships are installed with systems to control sound radiated into the water from the ship, the class notation "*Radiation Noise Control*" (abbreviated as "*RNC*") is affixed to the Classification Characters. This class notation, however, is only disclosed to shipowners.

9 Where ships adopt protective measures suitable for in-water threat situations (*e.g.* underwater explosions) expected to be encountered during operations and the impacts of such threats are evaluated appropriately, the class notation "*External Water Shock*" (abbreviated as "*EWS*") is affixed to the Classification Characters. This class notation, however, is only disclosed to shipowners.

10 Where ships adopt protective measures suitable for above-water threat situations (*e.g.* in-air explosions) expected to be encountered during operations and the impacts of such threats are evaluated appropriately, the class notation "*External Air Shock*" (abbreviated as "*EAS*") is affixed to the Classification Characters. This class notation, however, is only disclosed to shipowners.

11 Where ships adopt hull constructions with protective measures and devices suitable for small threat situations (*e.g.* the scattering of fragments) expected to be encountered during operations and the impacts of such threats are evaluated appropriately, the class notation "*Protection against Fragmentation*" (abbreviated as "*PF*") is affixed to the Classification Characters. This class notation, however, is only disclosed to shipowners.

12 Where ships are approved based upon the results of the safety assessments specified in the requirements of **Part 12** with respect to threat situations expected to be encountered during operations, the class notation "*Risk Assessment*" (abbreviated as "*RA*") is affixed to the Classification Characters. This class notation, however, is only disclosed to shipowners.

13 Where ships comply with the "Naval Ship Code": Goals, Functional Objectives and Performance Requirements (*NATO* Standard *ANEP*-77) of the North Atlantic Treaty Organization (*NATO*), the class notation "*NATO*" is affixed to the Classification Characters. This class notation, however, is only disclosed to shipowners.

1.3 Notations Affixed to Main Propulsion Machinery Characters

1.3.1 General

For ships applying the following special requirements related to main propulsion machinery in accordance with the requirements in this Rules, notation indicating the type of special requirement is affixed to the main propulsion machinery characters in accordance with the requirements of **Chapter 2 of the Regulations for the Classification and Registry of Ships**. In such cases, the applicable notation is affixed to the main propulsion machinery characters in the following order.

MNS* ((1)), ((2)), ((3))

where **(1)** to **(3)** mean as follows

(1) Kinds of propulsion machinery specified in **1.3.2**.

(2) Monitoring and control systems for periodically unmanned machinery spaces specified in **1.3.3**.

(3) Special schemes for class maintenance surveys of machinery specified in **1.3.4**.

1.3.2 Kind of Propulsion System

1 Where ships are installed with electric propulsion systems as their main propulsion machinery, the notation "*Electric Propulsion Plant*" (abbreviated as "*EPP*") is affixed.

2 Where ships are installed with waterjet propulsion systems as their main propulsion machinery, the notation "*Waterjet Propulsion System*" (abbreviated as "*WPS*") is affixed.

3 Where ships are installed with azimuth thruster systems as their main propulsion machinery, the notation "*Azimuth Thruster System*" (abbreviated as "*ATS*") is affixed.

1.3.3 Monitoring and Control Systems for Periodically Unmanned Machinery Spaces

Where ships are installed with monitoring and control systems for the periodically unmanned machinery spaces specified in **Chapter 15 of Part 7**, the class notation "M0" is affixed.

1.3.4 Special Schemes for Class Maintenance Surveys of Machinery

Where ships adopt special schemes for the class maintenance surveys of machinery in accordance with the requirements in **Chapter 7 of Part 2**, the following notation corresponding to scheme adopted is affixed.

(1) Continuous machinery survey: "*Continuous Machinery Survey*" (abbreviated as "*CMS*").

(2) Planned machinery maintenance scheme: "*Planned Maintenance Survey*" (abbreviated as "*PMS*").

(3) Condition based maintenance scheme: "*Condition Based Maintenance Survey*" (abbreviated

as "*CBM*").

Chapter 2 DEFINITIONS

2.1 General

2.1.1 Application

The definitions of terms and symbols which appear in the Rules are as specified in this Chapter, unless otherwise specified in other NK Rules, etc. or other Parts of the Rules.

2.2 Type of Ships and Sea Area

2.2.1 Governmental and Naval Ships

A governmental and naval ship is defined as a ship owned by a governmental organization, and is classified as follows.

(1) A ship owned by a governmental organization responsible for the defense of the state or its military forces.
A ship owned by a governmental organization means a ship described in article 29 of the United Nations Convention on the Law of the Sea, which is not subject to international conventions such as the *ICLL*, *SOLAS* and *MARPOL*.

(2) A ship owned by any governmental organizations other than that referred to in **(1)** above.

2.2.2 Sea Area

1 A threat sea area is defined as a sea area where damage of a ship, flooding, fire, and so on due to external threats need to be considered while a ship navigates said area. A threat sea area is categorised as either high threat or low threat, the determination of which is made by the shipowner or the relevant Administration in consideration of the purpose of the ship, the circumstances of the navigational area, etc.

2 Notwithstanding the requirement **-1** above, all ships need to consider hazards such as collision, grounding, storms, extreme waves, fire, etc. that may be encountered during operations.

2.3 Principal Dimension, etc.

2.3.1 Length of Ship (L)

Length of ship (L) is the distance in *metres* on the designed maximum load line (as defined in **2.3.11**), 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. However, for ships with a cruiser stern, L is as defined above or 96 % of the total length on the designed maximum load line, whichever is the greater. 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.

2.3.2 Length for Freeboard (L_f)

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 **2.3.10**.

2.3.3 Length Waterline (L_{WL})

Length waterline (L_{WL}) is the distance, in *metres*, measured on a waterline at the designed maximum draught from the fore side of the stem to the after side of the stern or transom

2.3.4 Length Overall (L_{OA})

Length overall (L_{OA}) is the distance, in *metres*, measured parallel to the designed maximum draught defined in **2.3.11** from the fore side of the stem to the after side of the stern or transom, excluding rubbing strakes and other projections.

2.3.5 Maximum Breadth (B_{max})

Maximum breadth (B_{max}) is the horizontal distance in *metres* from outside of frame to outside of frame measured at the broadest part of the hull.

2.3.6 Breadth of Ship (B)

Breadth of ship (B) is generally the maximum breadth in *meters* of ship. For ships having flare or tumblehome at the cross section, B is the mean breadth of the waterline breadth and the maximum breadth between the waterline and the main deck at the longitudinal center of floatation.

2.3.7 Breadth for Freeboard (B_f)

Breadth for freeboard (B_f) is the maximum horizontal distance in *metres* from outside of frame to outside of frame measured at the middle of L_f .

2.3.8 Waterline breadth (B_{WL})

Waterline breadth (B_{WL}) is generally the greatest moulded breadth, in *metres*, measured at the design draught.

2.3.9 Depth of Ship (D)

Depth of ship (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 cases 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. 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.

2.3.10 Load Line and Designed Maximum Load Line

(1) Designed maximum load line is the water line corresponding to the full load condition when the ship is in deepest condition loaded crew and their personal effects, fuel and other substances planned to be loaded, with consideration given to appropriate margins.

(2) Load line is the water line corresponding to each freeboard assigned in accordance with the provisions of International Conventions on Load Lines for ships required to assign load lines in accordance with said convention.

2.3.11 Load Draught and Designed Maximum Load Draught (d)

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

(2) Load draught is the vertical distance in *metres* from the top of the keel plate to the load line defined in **2.3.10 (2)**, measured at the middle of L_f.

2.3.12 Full Load Displacement (W)

Full load displacement (W) in tons is the value obtained by multiplying the moulded displacement in m^3 corresponding to that at the designed maximum load line defined in **2.3.11**, by the density of sea water.

2.3.13 Lightweight (*LW*)

Lightweight (*LW*) is the displacement in tons excluding cargoes, fuel oil, lubricating oil, ballast and fresh water in tanks, stored goods, and crew and their personal effects.

2.3.14 Deadweight Tonnage (*DW*)

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

2.3.15 Block Coefficient (C_b)

Block coefficient (C_b) is the coefficient given by dividing the moulded displacement in m^3 corresponding to that at the designed maximum load line defined in **2.3.11**, corresponding to full load displacement (*W*) by *LBd*.

2.3.16 Speed of Ship (*V*)

Speed of ship (*V*) is the designed speed in knots which a ship with a clean bottom can attain at maximum continuous output on calm sea in a loaded condition corresponding to the designed maximum load line defined in **2.3.11**, (hereinafter referred to as the full load condition in the Rules).

2.3.17 Maximum Astern Speed

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

2.3.18 Propulsion Machinery

Propulsion machinery is the prime mover for propulsion of a ship, which includes diesel engines, reduction gears for diesel propulsion, gas turbine machinery, reduction gears for gas turbine propulsion and the prime movers driving the propulsion generators for electric motor propulsion.

2.3.19 Maximum Continuous Output of Engine

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

2.3.20 Speed of Maximum Continuous Revolutions

Speed of maximum continuous revolutions is the speed of revolutions in $min.^{-1}$ at maximum continuous output.

2.3.21 Approved Working Pressure of Boiler and Pressure Vessel

Approved working pressure of a boiler or a pressure vessel is the maximum pressure in *MPa* intended by the manufacturer or user at its drum, and is not to exceed the minimum value among the allowable pressures of various parts determined in accordance with the relevant requirements of the Rules.

2.3.22 Estimated Gross Tonnage (GT_a)

Estimated gross tonnage is the value in *tons* obtained by multiplying 0.27 by the length waterline (L_{WL}), the waterline breadth (B_{WL}) and the depth of ship (*D*).

2.3.23 Ballast Load Condition

Ballast load condition is the shallowest draught condition adjusted for navigation by the filling of ballast water into ballast tanks and the loading of fuel oils, lubricating oils, stores, and crews and their belongings, in general.

2.4 Other Terminologies

2.4.1 Midship Parts of Ships

Midship parts of ships are the parts between the location $0.2L_{WL}$ forward of the midship and at location $0.2L_{WL}$ afterward of the midship.

2.4.2 Fore Parts of Ships and After Parts of Ships

Fore parts of ships and after parts of ships are the parts between at locations at the fore end from $0.2L_{WL}$ forward of the midship and between the locations at the after end from $0.2L_{WL}$ afterward of the midship.

2.4.3 Bulkhead Deck

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

2.4.4 Strength Deck

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 $0.15L_{WL}$ 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 $0.15L_{WL}$ in length.

2.4.5 Weather Deck

Weather deck is the uppermost deck maintaining the watertight or weathertight of the main hull or a deck which is completely exposed to the weather from above and from at least two sides.

2.4.6 Freeboard Deck

Freeboard deck is defined as follows, for a ship is required to be assigned freeboard in accordance with the provisions of the International Convention on Load Lines.

(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.
   - (a) 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.
   - (b) 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.
   - (c) Recesses not extending from side to side in the deck designated as the freeboard deck in accordance with the provisions of **(3)** which are below the exposed deck may be disregarded, provided all openings in the exposed deck are fitted with weathertight closing appliances.

(3) Where a ship has multiple decks, an actual deck lower than one that complies with the freeboard deck defined above in **(1)** or **(2)** can be deemed the freeboard deck, and the load line can be marked corresponding to this deck in accordance with the requirements of the International Convention on Load Lines. However, this lower deck is to be continuous in a fore and aft direction at least between the machinery space and peak bulkheads and continuous athwartships. Within cargo spaces, the deck is to be of suitably framed decks or stringers having adequate width and continuous in a fore and aft direction at the ship sides and

transversely at each watertight bulkhead that extends to the upper deck. When this lower deck is stepped, the lowest line of the deck and the continuation of that line parallel to the upper part of the deck are taken as the freeboard deck.

2.4.7 Damage Control Decks

Damage control decks are the watertight decks just underneath the bulkhead decks which are so designed to be used in the recovery from damage in the case of emergency situations.

2.4.8 Propeller Shafts

Propeller shafts are shafts fitting onto propellers, consisting of propeller tightening nuts, shaft sleeves, water-proof screw lids, keys and shaft bodies (including the anticorrosion film). Propeller shafts are categorised into three types: ones in which the propeller is fitted by using a key at the taper part of the propeller shaft (hereinafter referred to as "keyed propeller shafts"), ones in which the propeller is fitted by not using a key at the taper part of the propeller shaft (hereinafter referred to as "keyless propeller shafts") and ones in which the propeller is fitted using a flange with bolts (hereinafter referred to as "flanged propeller shaft").

2.4.9 Stern Tube Shafts

Stern tube shafts are intermediate shafts which lie in stern tubes.

2.4.10 Stern Tubes

Stern tubes consist of a stern tube bearing supporting the propeller shaft and stern tube seal sealing up the lubricating liquids for the propeller shaft bearing.

2.4.11 Waterjet Propulsion Systems

Waterjet propulsion systems are systems for thrusting ships by the thrust force generated by water jetting afterward from an impeller, the intake of water from the outside of a ship and controlling the direction of a ship. Waterjet propulsion systems consists of a shafting system (main shaft, bearings, shaft joints, shaft joints bolts and sealing devices), an intake water piping system, pump units, a wheeling system and a control system (including the function of the rudder).

2.4.12 Dead Ship Condition

Dead ship condition is the condition under which the main propulsion plant, boilers and auxiliaries are not in operation due to the absence of compressed air for staring the main propulsion plants and generators (including emergency generators). In cases where systems are started by compressors using the electric power of batteries, this condition includes the condition which is available to such batteries.

2.4.13 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.

2.4.14 Weathertight

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

2.4.15 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 by the Society or the organization deemed appropriately by the Society.

2.4.16 Cargo Space

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

2.4.17 Machinery Space

Machinery spaces are all machinery spaces of category *A* and all 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.

2.4.18 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 having a maximum combustion capacity over 34.5 *kW*.)

2.4.19 Accommodation Space

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

2.4.20 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.

2.4.21 Public Space

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

2.4.22 Control Stations

Control stations are those spaces in which the ship's radio or navigating equipment or the emergency source of power and emergency switchboard are located, or where the fire indicating or fire control equipment is centralised, or where other functions essential to the safe operation of the ship such as propulsion control, public address, stabilization systems, etc. are located.

2.4.23 Coordinate Stations

Coordinate stations are those spaces in which the information and devices or equipment related to the purpose of a ship or personnel on board are coordinated, managed or monitored.

2.4.24 Hazardous Areas

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.

(1) Zone 0: areas or spaces in which an explosive gas atmosphere is either continuously present or is present for long periods of time

(2) Zone 1: areas or spaces in which an explosive gas atmosphere is likely to occur under normal conditions

(3) Zone 2: areas or spaces in which an explosive gas atmosphere is likely to occur under abnormal conditions

2.4.25 Enclosed Spaces

Enclosed spaces are any place of an enclosed nature where there is a risk of death or serious injury from hazardous substances or dangerous conditions. Examples include, but are not limited to:

boilers, pressure vessels, cargo spaces (cargo holds, or cargo tanks), cargo space stairways, ballast tanks, double bottoms, double hull spaces, fuel oil tanks, lube oil tanks, sewage-tanks, pump-rooms, compressor rooms, cofferdams, void spaces, duct keels, inter-barrier spaces, engine crankcases, excavations and pits.

2.4.26 Superstructures

Superstructures are the decked structures on freeboard decks, extending from side to side of the ship or having its side walls no further than $0.04B_f$ inboard from the sides of the ship. Superstructures are classified as follows.

(1) A bridge is a superstructure which does not extend to either the forward or the after perpendicular.

(2) A poop is a superstructure which extends from the after perpendicular forward to a point which is aft of the forward perpendicular. The poop may originate from a point aft of the after perpendicular.

(3) A forecastle is a 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.

(4) A full superstructure is a superstructure which, as a minimum, extends from the forward to the after perpendicular.

2.4.27 Enclosed Superstructures

Enclosed superstructures are the superstructures complying with the following conditions:

(1) Access openings in the end bulkheads of the superstructure are provided with doors complying with the relevant requirements of the Rule.

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

(3) 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.

2.4.28 Deck Houses

Deck houses are the structures other than superstructures having decks which are their uppermost completely exposed deck.

2.4.29 Cargo Handling Appliances

Cargo handling appliances are appliances such as cranes, cargo lifters, cargo rampways and other lifting appliances for substances (including their prime movers and accessories).

2.4.30 Helicopter Facility

Helicopter facility is a helideck including any refuelling and hangar facilities.

2.4.31 Helideck

Helideck is a purpose-built helicopter landing area located on a ship including all structure, fire-fighting appliances and other equipment necessary for the safe operation of helicopters.

2.4.32 *D*-value (D_H)

D-value (D_H) means the largest dimension of the helicopter when rotor(s) are turning measured from the most forward position of the main rotor tip path plane to the most rearward position of the tail rotor path plane or helicopter structure.

2.4.33 Final Approach and Take-off Area (*FATO*)

Final approach and take-off area (*FATO*) is a defined area over which the final phase of the approach manoeuvre to hover or landing of the helicopter is intended to be completed and from which the take-off manoeuvre is intended to be commenced.

2.4.34 Obstacle-free Sector

Obstacle-free sector is a complex surface originating at, and extending from, a reference point on the edge of the *FATO* of a helideck, comprised of two components, one above and one below the helideck for the purpose of flight safety within which only specified obstacles are permitted.

2.4.35 Limited Obstacle Sector (*LOS*)

Limited obstacle sector (*LOS*) is a sector extending outward which is formed by that portion of the 360 degrees arc, excluding the obstacle-free sector, the centre of which is the reference point from which the obstacle-free sector is determined. Obstacles within the limited obstacle sector are limited to specified heights.

2.4.36 Obstacle

Obstacle is any object, or part thereof, that is located on an area intended for the movement of a helicopter on a helideck or that extends above a defined surface intended to protect a helicopter in flight.

2.4.37 Touchdown and Lift-off Area (*TLOF*)

Touchdown and lift-off area (*TLOF*) is a dynamic load-bearing area on which a helicopter may touch down or lift off. For a helideck it is presumed that the *FATO* and the *TLOF* will be coincidental.

2.4.38 Global corrosion

Global corrosion is the uniform corrosion of structural members located within a wide area of the hull structure and includes all structural members making up the hull girder section or the uniform corrosion of primary support members (in their entirety) such as girders and transverses.

2.4.39 Partial Corrosion

Partial corrosion is the uniform corrosion of local structural members (in their entirety) such as stiffeners and plates surrounded by stiffeners.

2.4.40 Local Corrosion

Local corrosion is pitting corrosion, crevice corrosion or grooving corrosion adjacent to welded joints along abutting stiffeners.

2.4.41 Ballast Water

Ballast water is water taken into and stored on board ships so as to adjust trim, heel, or draught, or to control the stability or hull strength of a ship.

2.4.42 Ballast Tanks

Ballast tanks are tanks which are used solely holding for salt water or fresh water.

2.4.43 Fuel Oil Tanks

Fuel oil tanks are tanks used to carry all kinds of oils used as a fuel for the propulsion machinery and auxiliary machinery of a ship; this, however, excludes tanks not used to carry fuel oil during ship navigation, such as tanks (*e.g.* overflow tanks) used to hold oil spilt during refuelling.

2.4.44 Oils

Oil means petroleum including crude oil, heavy fuel oil, lubricating oil, light oil, kerosene, gas oil, and others prescribed by the relevant laws and regulations.

2.4.45 Dangerous Goods

Dangerous goods are those goods referred to in the *IMDG* Code, as defined in Chapter VII, Regulation1.1 of the International Convention for *Safety of Life at Sea* 1974 (hereinafter referred to as "*SOLAS*"), as amended.

2.4.46 Ships Using Low-Flashpoint fuels

Ships using low-flashpoint fuels mean which use gas fuels or liquid fuels having its flashpoint defined in **2.4.15**, of 60 °C or under.

2.4.47 Oil Fuel Units

Oil fuel units are the following type of equipment. However, oil fuel transfer pumps are not considered to be 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 of heated oil for delivery to internal combustion engines

(3) Equipment used for the preparation of oil for delivery to internal combustion engines 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*

2.4.48 Non-combustible Materials

Non-combustible materials are materials 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.

2.4.49 Combustible Material

Combustible material is any material other than a non-combustible material.

2.4.50 Flammable Liquids

Flammable liquids mean liquids having flashpoints, as determined by through flashpoint measurement tests (*i.e.* the measuring of the flashpoint of a substance using a flashpoint apparatus approved in accordance with relevant laws).

2.4.51 Ships carrying Flammable Liquids

Ships carrying flammable liquids are cargo ships constructed or adapted for the carriage in bulk of liquid cargoes of a flammable nature except for fuel oils and lubricating oils used by herself.

2.4.52 Ships Carrying Liquefied Gases in Bulk

Ships carrying liquefied gases in bulk are cargo ships constructed or adapted and used for the carriage in bulk of liquefied gases specified in **Chapter 19, Part N of the Rules for the Survey and Construction of Steel Ships**.

2.4.53 Ships Carrying Dangerous Chemicals in Bulk

Ships carrying dangerous chemicals in bulk are cargo ships constructed or adapted and used for the carriage in bulk of dangerous chemicals specified in **Chapter 17, Part S of the Rules for the Survey and Construction of Steel Ships**.

Chapter 3 PRECONDITIONS

3.1 Design Conditions, etc.

3.1.1 Design Conditions on Temperature

1 In designing ships, machinery installations, equipment, etc., the following conditions on temperature are to be taken into account.

(1) Air temperature in enclosed spaces (1), (2), (3) 0 ℃ - 45 ℃
(2) Air temperature on open decks -25 ℃ - 45 ℃
(3) Sea water temperature 0 ℃ - 32 ℃

(Note)

(1) Design temperatures for machinery components or boilers in spaces subject to temperatures exceeding 45 ℃, and below 0 ℃ are to be those according to the specific design conditions.
(2) Other temperatures deemed appropriately by the Society may be accepted in ships intended for restricted service.
(3) For ships having facilities being capable of controlling temperature ranges within the specified ones planned for installations in spaces under any conditions by air conditioning systems, the design temperatures in such spaces may be of a specific one.
(4) Where usage restrictions or load limitations are provided regarding design temperature, the design temperature is to be of that approved by the Society.

2 The design temperatures of equipment, systems, etc., for maintaining the safety of ships and their crew, are to be -30 ℃ to 38 ℃ in air and -2.5 ℃ to 32 ℃ in sea water.

3.1.2 Angle of Inclinations

1 Hull structures as well as main propulsion machinery, prime movers for driving generators, auxiliary machineries and their prime movers, equipment and piping that are installed on ships are to be designed to operate under the design conditions given in **Table 1.3.1**.

Table 1.3.1 Angle of Inclinations

Type of machinery installation	Athwartship(2)		Fore-and-aft(2)	
	Static inclination (List)	Dynamic inclination (Rolling)	Static inclination (Trim)	Dynamic inclination (Pitching)
Main propulsion machinery, Main boilers and essential auxiliary boilers, Prime movers driving generators (excluding those for emergencies), auxiliary machinery and their driving units; however, electrical installations for emergencies as well as the installations listed are excluded.	15°	22.5°	5°(3)	7.5°
Emergency installations (emergency generators, emergency fire pumps and prime movers to drive them) Switchgears (1) (circuit breakers, etc.) Automatic or remotely operated equipment Emergency electrical installations, their switchgears (circuit breakers, etc.) as well as electrical and electric equipment	22.5°	22.5°	10°	10°

(Note)

(1) Up to angle of inclination of 45 *degrees*, undescribed switching operators or operational changes are not to be caused.
(2) Athwartships and bow-and-stern inclinations may occur simultaneously.
(3) Where L_{WL} exceeds 100 *m*, the angle may be taken as follows.

$\theta = 500/L_{WL}$

θ : The static angle of inclination (°)

(4) For a ship having multiple common installations, one of them is to be regarded as an emergency installation

(5) Where angles of inclination of the ship exceed those specified the table due to the possible flooding expected, the design condition is to be of the expected angles or the safety of installations and the ship applied to the design condition given by the table is to be assessed in accordance with the requirements of **Part 12**.

2 Hull structures as well as main propulsion machinery, prime movers for driving generators, auxiliary machinery and their driving units, equipment and piping that are installed on *GNS-A* ships and *GNS-B* ships are to be designed to operate under the design conditions given in **Table 1.3.2**.

Table 1.3.2 Angle of Inclination for *GNS-A* ships and *GNS-B* ships

Type of machinery installation	Athwartships		Fore-and-aft	
	Static inclination (List)	Dynamic inclination (Rolling)	Static inclination (List)	Dynamic inclination (Rolling)
All system, equipment and installation	15°	45°	5°	10°
All system, equipment and installation installed on *GNS-B* ships with L_{WL} of 100 *m* or less and high speed ships	10°	35°	5°	10°

3.1.3 Wind Speed

1 Design conditions for wind speed (relative wind speed) related to the functioning of installations and devices affected by wind are given in **Table 1.3.3**. Where a steady wind speed means a 10-minute average wind speed and an instantaneous wind speed means a 3-second average wind speed, *i.e.* as wind speed is measured at 0.25 seconds intervals, the values of wind speed in 3 seconds are 12, the instantaneous wind speed is the wind speed averaged from 12 measured values.

Table 1.3.3 Design Condition for Wind Speed for the Functioning of Installations

	GNS-A ships	*GNS-B* ships(1)	*GNS-C* ships	*GNS-D* ships
Steady wind speed	30 *m/s*	30 *m/s*	20 *m/s*	20 *m/s*
Instantaneous wind speed	45 *m/s*	45 *m/s*	30 *m/s*	30 *m/s*

(Note)
(1) For *GNS-B* ships with L_{WL} of 100 *m* or less, and high speed ships, the wind speed for *GNS-C* ships may be applied.

2 Design conditions for wind speed (relative wind speed) related to the structural strength of installations and devices affected by wind are given in **Table 1.3.4**.

Table 1.3.4 Design Condition for Wind Speed for the Structural Strength of Installations

	GNS-A ships	*GNS-B* ships(1)	*GNS-C* ships	*GNS-D* ships
Steady wind speed	40 *m/s*	40 *m/s*	30 *m/s*	30 *m/s*
Instantaneous wind speed	60 *m/s*	60 *m/s*	45 *m/s*	45 *m/s*

(Note)
(1) For *GNS-B* ships with L_{WL} of 100 *m* or less, and high speed ships, the wind speed for *GNS-C* ships may be applied.

3.2 Scantlings of Hull Structures

3.2.1 Net Scantlings

1 Scantlings of hull structural members in accordance with the requirements of **Part 5** are based on the net scantling concept, and are to be maintained as necessary scantlings from the viewpoint of hull strength even if they are deminuated due to global corrosion (as defined in **2.4.38**) or partial corrosion (as defined in **2.4.39**). Where the required thickness is calculated by strength requirements, the net thickness (t_{Net}) is to be obtained by a by adding a margin of 0.5 *mm* corresponding to possible corrosion diminution in intervals between special surveys to the required thickness as shown below.

$t_{Net} = t_{Require} + 0.5$ (mm)

2 Where the moment of inertia, section modulus, and the cross section of the subject structural member are required by the strength requirements of **Part 5**, these structural characteristics are to be calculated using the net thicknesses (t_{Net}) of plates which make up the subject structural member.

3 In the net scantling concept, the corrosion additions (t_c) to be considered are given by the following values corresponding to the exposed corrosive environment of one side of the structural member.

(1) Where hull structures are made of steels;

(a) parts exposed to sea water or air: 0.5 *mm*

(b) parts in ballast tanks 1.0 *mm*

(c) parts other than the above 0.25 *mm*

(For example, the corrosion additions of a member such as a girder in a ballast tank, whose both sides are exposed to ballast water, is 1.0 + 1.0 = 2.0 (*mm*).)

However, for ships affixed the class notation "*Corrosion Control*" to the Classification Characters in accordance with **1.2.4-3**, the corrosion additions may be 0.0 *mm*.

(2) For ships whose main hull structures are made of aluminium alloys or *FRP*, the corrosion additions are 0.0 *mm*.

4 Scantlings shown on drawings using the net scantling concept are to be in accordance with the following **(1)** and **(2)**.

(1) Thickness is to be obtained by rounding up in half millimeters the obtained from adding the required thickness (t_{req}) to the corrosion addition (t_c) specified in **-3**.

(2) Thicknesses of structural members whose structural characteristics are required to be obtained by rounding up in half millimeters the values for net thickness (t_{Net}) of each member which is used in calculations of structural characteristics.

5 Local corrosion (as defined in **2.4.40**), is not necessary for the determination of scantlings.

6 For the hull girder strength with respect to the hull girder bending moment and sheer force specified in **Part 5** and the strength assessments for ships affixed with class notation related to the application of structural strength analysis in accordance with **1.2.7**, half of corrosion additions are to be considered when applying the requirements of **Part 5**.

3.3 Special Requirements

3.3.1 General

For ships intended to operate in the threat sea area specified in **2.2.2**, the items specified in the following **(1)** to **(7)** are to be taken account in order to reduce the threat completely or reduce its level. The detailed items to be considered, however, are to be in accordance with specifications or documents provided by shipowners.

(1) For systems and equipment used to control sound radiated into the water from ships, measures for lowering sound levels of the systems or equipment themselves or the adoption of anti-vibration supports for systems or equipment. For piping connected to installations or equipment, adoption of anti-vibration supports and anti-vibration joints so as to control the propagation of vibration from piping.

(2) Measures to control noise from propellers.

(3) Measures for shock-proofing and vibration-proofing previously installed systems and equipment so as to ensure shock-proof and vibration-proof characteristics as well as installing new shock-proof and vibration-proof systems and equipment.

(4) In order to reduce radar cross section (*RCS*), the consideration of the features of masts and equipment on and above exposed decks or the hull form.

(5) Installation of systems applying reduction measures so as to reduce the radiation of infrared

rays.

(6) For installations and equipment, the adoption of systems to prevent interference caused by electro-magnetic waves and adoption of measures to control electro-magnetic wave radiation.

(7) For systems affecting ship operation or the continuity of operation immediately when operational capability is lost, redundant installation of important components of such systems, installing of redundant systems, preparation of alternative measures and emergency measures, and implementation of other effective protective measures.

Part 2 CLASS SURVEYS

Chapter 1 GENERAL

1.1 Surveys

1.1.1 Classification Surveys

1 For ships whose applications for registration by the Society are submitted by shipowners based upon the requirement of **1.1.1-1**, **Part 1**, Classification Surveys are to be carried out in accordance with the requirements specified in **Chapter 2**.

2 For ships whose applications for surveys are submitted by shipowners based upon the requirement of **1.1.1-2**, **Part 1**, such surveys are to be carried in accordance with the requirements of this Part, however, Classification Surveys are not to be carried out in such cases. In addition, statements describing the compliance with relevant requirements may be issued in cases where applications for such statements are submitted by shipowners, provided that it is confirmed that the structures, equipment, machinery, etc. of the ship comply with relevant requirements of the Rules.

3 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 7**. In addition, in cases where any modification of ship registration details is needed, the ship is to comply with **2.5** 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 hulls, machinery, equipment, firefighting equipment, etc. as specified in **Chapter 3**.
- (b) Intermediate Surveys: The surveys consist of general examinations of hulls, machinery, equipment, firefighting equipment, etc. and detailed examinations of certain parts as specified in **Chapter 4**.
- (c) Special Surveys: The surveys consist of detailed examinations of hulls, machinery, equipment, firefighting equipment, etc. as specified in **Chapter 5**.
- (d) Docking Surveys: The surveys consist of bottom inspections normally carried out in a drydock or on a slip-way as specified in **Chapter 6**.

(2) Planned Machinery Surveys
- (a) Continuous Machinery Surveys (*CMS*): The Surveys consist of open-up examinations of machinery and equipment specified in **Chapter 7** which are to be carried out systematically, continuously and sequentially so that each survey interval for all *CMS* items does not exceed five years.
- (b) Planned Machinery Maintenance Schemes (*PMS*): The Surveys consist of open-up examinations of machinery and equipment specified in **Chapter 7** which are to be carried out according to the machinery maintenance scheme approved by the Society.
- (c) Condition Based Maintenance Schemes (*CBM*): The Surveys consist of open-up

examinations of machinery and equipment specified in **Chapter 7** which are to be carried out based upon the results of condition monitoring and diagnosis according to a machinery condition based 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.

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 **(4)** below.

(1) Annual Surveys: Annual Surveys are to be carried out within three months before or after each anniversary date.

(2) Intermediate Surveys: Intermediate Surveys are to be carried out at the time of the second or 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.

(3) Special Surveys: Special Surveys are to be carried out within 3 months before the date of expiry of the Certificate of Classification (5 years)

(4) Docking Surveys: Docking Surveys are to be carried out as prescribed in **(a)** and **(b)** below.
  (a) Concurrently with Special Surveys
  (b) Within 36 months from the date of completion of the Classification Survey or the previous Docking Survey

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

(1) In the Continuous Machinery Survey, each survey item or part is to be examined in accordance with requirements in **7.2** at the interval not exceeding 5 years.

(2) In the Planned Machinery Maintenance Scheme, each survey item or part is to be examined according to the survey schedule table specified in **7.3** and at the general examination (including review of maintenance records) which is to be carried out every year.

(3) In the Condition Based Maintenance Scheme, each survey item or part is to be examined according to the survey schedule table specified in **7.4** and at the annual survey.

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 line is necessary to change, for ships which are intended to change maximum design load water line or marked with maximum design load water lines.

(3) When an alteration affecting the ships 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 Annual Surveys or Intermediate Surveys may be carried out in advance of the times specified in **1.1.3-1(1)** or **(2)** when requested by the owner. Annual survey may be dispensed with when Intermediate Surveys are carried out in advance of the times of Annual Surveys. In such cases, 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 and subsequent periodical surveys 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 Special Surveys may be carried out based upon following **(1)** through **(3)** in advance of the times specified in **1.1.3-1(3)** when requested by the owner.

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

(2) Where a Special Survey is commenced prior to the time of the fourth Annual Survey, the Special Survey is to be completed within 15 months from the date of its commencement.

(3) Notwithstanding **(2)**, where a Special Survey is commenced on or before the due date of the third Annual Survey and an Intermediate Survey is not carried out, the Special Survey is to be completed up to the following **(a)** or **(b)**, whichever is earlier.

    (a) Due date of third Annual Survey; or
    (b) 15 months from the date of its commencement

1.1.5 Postponement of Surveys

1 Special Surveys may be postponed as specified in **(1)** or **(2)** below subject to the approval by the Society in advance.

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

(2) Maximum 1 month for the ship engaged on short voyages.

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

3 The treatment about where the Classification Certificate is expired during the execution of the Special Surveys is the discretion of the Administration. In such case, the anniversary date is to be amended to the date when the survey is completed.

1.1.6 Modification of the Requirements

1 With respect to Periodical Surveys and Planned Machinery Surveys in cases where considered appropriate by the Society, the Surveyor may modify the requirements specified in **Chapter 3** through **Chapter 7** based on 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, close-up surveys, pressure tests or thickness measurements are to be carried out. Thickness measurements procedures and submission of gauging results are to be in accordance with the requirements of **5.2.6-1**.

3 For tanks and cargo holds where effective coatings are found to be in a good condition, the extent of internal examination, close-up surveys or gauging requirements may be reduced to a degree that is sufficient to confirm the actual average condition of the structure under the coating at the discretion of the Surveyor.

4 For Intermediate Surveys carried out at the time of the third Annual Survey in accordance with the requirements in **1.1.3-1(2)** examinations required for Intermediate Surveys carried out during the period between the 2nd and 3rd Annual Surveys as a part of another survey may be given special consideration or omitted at the discretion of the Surveyor. However, at a minimum the examinations required in **Chapter 3** are to be carried out at the Intermediate Survey.

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 Surveys or Planned Machinery Surveys have not transpired while the ship was laid-up, then surveys equivalent to the Periodical Surveys to be carried out as the next due survey before the ship was laid-up are 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 If the survey to be carried out under the requirements of **-2** above is a Special Survey, either the overdue Special Survey or the next due Special Survey is to be carried out based on ship's age.

1.1.8 Machinery Verification Runs

1 At the time of a special survey, a dock trial in the presence of the attending surveyor is to be carried out to confirm the satisfactory operation of main and auxiliary machinery and steering system and so on. Such confirmation may be made at sea trial if the Surveyor may deem a sea trial necessary.
2 If significant repairs have been carried out to main or auxiliary machinery or steering gear, the Surveyor may deem a sea trial necessary.
3 In cases where time of dry-docking exceeds 30 days, dock trials may be required at the discretion of the attending surveyor to confirm the satisfactory operation of main and auxiliary machinery and steering systems, etc. Such confirmations are to be made at sea trials when deemed necessary by the surveyor.

1.2 Definitions

1.2.1 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) Close-up survey is a survey where the details of structural components are within the close visual inspection range of the Surveyor, i.e. preferably within reach of hand.
(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 of structural members in excess of 75 % of allowable margins, but within acceptable limits, when the allowable limits are defined as the corrosion additions specified in **3.2.1-2**, **Part 1**. However, where ships are accepted to apply the corrosion addition of structural members of 0 *mm*, the term "substantial corrosion" is not used because the no corrosion is found in structural members.
(7) Corrosion Prevention System is normally considered a full hard coating.
(8) Coating condition is defined as follows:
(a) Good : condition with only minor spot rusting;
(b) Fair : condition with local breakdown of coating at edges of stiffeners and weld

connections and/or light rusting over 20 % or more of areas under consideration, but less than as defined for poor condition;

(c) Poor : condition with general breakdown of coating over 20 % or more of areas or hard scale at 10 % or more of areas under consideration.

(9) 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.

(10) Anniversary Date is the day corresponding to the expiry date of the Classification Certificate (5 years), excluding the expiry date of the Classification Certificate.

1.3 Preparation for Survey and Other Items

1.3.1 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.

1.3.2 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, micrometres) 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 is to submit a Survey Programme that details survey items as part of the preparation for the Special Survey and for the Intermediate Surveys of ships over 15 years of age. To ships which do not engage in international voyage and classed for restricted service, such as having the class notation Coasting Service, Smooth Water Service, etc., this requirement need not apply.

3 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.

4 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, ship owner or Company so as to ensure the safe and efficient conduct of the survey and measurement work to be carried out.

1.3.3 Suspension of Surveys

Surveys may be suspended where necessary preparations have not been made, any appropriate attendant is not present, or the Surveyor considers that the safety for execution of the survey is not ensured.

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

1 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.

2 Any damage in association with wastage over the allowable limits (including buckling, grooving, detachment or fracture), or extensive areas of wastage over the allowable limits, which affects or will affect the ship's structural, watertight or weathertight integrity, is to be promptly and thoroughly repaired. However, for locations where adequate repair facilities are not available, it may allow the ship to proceed directly to a repair facility subject to approval by the Administration. This may require discharging the cargo and/or temporary repairs for the intended voyage.

3 When a survey results in the identification of corrosion or structural defects, either of which will impair the ship's fitness for continued service, remedial measures are to be implemented before the ship continues in service.

4 Where the damage found on the structure is isolated and of a localized nature which does not affect the ship's structural integrity (as for example a minor hole in a cross-deck strip), consideration may be given by the surveyor to allow an appropriate temporary repair to restore watertight or weather tight integrity after evaluation of the surrounding structure and impose an associated outstanding recommendation with a specific time limit in order to complete the permanent repair and retain classification.

1.3.5 Procedure for Tests, Wear and Tear, etc.

1 Speed trial

A Speed trial is to be carried out at the Class Maintenance Survey, where alterations or repairs which might affect the ships speed have been made. A Speed trial or a trial of the ships propulsion machinery may be required where deemed necessary by the Surveyor at any survey.

2 Inclining test

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

3 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.

4 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.

1.3.6 Firms Engaged in Inspections, Measurements and Maintenance

1 Unless otherwise specified, third parties engaged in thickness measurements, in-water surveys by divers or remote operated vehicles, or tightness testing of closing appliances such as hatches, doors, etc., with ultrasonic equipment are to be firms approved by the Society in accordance with the Rules specified separately.

2 Unless otherwise specified, third parties engaged in inspections and maintenance of fixed fire extinguishing systems, portable fire extinguishers, self-contained breathing apparatuses, emergency escape breathing devices or fire detection and alarm systems are to be firms approved by the Society in accordance with the Rules specified separately, firms approved by the other organizations which are authorized by the Administration or deemed appropriate by the Administration.

1.3.7 Portable Atmosphere Testing Instruments for Enclosed Spaces

Ships are to carry an appropriate portable atmosphere testing instrument or instruments. As a minimum, these are to be capable of measuring concentrations of oxygen, flammable gases or vapours, hydrogen sulphide and carbon monoxide prior to entry into enclosed spaces. Instruments carried under other requirements may satisfy this regulation. Suitable means are to be provided for the calibration of all such instruments.

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 load lines, life-saving appliances, radio installations, accommodation, sanitation, marine pollution prevention, cargo handling appliances, etc., are to be examined in detail in order to ascertain that they meet the relevant requirements in the Rules.

2 When it is intended to build a ship for classification by the Society, the plans and documents specified in **2.1.2** are to be submitted for the approval by the Society before the work is commenced.

3 When it is intended to build a ship to the classification with the Society the plans and documents specified in **2.1.3** are to be submitted, in addition to those required in **2.1.2**.

4 The plans and documents specified in **-2** and **-3** are written in English or the languages used by the applicant. Where the used language is not English, the plans and documents are written in both the used language and English, except for the owner's instruction.

5 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.

2.1.2 Submission of Plans and Documents for Approval

1 The plans and documents specified in **(1)** through **(36)** in connection with the hull arrangements, hull structures, equipment, etc., are to be submitted to the Society. The plans are to indicate in detail the quality of materials used, scantlings and arrangements of structural members, their attachments, welded parts, applied welding procedure, information about welding such as leg length, shape of groove, clearance between the bottom of boilers and the top of floors, and other particulars necessary for review and examination of proposed constructions.

(1) General arrangement

(2) Midship section (cross sections of the hold, machinery space, and areas containing wing tanks (if fitted), intended classification characters and notations, designed maximum load draught, and for ships complying with the requirements in **1.2.5-2**, **Part 1**, design temperature are to be indicated in this plan.)

(3) Stem, sternframe, propeller post and rudder (indicating materials and the ships speed)

(4) Construction profile (showing arrangement of watertight bulkheads, the load draught, sizes of brackets and transverse sections of the ship at 0.1 L_{WL}, 0.2 L_{WL} and 0.3 L_{WL} from both ends of the ship)

(5) Deck plans (indicating arrangement and construction of hatchways, hatch beams, etc., the forward end of L_f and the point 0.25 L_f aft of it, the route that the vehicles use frequently during loading and unloading (the deck area which is subject to the dynamic load in the vicinity of the ramp way and is on the route taken by the vehicles when moving between decks for car decks of ships intended to carry vehicle, for ships fitted with movable car decks, plans of their support structures)

(6) Single bottoms and double bottoms

(7) Watertight and oiltight bulkheads (indicating the highest position of tank and positions of tops of overflow pipes)

(8) Superstructure end bulkhead (with details of closing appliances of openings on the bulkheads)

(9) Arrangements to resist panting in both peaks and their vicinity

(10) Pillars and deck girders

(11) Shell expansion (construction of bilge keel and its attachment, dimensions and arrangements of freeing ports, design temperature for ships which comply with the requirements in **1.2.5-2**, **Part 1**, draught at ballast condition for ships which comply with the requirements in **1.2.6**, **Part 1** and comparative table between the standard sheer specified in International Convention on Load Line 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 are to be indicated in this plan.)
(12) Shaft tunnels
(13) Seating 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)
(14) Machinery casings
(15) Long deckhouses, if fitted
(16) Masts, mast houses and winch platforms specified in **Chapter 7**, **Part 6**
(17) General arrangement of cargo gears and cargo ramp, construction drawings of cargo gears and cargo ramps (including the dimensions of structural members, specifications of materials and joint details) and Drawings of cargo fittings (including the dimensions, specifications of materials and the fixing methods of these fittings with structural members or hull structure)
(18) Plans showing locations, sizes and details of equipment forming part of the watertight and weather-tight integrity of the ship, including piping
(19) For ships with the ships total volume of fuel oil tanks of 600 m^3 and above, including fuel oil tanks with maximum capacity of 30 m^3 or less, arrangement of fuel oil tanks and calculation for the requirements of oil fuel tank protection. In the calculation, the volume of fuel oil tank is calculated by using the filling limits of 98 %.
(20) Pumping system (indicating capacity of each tank, water or oil)
(21) Construction for fire protection and plans showing ventilation systems (indicating materials used in the construction of superstructures, bulkheads, decks, deckhouses, trunks, stairways, deck coverings, etc. and arrangements of closing appliances of openings)
(22) Plans showing means of escape (escape routes including details of passage width, etc.)
(23) Plans showing fire extinguishing arrangement (the locations, numbers and types of firefighting systems, fire extinguishers, fire pumps, hydrants, hoses, fire fighter s outfits, 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). For ships equipped with air quality control systems in accordance with the requirement in **Part 9**, the locations and details of these systems.
(24) Plans showing arrangement for means of access or ship structure access manuals as applicable, as defined in **Chapter 4**, **Part 6**.
(25) Arrangement of the means of embarkation and disembarkation specified in **Chapter 4**, **Part 6**.
(26) General arrangement of navigation bridge (showing the details for fields of vision from conning position, windows and doors visibility) for a ship having a length overall (L_{oa}) of 55 m or over. In addition, drawings showing the horizontal and vertical fields of vision from the conning position when the ship is in the condition deemed worst such as full load condition, light ballast condition, etc. (If the view from the conning position in obstructed by cargo, cargo gear or other wheel house, those obstruction are to be shown on the drawings.)
(27) For venting systems for *GNS-B* ships, *GNS-C* ships or *GNS-D* ships carrying flammable liquids or dangerous goods, general arrangement of bilge systems and ventilation systems of

the cargo oil pump room and general arrangement of venting systems for cargo vapours, etc.

(28) Towing and mooring fittings arrangement plan specified in **Chapter 2**, **Part 6** and hull structure vicinity them to.

(29) For ships affixed a class notation "*NC*", plans and arrangements showing airborne sound insulation properties of bulkheads and decks within accommodation spaces specified in **1.2.9-1**, **Part 1**.

(30) Stability information made based on the requirements of **Chapter 2**, **Part 4**.

(31) For *GNS-B* ships, *GNS-C* ships and *GNS-D* ships carrying cargoes with L_f of 65 *m* or over, a loading manual including conditions for loading and other necessary information.

(32) For *GNS-B* ships, *GNS-C* ships and *GNS-D* ships carrying flammable liquids or dangerous goods with L_f of 100 *m* or over, the documents about a loading computer

(33) For ships affixed with the class notation of "*RC*" in accordance with the requirement in **1.2.12-3**, **Part 1**, arrangement of control systems for rolling motion such as fin stabilizers and anti-rolling tanks, construction thereof and attachment and hull structure vicinity them to.

(34) For ships having side thrusters, the construction of side thruster, attachment and hull structures vicinity them to.

(35) For FRP ships, lists and data of raw materials, laminating procedures and details of joints.

(36) For ships affixed with the class notation of "*NVC*" or "*MVA*" in accordance with the requirements in **1.2.9-2** or **1.2.9-3**, the measurement plans of noise and vibration including the following items.

  (a) spaces or compartments and locations to be measured
  (b) measurement procedure
  (c) details of measurement devices including calibration records thereof
  (d) driving state of main machineries and auxiliary machineries
  (e) draught condition of a ship

2 Machineries and electrical installations

Plans and documents related to machineries and electrical installations specified in the following **(1)** through **(23)** are to be submitted to the Society for approval. For the drawings including the pipings and valves, materials, dimensions, types, design pressures, design temperatures and other necessary information of pipes and valves are to be indicated.

(1) Arrangement of machinery in machinery space, diagram for internal communication systems including diagram for engineers alarm systems.

(2) For main and auxiliary diesel engines, drawings and documents specified in **2.1.3-1(1)**, **Part 7**.

(3) For main gas turbines, drawings and documents specified in **3.1.3 (1)**, **Part 7**.

(4) For ships having a power-driven emergency generator, documents showing specifications of louvers for emergency generator rooms and closing appliances of ventilators fitted to the rooms.

(5) For power transmission gears, plans and data specified in **4.1.2**, **Part 7**.

(6) For shafting, plans and data specified in **5.1.2 (1)**, **Part 7**.

(7) For propellers, plans and data specified in **6.1.2**, **Part 7**.

(8) For azimuth thrusters, plans and data specified in **6.4.2**, **Part 7**.

(9) For waterjet propulsion systems, plans and data specified in **7.1.4 (1)**, **Part 7**.

(10) Plans and data related to torsional vibration for the shafting systems, specified in **8.1.2**, **Part 7**.

(11) For boilers and incinerators, plans and data specified in **9.1.3 and 9.12.2**, **Part 7**

(12) For pressure vessels, plans and data specified in **10.1.4**, **Part 7**

(13) For auxiliary machineries and piping, plans and data specified in **13.1.3**, **Part 7**.

(14) Arrangement and construction plan for funnels

(15) For ships carrying flammable liquids (except for liquids used by own ship) and dangerous goods, plans and documents specified in **14.1.2**, **Part 7**.
(16) For automatic and remote controls, plans and data specified in **15.1.3 (1)**, **Part 7**.
(17) For windlasses, plans and data specified in **2.2.3 (1)**, **Part 6**.
(18) For winches, the particular list including the applied standard and on-board arrangement
(19) For steering gears, plans and data specified in **3.1.3**, **Part 6**.
(20) Plans and documents related to pipings specified in the following **(a)** through **(g)**.
   (a) Piping diagrams for the entire ship
   (b) Piping diagrams for the engine room
   (c) Methods for preventing oil from spraying out from flange joints and special joints (threaded pipe joints, mechanical joints, etc.) in fuel oil, lubricating oil and other flammable oil piping (if any)
   (d) Piping diagrams of those tanks which form part of the hull construction are to be accompanied by a piping list specified the names and purposes of tanks, purposes of pipes such as sounding pipes, air vent pipes, overflow pipes, filling and discharge pipes, etc., dimensions (nominal diameter, outer and inner diameter, thickness, types and cross section area, and so on) of the pipes
   (e) Regarding scupper piping system drawings, maximum load line or designed maximum load line, the line above 600 *mm* thereof, the line showing the location of $0.01L_f(m)$ and $0.02L_f(m)$ and the line 450 *mm* below the freeboard deck.
   (f) Regarding distance pieces directly fitted to the sides of ships, drawings of their construction and details fitted to the sides of ships or sea chests
   (g) Machinery particulars
(21) For refrigeration systems, plans and data specified in **10.3.2-3 (2)**, **Part 6**.
(22) Plans and documents related to electric devices and electrical installations specified in the following **(a)** through **(m)**.
   (a) Sectional assembly of generators motors and electromagnetic slip couplings for electric propulsion equipment including their complete ratings, main dimensions, materials used and weights.
   (b) Key diagrams and explanations of electric propulsion control gears.
   (c) Sectional assembly of generators (main, auxiliary and emergency) of 100 *kW* (or *kVA*) and over, including their complete ratings, main dimensions, main materials used and weights. The submission of the sectional diagrams of generators less than 100 *kW* (or *kVA*) for *GNS-C* ships and *GNS-D* ships may be dispensed with.
   (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.
   (h) Sectional assembly of electric prime movers for windlasses, including their complete ratings, main dimensions, main materials used and weights. The submission of the sectional diagrams of electric prime movers for windlasses for *GNS-C* ships and *GNS-D* ships may be dispensed with.
   (i) Explanations of electric propulsion systems

(j) Investigation tables of electrical power
(k) Lists of particulars for high voltage electrical equipment
(l) For ships carrying flammable liquids other than fuel oils or dangerous goods, drawings indicating any hazardous areas and lists of any electrical equipment installed in such hazardous areas specified in the following **i)** and **ii)**.
  i) 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
  ii) 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).
(m) The following data specified in **i)** and **ii)** in cases where the electrical distribution system on board a ship includes harmonic filters, except in cases where the filters are installed for single application frequency devices such as pump motors.
  i) Total Harmonic Distortion (*THD*) calculation report
    1) Results of the calculation of the *THD* value experienced when a failure of a harmonic filter occurs.
    2) In cases where a.c. generators are driven at rated speeds, giving rated voltages and rated symmetrical loads, the *THD* of distribution systems connected such generators is not to exceed values of 5 %, the acceptable limit of the *THD* value.
  ii) Harmonic filter operation guide
    1) The permitted operating mode of the electrical distribution system while maintaining the *THD* values within acceptable limits during normal operation.
    2) The permitted operating mode of the electrical distribution system in the case of failure of any combination of harmonic filters.
(23) For ships affixed with the class notation ”*RC*”, detail documents of equipment for operation of fin stabilizers and anti-rolling tanks and their arrangements.

3 For ships affixed with the class notation “*LFF*” in accordance with the requirements specified in **1.2.12**, **Part 1**, the following plans and documents are to be submitted to the Society for approval.
(1) Manufacturing specifications for fuel tanks, thermal insulations and secondary barriers including welding procedures, inspection and testing procedures for welds and fuel tanks, installation procedures of thermal insulation materials and secondary barriers, and working standards.
(2) Arrangements and construction of fuel tanks
(3) System drawings and arrangements of fuel tank accessories including details of the internal fittings.
(4) Arrangements and construction of fuel tank supports
(5) Construction of fuel tank deck portions through which fuel tanks penetrate, and their sealing arrangements
(6) Arrangements and construction of secondary barriers
(7) Specifications or standards for materials used for fuel tanks, thermal insulations, secondary barriers and fuel tank supports
(8) Layout and detailed installation of thermal insulations
(9) Manufacturing specifications for fuel piping systems including welding procedures, testing and inspection procedures for fuel piping, installation procedures of double wall piping, ducts and thermal insulation materials and secondary barriers, and working standards.
(10) Piping diagrams including materials, sizes, kinds, design pressures, design temperatures, etc.

of pipes, valves, etc., hereinafter the same in this sub-paragraph **3** of fuel piping, fuel gauging systems and fuel vent piping.

(11) Bilge systems in fuel storage hold spaces or interbarrier spaces, fuel preparation rooms, tank connection spaces and bunkering stations

(12) Specifications, piping diagrams and arrangements of gas detection systems

(13) Piping diagrams of inert gas lines and details including information on design specifications, construction, materials, etc., hereinafter the same in this sub-paragraph **3** of pressure adjusting devices in cases where fuel storage hold spaces or interbarrier spaces may be inerted.

(14) Details of pressure relief systems for fuel storage hold spaces, interbarrier spaces and tank connection spaces as well as details of drainage arrangements for leaked fuel.

(15) Assembly cross section of various pressure vessels, details of nozzles, system drawings of fittings and details of fittings.

(16) Electric wiring plans for hazardous areas and tables for electrical equipment in hazardous areas

(17) Arrangements of electrical bonding for fuel tanks, piping systems, machinery, equipment, etc.

(18) Plans showing hazardous areas

(19) Arrangements of equipment installed in fuel preparation rooms, tank connection spaces, bunkering stations and bunkering control stations

(20) Inspection plans for liquefied gas fuel containment systems at periodical surveys (for independent tanks of Type B (which is defined by the requirement in 4.22 of international Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (*IGC* Code), which had been adopted by *IMO* resolution *MSC*.5(48)), including programs of non-destructive testing for periodical surveys

(21) Arrangements of access to hazardous areas, fuel preparation rooms, tank connection spaces, ESD-protected machinery spaces and inerted spaces and guides for said access thereto (including air locks).

(22) Diagrams of control systems including monitoring, safety and alarm systems for bunkering systems, fuel tanks, fuel supply systems and fuel consumers and lists of the setting values

(23) Plans and documents of the low-flashpoint fuel equipment and fittings specified in **Part GF of the Rules for Survey and Construction of Steel Ships**.

(24) Plans and documents for the gas-fuelled boilers and gas-fuelled engines specified in **Part GF of the Rules for Survey and Construction of Steel Ships**.

(25) Arrangements and construction of ventilation systems including materials, ventilation capacity, etc.

(26) Arrangements of ventilation inlets and exhaust outlets.

(27) Ventilation duct diagrams including design pressures, materials, and arrangements and construction of fittings.

(28) Details of bunkering manifold connections.

(29) Drawings showing distance between fuel tanks and shell plating at each section.

(30) Arrangements, capacity calculation sheets and details of drip trays including materials, thermal protection for the hull structure and drainage arrangements.

(31) Access routes and means of access to protected spaces within hold spaces

(32) Arrangements of air lock doors, air lock ventilation capacity calculation sheets and details of air lock alarm systems

(33) The operational procedures and emergency procedures specified in **Part GF of the Rules for Survey and Construction of Steel Ships**.

4 For ships affixed with the class notation "*CHG*" in accordance with the requirement in **1.2.13-1**, **Part 1**, the following plans and documents are to be submitted to the Society for approval.

(1) General arrangement of cargo gears and cargo ramps

(2) Construction drawings of cargo gears and cargo ramps including the dimensions of structural members, specifications of materials and joint details
(3) Drawings of cargo fittings including the dimensions, specifications of materials and the fixing methods of these fittings with structural members or hull structure.
(4) Arrangement of loose gears including rigging arrangement
(5) List of loose gears showing the construction, dimensions, materials and locations. For those in compliance with the well-known code or standard such as *ISO* or national standards, the type symbol may be used in place of dimensions and materials.
(6) Construction drawings of driving gears
(7) Power system diagram
(8) Drawings of operation and control mechanism
(9) Drawings of safety devices
(10) Drawings of protective devices

5 For ships affixed with the class notation “*PSPC*” in accordance with the requirement in **1.2.4-2**, **Part 1**, the a Coating Technical File for dedicated seawater ballast tanks, etc. including the format specified in the following items or been able to fulfil the following items.

(1) A copy of the Statement of Compliance or Type Approval Certificate in accordance with the *IMO* Res. *MSC*. 215(82).
(2) A copy of the Technical Data Sheet including:
    (a) Product name and identification mark and/or number;
    (b) Materials, components and composition of the coating system, colours;
    (c) Minimum and maximum dry film thickness;
    (d) Application methods, tools and/or machines;
    (e) Condition of surface to be coated (de-rusting grade, cleanness, profile, etc.); and
    (f) Environmental limitations (temperature and humidity).
(3) Shipyard work records of coating application, including:
    (a) Applied actual space and area (in square meters) of each compartment;
    (b) Applied coating system;
    (c) Time of coating, thickness, number of layers, etc.;
    (d) Ambient condition during coating; and
    (e) Method of surface preparation
(4) Procedures for inspection and repair of coating system during ship construction
(5) Coating log issued by the coating inspector, stating that the coating was applied in accordance with the specifications to the satisfaction of the coating supplier representative and specifying deviations from the specifications, see *IMO* Resolution *MSC*.215(82) Annex 2 or *MSC*.288(87) Annex 2 for an example of the daily log and non-conformity report.
(6) Shipyard s verified inspection report, including:
    (a) Completion date of inspection;
    (b) Result of inspection;
    (c) Remarks (if given); and
    (d) Coating inspector s signature
(7) Procedures for in-service maintenance and repair of coating system.

6 For ships affixed with class notation “*CoC*” in accordance with the requirement in **1.2.4-3**, **Part 1**, documents showing the methods of corrosion control applied to each compartment and structure are to be submitted to the Society for approval.

7 For ships affixed with class notations regarding the marine pollution prevention and air pollution prevention in accordance with the requirements in **1.2.8 (1)** to **(5)**, **Part 1**, plans and documents specified in the requirement in **2.1.2**, **Part 2 of the Rules for Marine Pollution Prevention Systems** are to be submitted to the Society for approval.

8 For ships affixed with the class notation "*BWMS*" in accordance with the requirement in **1.2.8 (7)**, **Part 1**, plans and documents specified in the following **(1)** through **(3)** are to be submitted to the Society for approval.

(1) For ships conducting the ballast water exchange specified in **1.8**, **Part 11**, the following plans and documents specified in **(a)** to **(e)**:
   (a) Arrangement of ballast tanks;
   (b) Plans and documents relevant to air pipes and sounding pipes for ballast tanks;
   (c) Capacities of ballast pumps;
   (d) Arrangement of ballast piping; and
   (e) Plans and documents relevant to sampling facilities.

(2) For ships conducting the ballast water management specified in **1.8**, **Part 11** the following plans and document specified in **(a)** to **(f)**:
   (a) Plans showing ballast water management systems;
   (b) Arrangements of ballast water management systems;
   (c) Arrangements of ballast tanks;
   (d) Capacities of ballast pumps;
   (e) Arrangement of ballast piping;
   (f) Plans and documents related to electrical installations specified in **2(17)(e)**, **(f)**, **(j)** and **(l)**.

(3) Ballast water management plan

9 For ships affixed with the class notation in accordance with the requirements in **1.2.8 (8)** or **1.2.8 (9)**, **Part 1**, plans and documents specified in the NK guidelines; the "*Guideline for Inventory of Hazardous Material onboard ships*" or the "*Guideline for Environmental Awareness*" separately, are to be submitted to the Society for approval.

10 For ships affixed with the class notation "*AAS*" in accordance with the requirements in **1.2.10-4**, **Part 1**, plans and documents specified in the following **(1)** through **(9)** related to the accommodation equipment, sanitary equipment and so on, are to be submitted to the Society for approval.

(1) Construction and particular lists of rooms for crews, hospitals and others occupied by persons
(2) Diagrams of piping in connection with bath rooms, lavatories and other sanitary spaces
(3) Arrangements and particular lists of ventilation systems
(4) Particulars of air conditioning systems
(5) Arrangement of skylights and side scuttles
(6) Arrangement and particular list of beds and spares
(7) Procedures for installation of soundproof equipment
(8) Procedures for installation of waterproof equipment
(9) Arrangement and construction of elevators or lifting devices for persons, documents for strength calculation and used materials of elevators and operation manuals, if installed.

11 For ships affixed with the class notation "*LSA*" or "*SN*" in accordance with the requirements **1.2.10-1** and **1.2.10-2**, **Part 1**, plans and documents specified in the following **(1)** through **(8)** are to be submitted to the Society for Approval.

(1) Plans and arrangements for lifeboats, life rafts, their fittings, launching appliances and embarkation stations
(2) Arrangement of lighting systems (muster stations, embarkation stations, means of access, stairways, entrances and electric circuits from emergency electric systems
(3) Arrangement and particular of navigation lights, day shapes, gongs and bells
(4) Plans for life saving appliances showing the numbers, particulars and storages of rocket parachutes, rocket signals and life throwing appliances
(5) Plans for life saving appliances showing the numbers, particulars and locations of life buoys

including self-ignition lights, smoke signals, floatable lines, life jackets, immersion suits, thermal protective aids

(6) Plans for navigation equipment showing magnetic compasses including bowls, gyro compasses, radars, electronic plotting systems, automatic tracking systems, automatic radar plotting aids, echo sounding devices, devices to indicate speed and distance, rudder angle indicators, propeller speed indicators, propeller rotating angle indicators (pitch angle indicator for controllable pitch propeller), thrust indicators, if any, rate-of-turn indicators, electronic navigational aids, radar reflectors, sound reception systems, heading control systems, universal shipborne automatic identification systems, voyage data recorders, auto pilot systems, bridge navigational watch alarm systems, electronic chart display and information systems, daylight signaling lamps.

(7) Plans for pilot transfer arrangements showing the numbers, particulars and arrangement.

(8) Plans for *GMDSS* (*NAVTEX* systems, enhanced group call Safety Net receivers, digital selective calling (*DSC*) systems, *VHF* systems using *DSC*, *EPIRBs*, radar transponders, *AIS-SART*, two-way radiotelephone apparatus and auxiliary source of power.

12 For ships affixed with the class notation "*SR*" in accordance with the requirement in **1.210-3**, **Part 1**, plans and documents related to radio installation specified in the following **(1)** through **(6)**.

(1) Particular list including the following **(a)** and **(b)**.
  (a) Name of ship and shipyard and ship number, ship's flag and gross tonnage.
  (b) Equipment lists of radio communication systems including the following items.
    i) Particular of radio communication systems and life saving appliances related to radio communication systems including name of manufacturer, type, number of type approval, numbers
    ii) Particular of duplicated radio communication systems, if any.
    iii) Secondary means of alerting)
    iv) Sea area and selection of maintenance requirements
    v) Particular of main and auxiliary source of energy and the calculation sheets for capacity of battery used as auxiliary source of power
    vi) Radio communication systems other than *GMDSS* and navigational equipment related to radio communication systems

(2) Specification of *GMDSS* equipment and list of equipment including the calculation sheet for capacity of auxiliary source of energy (battery).

(3) Arrangement of radio communication systems and life-saving appliances related to radio communication systems including the arrangements showing the radio communication systems for normal operation and lighting systems for radio communication systems supplied by the source of energy independent from main and auxiliary ones and life saving appliances related to radio communication systems

(4) Electronic circuits for radio communication systems including electronic circuits of power supply

(5) Development plan for antennas. Where *INMARSAT* communication systems are installed as mandatory systems, an air development plan is to be included the drawings showing the relations between antennas and hull structures

(6) Maintenance procedure for radio communication systems

13 For ships affixed with the class notation "*IWS*" in accordance with the requirement in **1.2.11**, **Part 1**, the in-water survey pans and documents including the following **(1)** through **(4)** are to be submitted to the Society for approval.

(1) Plans of shell plating below the maximum designed 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 the following **(a)** through **(i)**, together with their colour photographs, and detailed instructions for inspection of such constructions and arrangements
   (a) A means of measuring the clearance of the rudder in way of each pintle is provided
   (b) Rope-guard ring plates are of such construction as to facilitate the inspection of the shafting between propeller hubs and stern frame boss
   (c) For water lubricated stern tube bearings, a means of measuring the clearance between the propeller shafts and their bearings is provided
   (d) For oil or freshwater lubricated stern tube bearings, a suitable means of ascertaining the performance of the stern tube bearings including oil sealing devices is provided
   (e) A suitable means of ascertaining the position and identity of each blade of the propellers is provided
   (f) Hinged gratings are installed on all sea chests and constructed so as to facilitate opening and closing by the diver
   (g) Markings indicating the position of longitudinal and transverse bulkheads and the names of interior spaces on the hull below the maximum designed load water line, so that the diver is able to orient his/her position relative to the ship
   (h) Documents showing the procedures to ascertain no abnormality of clearance between the propeller shafts and their bearings or performance of the stern tube bearings including oil sealing devices from the results of general examination of the shafting system and review of all condition monitoring data (lubricating oil analysis or freshwater sample tests) available on board ship, instead of the documents specified in **(a)** or **(d)**
   (i) Other necessary documents in order to carry out the in-water survey

14 For ships affixed with the class notation "*HF*" or "*HD*" in accordance with the requirement in **1.2.12-7**, **Part 1**, the following plans and documents are to be submitted to the Society for approval.

(1) Particulars of type of helicopter intended to use, D-value defined by **2.4.32**, **Part 1**, and weights
(2) Construction of helideck and storage
(3) Where the fuel tanks for helicopter are provided, the detail information including the construction of tanks, piping, installations such as pumps.
(4) Drawings showing the final approach and take-off area, obstacle-free sector, limited obstacle sector, obstacle, touchdown and lift-off area defined by **2.4.33** through **2.4.37**, **Part 1**.
(5) Arrangement of securing devices for helicopters
(6) Arrangement of lighting system provided on helideck and its surrounding area, measurement systems, alarm systems, and so on.
(7) Firefighting system for helideck and spaces containing the fuel tanks for helicopters
(8) Drawings for safety net, if it is provided around the helideck

15 For ships affixed with the "*M*0" notation to the Characters of main propulsion machinery, plans and documents specified in the following **(1)** through **(5)** are to be submitted to the Society for approval, in addition to those specified in **2(14)**.

(1) Drawings and data concerning automation and remote controls for all automation and remote control systems.
(2) Drawings showing construction and layouts
(3) Particulars
(4) On-board test plan
(5) Sea trial plan

16 For ships affixed with the class notation "*EMC*" in accordance with the requirement in **1.2.12-6**, **Part 1**, lists and arrangements of devices showing electromagnetic compatibility, and lists of other devices arranged in the space where the devices in question are provided.

17 For ships affixed with the class notation "*RNC*" in accordance with the requirement in **1.2.12-8**, **Part 1**, lists and arrangements of related devices
18 Other plans and documents deemed necessary by the Society are to be submitted to the Society for approval, in addition to those specified in **-1** through **-17**.

2.1.3 Submission of Other Plans and Documents for Reference

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**.

(1) Specifications for hull and machinery
(2) Calculation sheets for the minimum section modulus of the midship cross section
(3) Corrosion prevention scheme (Items included in the Coating Technical Files specified in **2.1.2-5** may be omitted.)
(4) 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.
(5) 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 arrangement and size of hull constructions and cargoes on deck which are counted to the projected area against wind and/or 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 projected area against winds, 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.
(6) For ships required to assign the freeboard based on the International Convention of Load Line, the following plan:
   (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)
(7) Strength calculation sheets showing the design loads associated with various supporting hull structures of towing and mooring fittings. Where the towing and mooring fittings are comply with the standards not deemed appropriately by the Society, the strength calculation sheets including the mooring and towing fittings themselves.
(8) For ships required to provide the poster showing the operation procedure for opening/closing doors and inner doors and their securing.

2 For ships affixed class notations concerning the strength assessment of hull structures specified in **1.2.7**, **Part 1**, detail information about programs or software used for strength assessment of hull structures are to be the Society for reference.
3 For ships affixed class notations specified in **1.2.12-9** and **-10**, **Part 1**, plans and documents concerning the accident scenario, estimated damages, protection measures are to be submitted to the

Society for reference.

4 For main and auxiliary machineries, the following plans and documents are to be submitted to the Society for reference, in addition to those specified in **2.1.2-2**.

(1) Plans and documents specified in **2.1.3-1(2)**, **Part 7** for main diesel machinery and auxiliaries including their attachments.
(2) Plans and documents specified in **3.1.3(2)**, **Part 7** for main gas turbine and auxiliaries including their attachments.
(3) Documents required for the calculation in accordance with the relevant requirements for power transmission systems, shaftings and propellers
(4) Shop test plans for auxiliary machineries and pipings and strength calculation sheets for main parts thereof.

5 Drawings and data for the purpose of inspection and testing of diesel engines specified in **2.1.3-1 (3)**, **Part 7** are to be submitted to the Society, in addition to those specified in **-2(1)**.

6 For ships affixed with the class notation "*LFF*" in accordance with the requirement in **1.2.12**, **Part 1**, plans and documents specified in the following **(1)** through **(20)** are to be submitted to the Society, in addition to those specified in **2.1.1-3**.

(1) Basic design principal and technical reports for fuel containment systems
(2) Data on test methods and results of model tests, etc. carried out in accordance with the requirements of **Chapter 16**, **Part GF of Rules for the Survey and Construction of Steel Ships**
(3) Data on physical and mechanical properties of materials and welded parts at low and normal temperatures as well as their toughness at low temperatures and corrosion resistance where new materials and welding methods are adopted for construction of the fuel tanks, secondary barriers, thermal insulations, etc.
(4) Data on design loads specified in **6.4.9**, **Part GF of Rules for the Survey and Construction of Steel Ships**
(5) Strength calculation sheets of fuel tanks and supports specified in **6.4.6** and **6.4.15, Part GF of Rules for the Survey and Construction of Steel Ships**
(6) Heat transfer calculation sheets for the primary members of fuel tanks under various loading conditions, thermal stress calculation sheets for the primary members at the temperature distributions and temperature distribution calculation sheets for hull structures.
(7) Specifications of fuel systems
(8) Composition and physical properties of fuels (including a saturated vapour pressure diagram within the necessary temperature range)
(9) Calculation sheets of relieving capacities of pressure relief systems for fuel tanks (including calculation sheets of back pressure in discharge lines)
(10) Technical data relating to the design concepts of fuel preparation rooms and tank connection spaces
(11) Calculation sheets for refrigeration system capacities
(12) Strength calculation sheets for pipes
(13) Investigation reports of the stress analysis for high pressure fuel piping systems
(14) Investigation reports of the stress analysis for piping systems with design temperatures of -110 °C or lower
(15) Investigation reports of the design pressures for outer pipes or ducts of high pressure fuel piping
(16) Details of pump shaft penetrations (including information on design specifications, construction, materials, etc.)
(17) Investigation documents for fuel tank filling limits
(18) Probability calculation sheets in cases where a probabilistic approach is used to decide

arrangements of fuel tanks
(19) List of data on risk assessment
(20) Documents related to the failure mode and effects analysis required by **14.3.4**, **Part GF of Rules for the Survey and Construction of Steel Ships**

7 For ships affixed with the class notation "*CHG*" in accordance with the requirement in **1.2.13-1**, **Part 1**, plans and documents specified in the following **(1)** through **(5)** are to be submitted to the Society for reference.
(1) Specifications for cargo gears and cargo ramps
(2) Calculation sheets or check sheets relevant to drawings and documents for approval specified in **1.2.1-4**.
(3) Operation manual for cargo gears and cargo ramps
(4) Procedures of non-destructive testing
(5) Procedures of Load tests

8 For ships affixed with the class notation "*BWMS*" in accordance with the requirement in **1.2.8 (7)**, **Part 1**, the plans and documents specified in the following **(1)** and **(2)** are to be submitted to the Society for reference.
(1) A copy of the certificate for type approval of ballast water management system issued by the Society or the Administration, in accordance with *IMO* Res. *MEPC*.174(58) Guidelines for Approval of Ballast Water Management Systems (*G*8) , as amended
(2) On-board test procedures

9 For ships affixed with the class notation "*RNC*" in accordance with the requirement in **1.2.12-8**, **Part 1**, documents concerning the specification of equipment and installation procedures

10 Other plans and documents deemed necessary by the Society are to be submitted to the Society for approval, in addition to those specified in **-1** through **-9**.

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 materials prescribed in **Part K of the Rules for the Survey and Construction of Steel Ships** and 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 each installations or equipment are installed.
(7) When hydrostatic tests and watertight tests are carried out.
(8) When non-destructive tests are carried out.
(9) When the hull is completed.
(10) When performance tests are carried out on closing appliances of openings, remote control devices, steering gears, anchoring and mooring equipment, emergency towing arrangements, means of embarkation and disembarkation, means of escape, firefighting systems, ventilation systems, piping, discharge systems, etc.
(11) When rudder installation, keel line profiling, measurement of principal dimensions, measurement of hull deflection, etc. are carried out.
(12) For ships installed loading computer on board, when a loading computer is installed on board ships.
(13) When the ships are marked with the load lines in accordance with the requirements in

International Convention on Load Line (ICLL) and when fittings associated with the requirements in ICLL are fitted.

(14) When sea trials are carried out.

(15) When stability experiments are carried out.

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. In the cases where the welded parts are required to carry out non-destructive tests, when non-destructive tests are carried out.

(e) When shop trials are carried out.

(3) When hydrostatic tests, leak or air-tight tests according to the kind of machinery are carried out.

(4) When main parts of machinery are installed on board.

(5) 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, mooring equipment, fire extinguishing equipment, piping, etc.

(6) When accumulation tests and performance test for safety devices of boilers are carried out.

(7) When sea trials are carried out.

3 For a ships affixed with the class notation "*LFF*" in accordance with the requirement in **1.2.12**, **Part 1**, the presence of the surveyor is required for tests stipulated in **Part GF of the Rules for the Survey and Construction of Steel Ships**.

4 For ships affixed with the class notation "*CHG*" in accordance with the requirement in **1.2.13-1**, **Part 1**, the presence of the surveyors is required at the stage specified in the following **(1)** through **(9)**.

(1) When the tests for the materials prescribed in **Part K of the Rules for the Survey and Construction of Steel Ships** and the equipment prescribed in **Part L of the Rules for the Survey and Construction of Steel Ships** are carried out.

(2) When, in process of manufacturing and assembling of structural members, requested by the Society. Especially, the full penetration weld are required for welding, the presence of the surveyors may be required at grooving process, tack welding and intermediate stages according to the applied welding procedures

(3) When structural members are installed on board the ship

(4) For driving gears, at the times when the finishing work on major parts is completed and when the Surveyor considers necessary during the process of manufacture

(5) When the subcontracted materials, parts or equipment are incorporated to the cargo handling appliances

(6) Non-destructive testing when requested by the Surveyor

(7) Shop trial of the driving gears

(8) Operation tests of the cargo handling appliances

(9) Operation tests of the safety devices and protective devices (including braking tests and

electric power source cut-off tests with a testing weight equal to the safe working load applied.

5 For ships affixed with the class notation "*PSPC*" in accordance with the requirement in **1.2.4-2**, **Part 1**, the verification of the contents of Technical Data Sheets and Coating Inspection Records is to be made.

6 For a ship affixed with the class notation "*CoC*" in accordance with the requirement in **1.2.4-3**, **Part 1**, the presence of surveyors is to be required at the stage when the corrosion protective measures applied are proceeded based on the documents showing corrosion protective measure for each compartment and structural member and for ships provided an impressed current protection system, the presence of surveyors is required for the performance tests of the system and verification for effectiveness of the protection measures is to be made.

7 For ships affixed with the class notations in accordance with the requirements in **1.2.8 (1)** through **(5)** concerning marine pollution prevention systems, surveys are to be carried out according to the requirements in **2.1.3**, **Chapter 2**, **Rules for Marine Pollution Prevention Systems**.

8 For ships affixed with the class notation "*AFS*" in accordance with the requirement in **1.2.8 (6)**, **Part 1**, the confirmation is to be made at the stage when the materials or paints manufactured away from the site are being applied to the ship concerned, and at appropriate occasions during or after the works for anti-fouling systems which are done in line with the procedures.

9 For ships affixed with the class notation "*BWMS*" in accordance with the requirement in **1.2.8 (7)**, **Part 1**, the following inspections are to be carried out.

(1) For ships conducting the ballast water exchange, it is to be confirmed that the ballast piping, ballast pump and air pipes and sounding pipes for ballast tanks are in good condition in accordance with the approved plan. In addition, other inspections deemed necessary by the Society are to be carried out.

(2) For ships conducting the ballast water management specified in **Chapter 6**, **Part 11**, the following inspections are to be carried out:

  (a) Confirmation that installations for ballast water treatment (ballast water management system, ballast pump and ballast piping, etc.) are located in their proper positions based upon approved drawings;

  (b) Confirmation that the *BWMS* is in good working order (in principle, includes operation tests associated with ballasting and de-ballasting at rated capacity);

(3) Confirmation that any consumables such as active substances and preparations necessary for conducting ballast water treatment are provided on board under appropriate controls;

(4) Confirmation that the *BWMS* is the same as that listed on the certificate for type approval;

(5) For *BWMS* which make use of active substances or preparations, confirmation that the type of said *BWMS* complies with relevant requirements;

(6) Confirmation that the recording devices for control equipment and monitoring equipment are operable and that sufficient supply of any consumables necessary for the recording devices is provided on board;

(7) For *BWMS* generating by-products such as sediments, dedicated installations to store such by-products are provided on board;

(8) Confirmation that ballast water management plan complying with the relevant requirements specified in **Chapter 6**, **Part 11** is kept on-board.

10 For ships affixed a class notation "*IHM*" and/or "*EA*" in accordance with the requirements in **1.2.8 (8)** and/or **(9)**, **Part 1**, confirmation that the items described in the plans and documents submitted according to the NK guideline, the "*Guideline for the Inventory of Hazardous Materials*" and the "*Environmental Guideline*"

11 For ships affixed with the class notation "*LSA*" or "*SN*" in accordance with the requirements in **1.2.10-1** or **1.2.10-2**, **Part 1**, the following items are to be confirmed.

(1) When the materials or parts manufactured away from the site are being applied to the ship concerned.
(2) When the launching appliances for lifeboat or liferaft are tested
(3) When the machinery systems of lifeboat or rescue boats are tested.
(4) When *GMDSS* installations are tested.
(5) When the on-board communication systems and general alarm systems are tested.
(6) When emergency lighting systems are tested.
(7) When navigation lights and sounding devices are tested.
(8) When the following equipment or devices are tested.
magnetic compasses including bowls, gyro compasses, radars, electronic plotting systems, automatic tracking systems, automatic radar plotting aids, echo sounding devices, devices to indicate speed and distance, rudder angle indicators, propeller speed indicators, propeller rotating angle indicators (pitch angle indicator for controllable pitch propeller), thrust indicators, if any, rate-of-turn indicators, electronic navigational aids, radar reflectors, sound reception systems, heading control systems, universal shipborne automatic identification systems, voyage data recorders, auto pilot systems, bridge navigational watch alarm systems, electronic chart display and information systems, daylight signaling lamps.
(9) When the marking for life saving appliances are provided

12 For ships affixed with the class notation "*SR*" in accordance with the requirement in **1.2.10-3**, **Part 1**, the following items concerning the radio installations are to be confirmed.
(1) For radio installations such as *VHF* systems, *MF* systems, *MF/HF* systems, *INMARSAT*, *NAVTEX* systems, radar transponders, EPIRBs, two-way radiotelephone apparatus, confirmation of the certificates and arrangement of these systems and performance tests.
(2) Where the source of power for radio installations are supplied by normal source of power, emergency source of power and battery, performance tests of each source of power and changeover.
(3) For *EPIRBs*, the confirmation of the way for release, the validity of release appliances and battery

13 For *FRP* ships, surveys are to be carried out at the following stages.
(1) When the material tests specified in **Part 3** are carried out.
(2) During forming process, the stage designated by the Society
(3) When the strength tests of *FRP* specified in **Part 3** are carried out.
(4) When the joint works of formed *FRP* are completed (Joint of a side shell and a deck)
(5) When the *FRP* or parts manufactured away from the site are being applied to the ship concerned.
(6) When the hydraulic tests or watertight tests are carried out.
(7) When sea trial is conducted.

14 The applicant is to be made and submit the documents for testing specified in **-1** through **-13** to the Society for approval, prior to tests. The applicant is to be submitted the results of tests and measurements records to the Society.

15 The requirements specified in **-1** through **-13** 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 sea trials.

2.1.5 Hydrostatic Tests, Watertight Tests, and Relevant Tests

1 Application
(1) For tanks and structures or equipment required to be watertight by the relevant requirements, the watertightness and structural integrity are to be verified by the hydrostatic tests and watertight tests.
(2) For structures or equipment required to be weathertight by the relevant requirements, the

weather-tightness is to be verified by the tests deemed appropriately by the Society.

2 Test types and definitions of hydrostatic test, etc.

(1) Test types and definitions of hydrostatic test, etc. are indicated in **Table 2.2.1**.

(2) Tests are to be carried out in the presence of a Surveyor at a stage sufficiently close to the completion of work with all hatches, doors, windows, etc. installed and all penetrations including pipe connections fitted, and before any ceiling and cement work is applied over the joints.

(3) For the hull block butt joints welded by automatic process, leak test may not be required. For the hull block butt joints welded by flux core arc welding semiautomatic process, the leak test may not be required provided that careful visual inspections show continuous uniform weld profile shape, free from repairs, and the results of NDE testing show no significant defects.

3 Structural tests

(1) Structural test is to be carried out by filling the spaces or tanks with fresh water or sea water, whichever is appropriate, having a head of water specified in **(a)** through **(f)**, whichever is higher.

(a) A head of water obtained from the following formula.

A head of water = $(\gamma - 1) \times H/2 + 2.4\ \ (m)$

Where,

γ: Density of cargoes loaded in the tank. Where γ is less than 1.0, γ=1.

H: Vertical distance measured from the lower edge of the bulkhead plate of the tank to the top of the tank (m)

(b) A head of water up to the top of overflow pipe

(c) A head of water up to bulkhead deck, where bulkhead deck is provided and where double bottom tanks or double side compartments are provided.

(d) A head of water for tanks having a relief valve obtained from a head of water up to the top of tanks plus a head of water corresponding to the design pressure of relief valve, for tanks having a relief valve.

(e) A head of water for ballast tanks corresponding to the maximum pressure of ballast pump or design pressure of relief valve, whichever is greater.

(f) A head of water for chain lockers up to the top of chain pipe

(2) Regardless of **-1**, hydropneumatic tests may be accepted as alternative tests of structure tests, where hydrostatic tests are not considered practicable due to the strength of blocks, density of liquids and limitation of tests. A head of water of a hydropneumatic test is to be approved by the Society.

(3) For pressure tanks, machinery installations and pipings hydrostatic tests with pressures required by the relevant requirements are to be carried out.

(4) Structure test is to be carried out at the time after 12 hours passed from the loading the required pressure.

(5) Structure test may be carried out in afloat condition, where tanks required to be carried out structural test are found no leak by leak test such as air test prior to structure test.

(6) Hydrostatic tests for doors, windows, hatches and closing appliances provided for openings required to be watertightness are to be carried out in the required a head of water after installation. Where water tightness of a watertight door has been confirmed by prototype test, testing by filling watertight spaces with water is dispensed with. In this case, the fitting condition is to be confirmed by leak test or other appropriate tests after fitting.

(7) All external surfaces of the tested space are to be examined for structural distortion, bulging and buckling, other related damage and leaks at the structure test.

4 Leak test

(1) A test pressure for air test including hydropneumatic test is to be confirmed by U-tube with a

height sufficient to hold a head of water corresponding to the required test pressure is to be arranged, and having a cross sectional area is not to be less than that of the pipe supplying air to the tank. Instead of using a U-tube, two calibrated pressure gauges may be acceptable to verify required test pressure.

(2) Leak tests for machinery installations and equipment are to be carried out using a pressure required by the relevant requirement.

(3) For leak tests of welded line, double inspections are to be carried out. The first is to be immediately upon applying the leak indication solution; the second is to be after approximately four or five minutes in order to detect those smaller leaks which may take time to appear.

(4) Where leak tests are required for fabrication involving partial penetration welds, a compressed air tests are also to be applied in the same manner as to fillet weld where the root face is large.

(5) Ultrasonic tests are to be carried out by the firm approved by the Society.

(6) Ultrasonic test equipment is to be calibrated prior to testing and ultrasonic tests are to be carried out after ultrasonic echo transmitters and receivers are to be arranged in order to detect leakage by ultrasonic sound level received by the receiver.

(7) In case of penetration tests, if no liquid is detected on the opposite sides of the boundaries after the expiration of a defined period of time, this indicates tightness of the boundaries. In certain cases, a developer solution may be painted or sprayed on the other side of the weld to aid leak detection considering the plate thickness or welding dimension in question.

5 The testing procedures other than those specified in **-1** through **-4** may be accepted to submit the details to the Society prior to testing.

6 The test procedures for hydrostatic and watertight tests, etc. are to be submitted to the Society for approval.

2.1.6 Non-Destructive Inspections of Welded Joints of the Hull Construction

1 Non-destructive inspections of welded joints of the hull construction designated by the surveyor considering the results of inspection for butt welding and fillet welding are to be carried out in order to confirm the welding quality in accordance with **Table 2.2.2**.

2 The locations required to carry out the non-destructive inspections for butt welding are the welded joints of hull block. For the weld joints used by automatic welding process and welded parts other than cross parts of welded lines, the number of locations required to carry out non-destructive inspections may be reduced subject to the approval of the surveyor.

3 For *GNS-C* ships and *GNS-D* ships, the number of locations required to carry out non-destructive inspections for insides of butt weld of outer shell plates and internal members may be reduced to 1/2 of those specified in **Table 2.2.2**.

4 Where the defects detected by radiographic tests in structures made of steels and the defects come under the following conditions, the defects are to be judged unacceptable. Instead of Japanese Industrial Standards (hereinafter referred to as *JIS*) specified in the following requirements, *ISO* or other national standards deemed appropriately by the Society may be applied.

(1) Cracks and similar defects

(2) Where defects are judged as incomplete penetrations, the unacceptable defects are as follows.
  (a) Type 2 defects specified in *JIS Z* 3104 for *GNS-A* ships and *GNS-B* ships.
  (b) Type 3 defects specified in *JIS Z* 3104 for *GNS-C* ships and *GNS-D* ships.

(3) Where defects are judged as incomplete fusion, elongated slag inclusion, pipe and similar defects, the unacceptable defects are as follows.
  (a) Type 3 defects specified in *JIS Z* 3104 for *GNS-A* ships and *GNS-B* ships.
  (b) Type 4 defects specified in *JIS Z* 3104 for *GNS-C* ships and *GNS-D* ships.

(4) Where defects are judged as round blow holes and similar defects, type 4 defects specified in *JIS Z* 3104 or similar defects specified in are unacceptable.

(5) Where two or more types of defects specified in **(2)** through **(4)** are coexistent, the defects are to be judged unacceptable, provided the size of defects of each type specified in *JIS Z* 3104 are more than half of the size specified in **(2)** through **(4)**.

5 Where the defects detected by radiographic tests in structures made of aluminium alloys and defects specified in *JIS* or *ISO* or other national standards come under the similar conditions specified in **-4** are to be judged unacceptable.

6 Where the defects detected by ultrasonic tests in structures made of steels, cracks and similar defects and the defects come under the following conditions, the defects are to be judged unacceptable.

(1) For *GNS-A* ships and *GNS-B* ships: type 3 defects judged by the detected region of echo heights and indicating length of defects specified in Annex G of *JIS Z* 3060 or *ISO* or other national standards deemed appropriately by the Society.

(2) For *GNS-C* ships and *GNS-D* ships: type 4 defects judged by the detected region of echo heights and indicating length of defects specified in Annex G of *JIS Z* 3060 or *ISO* or other national standards deemed appropriately by the Society.

7 For magnetic particle examinations and liquid penetrant examinations, the defects come under the following conditions in those indications which have any dimension greater than 2 mm are to be judged unacceptable.

(1) Defects judged as crack, lack of fusion, incomplete root penetration

(2) Defects judged as surface pore which come under the following conditions.

(a) For butt welds: single pore diameter *d* (*mm*) ≦ 0.25 thickness of thinner plate with maximum diameter 3 *mm* or 2.5*d* as minimum distance to adjacent pore

(b) For fillet welds: single pore diameter *d* (*mm*) ≦ 0.25 throat thickness with maximum diameter 3 *mm* or 2.5*d* as minimum distance to adjacent pore

(3) Defects judged as undercut which come under the following conditions.

(a) For fillet welds: depth ≦ 0.8 *mm* whatever in the length

(b) For butt welds:

depth ≦ 0.8 *mm* whatever in the length

depth ≦ 0.5 *mm* with a maximum continuous length of 90 *mm*

In this case, adjacent undercuts separated by a distance shorter than the shortest undercut are to be regarded as a single continuous

8 Non-destructive inspection for welded parts of machinery installations, boiler, pressure vessels and piping are to be subjected to the relevant requirements in **Chapter 3**, **Part 3**.

2.1.7 Documents to be Maintained On Board

1 For *GNS-A* ships and *GNS-B* ships, at the completion of a classification survey, the Surveyor confirms that the finished versions of drawings, plans, manuals lists, etc., designated by the owner are kept on board.

2 For *GNS-C* ships and *GNS-D* ships, at the completion of a classification survey, the Surveyor confirms that the finished versions of the following applicable drawings, plans, manuals lists, etc., are kept on board, except that the finished documents designated by the owner.

(1) General arrangement

(2) Midship section, scantling plans (construction profile), deck plans, shell expansion, transverse bulkheads, plans for rudder and rudder stock, and plans for cargo hatch covers

(3) Bilge, ballast and cargo piping diagrams

(4) Fire protection plans

(5) Fire extinguishing appliances arrangement

(6) Plans and data showing the navigation bridge visibilities

(7) For ships affixed a class notation “*CoC*”, “*IWS*” or “*HF*”, drawings and plans for those class

notations

(8) Other drawings or plans deemed necessary by the Society.

2.1.8 Finished Plans

1 For *GNS-A* ships and *GNS-B* ships, at the completion of a classification survey, the applicant is to be submitted the finished plans designated by the owner to the Society.

2 For *GNS-C* ships and *GNS-D* ships, at the completion of a classification survey, the applicant is to be submitted the finished plans specified in **2.1.6-2** to the Society.

2.1.9 Verification of Coating Application

1 For ships affixed with the class notation "*PSPC*", the following items are to be carried out by the Society prior to reviewing the Coating Technical File for dedicated seawater ballast tanks, etc. for the coatings of internal spaces.

(1) Check that the Technical Data Sheet and Statement of Compliance or Type Approval Certificate comply with the *PERFORMANCE STANDARD FOR PROTECTIVE COATINGS FOR DEDICATED SEAWATER BALLAST TANKS IN ALL TYPE OF SHIPS AND DOUBLE-SIDE SKIN SPACES OF BULK CARRIERS* (*IMO Performance Standard for Protective Coatings for Seawater Ballast Tanks, etc.* / *IMO* resolution *MEPC.*215(82) as may be amended), however, the Statement of Compliance or Type Approval Certificate is to be a certificate deemed appropriate by the Society

(2) Check that the coating identification on representative containers is consistent with the coating identified in the Technical Data Sheet and Statement of Compliance or Type Approval Certificate in **(1)** above

(3) Check that the inspector is qualified in accordance with the qualification standards deemed appropriate by the Society

(4) Check that the inspector's reports of surface preparation and the coatings application indicate compliance with the manufacturers Technical Data Sheet and Statement of Compliance or Type Approval Certificate in **(1)** above

(5) Monitor implementation of the coating inspection requirements deemed appropriate by the Society

2 For ships affixed with the class notation "*AFS*" in accordance with the requirement specified in **1.2.8**, **Part 1**, during classification surveys, the following plans and documents are to be submitted to the Society.

(1) Purchase order sheets of anti-fouling systems

(2) Receipt of anti-fouling systems issued by manufacturers

(3) Plans and/or documents showing specifications of anti-fouling systems applied to ships, including plans/documents showing areas where such anti-fouling systems are applied and their procedures, Material Safety Data Sheets (*MSDS*) for those anti-fouling systems applied to ship

(4) Declaration letter certifying the anti-fouling system used on the ship complying with the requirements in **Chapter 3**, **Part 3**, issued by the manufacturer, including the Chemical Abstract Service Registry Number (CAS No.)

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, load lines lifesaving appliances, radio installations, accommodation and sanitary facilities, marine pollution prevention systems, cargo handling appliances, etc., as required for the Special Survey corresponding to the ship's age in order to ascertain that they meet the relevant requirements in the Rule.

2 For ships subject to Classification Survey of ships not built under the Society s survey specified in -1, plans and documents necessary for registration to the Society are to be submitted according to the relevant requirements.

2.2.2 Hydrostatic Tests, Watertight Tests, and Relevant Tests

In the Classification Survey prescribed in **2.2.1**, sea 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 cannot be inspected; and tests for gas leakage of refrigerating machinery on board.

(1) Double bottoms, both peaks, tanks, cofferdams and chain lockers, watertight bulkheads and shaft tunnels are to be tested as specified in **2.1.5**.

(2) Hydrostatic, leakage or airtight tests are to be carried out on machinery and its parts at the pressures specified in the relevant requirements of the Rule.

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.

2.3 Sea Trials and Stability Experiments

2.3.1 Sea Trials

1 In the Classification Survey of all ships, sea trials specified in following **(1)** to **(14)** are to be carried out in full load condition, in the calmest possible sea and weather condition and in deep unrestricted water. However, where sea trials cannot be carried out in full load condition, sea trials may be carried out in an appropriate loaded condition. The noise measurements specified in **(11)** are to be carried out at either the full load condition or the ballast condition.

(1) Speed test

(2) Astern test

(3) Steering test and the change-over test from the main to auxiliary steering gears

(4) Confirmation test for ship's maneuverability such as turning test, stopping test, yaw checking test and course keeping test (zigzag test). For *GNS-C* ships and *GNS-D* ships, only turning test and stopping test may be accepted.

(5) Confirmation of no abnormality for the operating condition of machinery, starting system of machinery, alarm system, safety devices, governors and exhaust gas economizer and behavior of the ship during the trials

   (a) For diesel engines, the following tests are to be carried out.

      i) For main diesel engines and diesel engines of electric propulsion ships, load tests selected in two cases among 75 %, 50 % and 25 % power with sufficient duration to ensure to carry out necessary measurement, in addition to 4 hours in 100 % power. For ships that are unable to perform the speed test with 100 % power in full load condition, the load test with the ship speed at maximum continuous revolution of the main engine corresponding to 100 % power at shop test is to be confirmed. For ships having controllable pitch propellers, the test is to be performed at rated engine speed n0 at a propeller pitch leading to 100 % power, or to the maximum achievable power if 100 % power cannot be reached.

ii) For main diesel engines, load test in over speed run corresponding to 1.032 n0 or more for 30 *minutes* is to be carried out.

iii) For main diesel engines, the load test at the minimum working revolution of the main engine when the ship is steered to the maximum rudder angle is to be carried out to confirm that main engine works stably

iv) For engines for which intermittent overload is approved, intermittent overload test is to be performed for the duration agreed upon with the manufacturer.

v) For engine driving generators including main engines of electric propulsion ships, the load test in 110 % power run is to be carried out for 10 minutes at the rated engine speed, in addition to the test specified in **i)**. In this case, the tests are to be performed based on the rated electrical powers of the driven generators. However, where the other test deemed appropriately by the Society is carried out separately, this test may be dispensed with at the sea trial.

vi) For engines driving auxiliaries, the load test in 100 % power run is to be carried out for 30 *minutes* at the rated engine speed, in addition to the test specified in **iv)**.

(b) For gas turbines for main propulsion machinery, the output test is to be carried out at 3 levels of power output selected from normal continuous cruise power run and 3/4, 2/4 and 1/4 of the maximum continuous output of the engine for appropriate duration capable of ensuring the measurement of necessary items, in addition to the output test at 4/4 of the maximum continuous output for 4 hours.

(c) For ships having characters of main propulsion machinery affixed with a notation related to monitoring and control systems for unattended machinery spaces installed in accordance with the requirement in **1.3.3**, **Part 1**, where the tests of the systems related to the notation contain the items specified in **(a)** and **(b)**, of concerning the system, these tests are considered as implemented.

(d) For the alarms and safety devices, where the function tests of these are carried out in moored condition of ships, the function tests need not to carry out at sea trial.

(6) Confirmation of no abnormality on windlasses and performance of windlasses by the following performance test of windlasses.

(a) Performance tests to confirm braking ability, clutch ability, pay out and hoisting ability of chain cables and anchors, mesh of chain wheel, handling and storing of chain cables, handling and storing of anchors and function of chain stoppers are to be carried out.

(b) With anchor chain with length of 3 or more submerged and freely suspended at commencement of lifting, hoisting up each 2 lengths of chain on each one side and hoisting up one length of chain together on both sides, it is confirmed that the hoisting up speed of windlasses is to average a nominal speed of not less than 0.15 *m/s*.

(c) The pay out and holding ability of the cable lifter brake is to be confirmed by dropping the anchor and applying the brake at every 1/2 length of chain. Generally, this test is carried out at the test for pay out of 3 lengths anchor chain specified in **(b)**.

(7) For automatic and remote control systems for main propulsion machinery, controllable pitch propellers, boilers and electric generating sets, performance test of automatic and remote control systems are to be carried out. However, where the performance of these systems are confirmed at the tests carried out in the loading conditions tests similar to actual one after installation, some items of sea trial may be dispensed with.

(a) The control systems for main propulsion machinery and controllable pitch propellers are to be subjected to the following **i)** to **iv)**.

i) 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.

ii) 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.

iii) 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 able to transfer the controls during stoppage condition of the main propulsion machinery, the test on transfer of control is to be carried out while the main propulsion machinery is stopped.

iv) After completion of the test on transfer of control specified in **iii)**, 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.

(b) Function tests of the control systems for boilers are to be carried out in accordance with the following **i)** and **ii)**.

i) With respect to essential auxiliary 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.

ii) 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.

(c) 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.

(d) Where main sources of electrical power are necessary for the propulsion and steering of ships, systems are arranged so that electrical supplies to equipment necessary for propulsion and to ensure ship safety is maintained or immediately restored in cases where there is the loss of any one of the generators in service, the following items are to be confirmed while the main propulsion machinery is operating in normal continuous cruise output. However, in cases where the main propulsion machinery is operating at an output other than normal continuous cruising output, the tests may be carried out while main propulsion machinery is operating at said output on the condition that all active peripheral equipment are operating at outputs that are the same as the normal continuous cruising output of the main propulsion machinery.

i) Where only one electric generating set is normally used, the standby generator, air circuit breakers, and important auxiliary machinery start up automatically when the main source of electrical power is stopped by tripping a circuit breaker

ii) Where two electric generating sets are normally used, preference tripping of unnecessary loads is performed and propulsion and steering of the ship are maintained, when the circuit breaker of one of the sets is tripped

(8) Measurement of torsional vibration for the shafting systems

(9) Measurement of the sound pressure levels of fixed fire detection and fire alarm systems

(10) The noise measurements are to be in accordance with procedures for on board noise

measurement specified separately.

(11) Verification of Total Harmonic Distortion (*THD*) calculation report and harmonic filter operation guide

(12) For waterjet propulsion systems, the following tests are to be carried out during sea trials. However, the items specified in **(c)**, **(d)**, **(e)**, **(f)** and **(g)** may be carried out either at dockside or in dry dock.
   (a) Tests on steering capabilities
   (b) Tests on operation of controls for steering and reversing systems, including tests on change-overs of control systems between navigation bridges and auxiliary steering stations, and change-overs between manual steering and automatic steering, if provided.
   (c) Tests on measures for maintaining power supplies and on the alternative source of power
   (d) Tests on means of communication between navigation bridges and auxiliary steering stations, and between engine rooms and auxiliary steering stations
   (e) Tests on the functioning of relief valves for preventing over-pressure
   (f) Tests on the functioning of alarm and safety devices, and indication devices for deflector positions, reverser positions and impeller speed, and running indicators of electric motors for hydraulic power systems
   (g) Tests on the functioning of stoppers of reversers

(13) For azimuth thruster systems, the following tests are to be carried out during sea trials. However, those tests required in **(c)**, **(d)**, **(e)** and **(f)** may be carried out either at dockside or in dry dock. Also, when it is difficult to carry out tests on the functioning of relief valves mentioned in **(e)** after installation on board, these tests may be carried out as shop tests.
   (a) Tests on steering capability
   (b) Tests on the operation of controls for steering, including tests on change-overs of control systems between navigation bridges and azimuth thruster compartments, and change-overs between manual steering and automatic steering, if provided.
   (c) Tests on measures for maintaining power supplies and on the alternative source of power, except for mechanical type of azimuth thruster
   (d) Tests on means of communication between navigation bridges and the azimuth thruster compartments, and between engine rooms and azimuth thruster compartments.
   (e) Tests on the functioning of relief valves for preventing over-pressure.
   (f) Tests on the functioning of alarm and safety devices as well as indication devices for azimuth angles, propeller speeds and direction of rotation and pitch positions, and running indicators of electric motors for azimuth steering gears

(14) Other tests where deemed necessary by the Society

2 In the steering test specified in **-1(3)**, the steering capabilities required by **Chapter 3**, **Part 6**, are to be confirmed. Where it is impractical to perform the test with the ship at its deepest seagoing draught and running ahead at the speed corresponding to the number of maximum continuous revolutions of the main engine and maximum design pitch, ships may demonstrate compliance with this requirement by one of the following methods, except that special instructions are given by the Administration.

(1) During sea trials, the ship is at even keel and the rudder fully submerged whilst running ahead at the speed corresponding to the number of maximum continuous revolutions of the main engine and maximum design pitch (in case of the auxiliary steering gear, one half of this speed or 7 *knots*, whichever is greater).

(2) Where full rudder immersion during sea trials cannot be achieved, an appropriate ahead speed is to be calculated using the submerged rudder blade area in the proposed sea trial loading condition. The calculated ahead speed is to result in a force and torque applied to the main steering gear which is at least as great as if it was being tested with the ship at its deepest

seagoing draught and running ahead at the speed corresponding to the number of maximum continuous revolutions of the main engine and maximum design pitch (in case of the auxiliary steering gear, one half of this speed or 7 knots, whichever is greater).

(3) The rudder force and torque at the sea trial loading condition have been reliably predicted and extrapolated to the full load condition. The speed of the ship is to correspond to the number of maximum continuous revolutions of the main engine and maximum design pitch of the propeller (in case of the auxiliary steering gear, one half of this speed or 7 knots, whichever is greater).

3 Testing procedure for sea trial is to be submitted to the Society for approval.

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

5 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.

2.3.2 Stability Experiments

1 In the Classification Survey, stability experiments consisting of inclining tests and oscillation tests are to be carried out upon completion of the ship.

2 Regarding rolling period related to the particular of stability, for ships adopting the rolling period determined by approximate calculation specified in **2.3.1-1(2)**, **Part 4**, the oscillation test may be dispensed with.

3 Testing procedures for stability experiments are to be submitted to the Society for approval. 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.

4 Regardless of the requirement specified in **-1**, for sister ships which are built after the lead ship built by the same shipyard and used the same drawings, the stability experiments of an individual ship may be dispensed with, provided that reliable stability data is obtained from the stability experiments of sister ships or other adequate means and complied with the following conditions and a special approval is given by the Administration.

(1) Lightweight measurement is to be carried out, and it is to be confirmed that the deviation of lightweight as given by a ratio of deviation to the lightweight of the lead ship subjected to the inclining test does not exceed 1 % for ships with Lf greater than 160 *m*.

(2) Lightweight measurement is to be carried out, and it is to be confirmed that the deviation of lightweight as given by a ratio of deviation to the lightweight of the lead ship subjected to the inclining test does not exceed 2 % for ships with Lf less than 50 *m*.

(3) Lightweight measurement is to be carried out, and it is to be confirmed that the deviation of lightweight as given by a ratio of deviation to the lightweight of the lead ship subjected to the inclining test does not exceed the values obtained by the interpolation of the values specified in **(1)** and **(2)** for ships with Lf not less than 50 *m* and not greater than 160 *m*.

5 Regardless of the requirement specified in **-1**, stability experiments in the Classification Survey of ships not built under the Society's survey 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.

6 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. The modification, etc. of any main particulars are to satisfy the requirements for ships constructed on or after the date on which any relevant amendments enter into force. 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 Types of hydrostatic test, watertight test, etc.

Type of test	Confirmation item	Outlines of test	Test procedures
Hydrostatic Test:	Leak and Structural	A test wherein a space is filled with a liquid to a specified head	Unless another liquid is approved, hydrostatic tests are to consist of filling the space with fresh water or sea water, whichever is appropriate for testing, to the level specified in **2.1.5-3(1)**
Hydropneumatic Test:	Leak and Structural	水 A test combining a hydrostatic test and an air test, wherein a space is partially filled with a liquid and pressurized with air.	Hydropneumatic tests, where approved, are to be such that the test condition, in conjunction with the approved liquid level and supplemental air pressure, will simulate the actual loading as far as practicable.
Hose Test:	Leak	A test to verify the tightness of a joint by a jet of water with the joint visible from the opposite side.	Hose tests are to be carried out with the pressure in the hose nozzle maintained at least at 0.2 *MPa* during the test. The nozzle is to have a minimum inside diameter of 12 *mm* and be at a perpendicular distance from the joint not exceeding 1.5 *m*. The water jet is to impinge directly upon the weld.
Air Test	Leak	A test to verify tightness by means of air pressure differential and leak indicating solution. It includes tank air test and joint air tests, such as compressed air fillet weld tests and vacuum box tests.	All boundary welds, erection joints and penetrations, including pipe connections, are to be examined in accordance with approved procedure and under a stabilized pressure differential above atmospheric pressure not less than 0.015 *MPa*, with a leak indicating solution such as soapy water/detergent or a proprietary brand applied.
Compressed Air Fillet Weld Test:	Leak	An air test of fillet welded tee joints wherein leak indicating solution is applied on fillet welds.	Compressed air is injected from one end of a fillet welded joint and the pressure verified at the other end of the joint by a pressure gauge. Pressure gauges are to be arranged so that an air pressure of at least 0.015 *MPa* can be verified at each end of all passages within the portion being tested.
Vacuum Box Test:	Leak	A box over a joint with leak indicating solution applied on the welds. A vacuum is created inside the box to detect any leaks.	A box (vacuum testing box) with air connections, gauges and an inspection window is placed over the joint with a leak indicating solution applied to the weld cap vicinity. The air within the box is removed by an ejector to create a vacuum of 0.020 0.026 *MPa* inside the box.
Ultrasonic Test:	Leak	A test to verify the tightness of the sealing of closing devices such as hatch covers by means of ultrasonic detection techniques.	An ultrasonic echo transmitter is to be arranged inside of a compartment and a receiver is to be arranged on the outside. The watertight/weathertight boundaries of the compartment are scanned with the receiver in order to detect an ultrasonic leak indication. A location where sound is detectable by the receiver indicates a leakage in the sealing of the compartment.
Penetration Test:	Leak	A test to verify that no visual dye penetrant indications of potential continuous leakages exist in the boundaries of a compartment by means of low surface tension liquids (i.e. dye penetrant test).	A test of butt welds or other weld joints uses the application of a low surface tension liquid at one side of a compartment boundary or structural arrangement. If no liquid is detected on the opposite sides of the boundaries after the expiration of a defined period of time, this indicates tightness of the boundaries.

Table 2.2.2 Members Subject to Inspections and Number of Inspections

<table>
<tr><th colspan="2" rowspan="3">Members subject to inspection</th><th colspan="4">Number of inspections for each members subject to inspection</th><th rowspan="3">Procedures of Non-destructive inspection</th><th rowspan="3">Note</th></tr>
<tr><th colspan="2">Midship part of ship
(Hull within 0.4LWL amidship)</th><th colspan="2">Fore and aft parts of ship</th></tr>
<tr><th>Butt joints</th><th>Seam joints</th><th>Butt joints</th><th>Seam joints</th></tr>
<tr><td>Internal of butt welds for shell members</td><td>Strength deck plate
Side shell plate
Bottom shell plate
Deck and wall plates of superstructure located on the 1st layer</td><td>All intersections of weld lines and 6L/10</td><td>4L/10</td><td>All intersections of weld lines and 2L/10</td><td>L/10</td><td rowspan="7">Radiographic testing suitable for the thickness of welded parts and conforming to ISO 17636, JIS Z 3104 or equivalent thereto or ultrasonic testing conforming to JIS Z 3060 or equivalent thereto.
For non-destructive inspections applying to plate thickness of 50 mm or more, the applicability of applied procedures are to be confirmed by the Surveyor prior to testing.</td><td rowspan="7">1. Number of inspections is to round up decimal places per joints of each member subject to inspections.
2. Operators of radiographic testing or ultrasonic testing are to have Level 2 qualification or above, and such qualifications are to be certified by a certification body deemed appropriate by the Society, e.g. The Japanese Society for Non-destructive Inspection, in accordance with ISO 9712, JIS Z 2305 or the equivalent thereto. Notwithstanding the above, operators having Level 1 qualification can perform the procedures under the supervision of another operator having Level 2 qualification or above.
3. For ultrasonic testing, the Surveyor is, in principle, to be present during the test. Where the ultrasonic testing procedures capable of recording echo height of the indicator and necessary information such as Time-of-flight diffraction (TOFD) technique are applied, the presence of surveyor may be dispensed with.</td></tr>
<tr><td rowspan="6">Internal if butt welds of internal members</td><td>Plate</td><td>All intersections of weld lines and 3L/40</td><td>L/20</td><td>All intersections of weld lines and L/40</td><td>L/40</td></tr>
<tr><td>Plates fitted in the ship’s length direction</td><td>L/10</td><td></td><td>L/20</td><td></td></tr>
<tr><td>Plates fitted in athwartship direction</td><td></td><td>L/20</td><td></td><td>L/40</td></tr>
<tr><td>Longitudinal stiffeners</td><td>6L/40</td><td></td><td>L/20</td><td></td></tr>
<tr><td>Stiffeners other than those mentioned above</td><td></td><td>3L/40</td><td></td><td>L/40</td></tr>
<tr><td colspan="2">Surface of butt welds</td><td colspan="2">Locations designated by the Surveyor</td><td colspan="2">Locations designated by the Surveyor</td><td rowspan="2">Magnetic particle examination conforming to ISO 9934 or JIS Z 2320 or the equivalent thereto and liquid penetrant examination conforming to ISO 3452, JIS Z 2343 or the equivalent thereto.</td><td rowspan="2">A Surveyor is, in principle, to be present during the magnetic particle examination or liquid penetrant examination.</td></tr>
<tr><td colspan="2">Surface of fillet welds</td><td colspan="2">Fillet welds required to be watertight and fillet welds of plating and girders/transverses at block joints, which are designated by the surveyor</td><td colspan="2">Fillet welds required to be watertight and fillet welds of plating and girders/transverses at block joints, which are designated by the surveyor</td></tr>
</table>

Note：For aluminum alloys, radiographic testing and ultrasonic testing are to conform to *JIS Z* 3105 and *JIS Z* 3080, respectively, or the equivalent thereto.

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 upon the service and repair history of the ship or the damage histories of similar ship types or ships with similar tanks and spaces.

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

3.2.1 Examination of Plans and Documents

At Annual Surveys, the management conditions of the plans and the documents listed in **2.1.6**, **Chapter 2** are to be examined.

3.2.2 General Examinations

At Annual Surveys, examinations specified in the following **(1)** to **(21)** are to be carried out for of hulls, equipment, fire-extinction and fittings.

(1) Shell plating above the load waterline and weather deck plating

(2) Openings on decks and the sides of hulls as well as the coamings and closing appliances of hatchways and flush deck openings on exposed decks and within unenclosed superstructures, gangway ports, cargo ports and coal ports, and side scuttles below freeboard or superstructure decks. For closing appliances of hatchways, examinations are to be carried out to verify that the following **(a)** to **(c)** items are in good conditions.

- (a) Where controlled atmosphere systems are installed on board, the air-tightness and general condition of controlled atmosphere zones.
- (b) General conditions of all hatches cover plating, hatch coaming plating, and structural members (*e.g.* stiffeners)
- (c) For mechanically operated steel hatch covers, the stowage and securing in open condition and proper fit and efficiency of sealing in closed condition as well as the tightness devices of longitudinal, transverse and intermediate cross junctions (gaskets, gasket lips, compression bars, drainage channels), clamping devices, retaining bars, and cleating, closed cover locating devices, chain or rope pulleys, guides, guide rails and track wheels, stoppers and other similar devices, wires, chains, gypsies, tensioning devices, hydraulic systems essential to closing and securing, safety locks and retaining devices, and end and internal hinges, pins and stools.

(3) Casings of engine rooms, exposed engine casings and their openings, skylights of engine rooms, boiler rooms, and their closing appliances.

(4) Verification that ventilators, especially coamings and closing appliances of ventilators to spaces below freeboard decks or within enclosed superstructures are in good condition.

(5) Air pipes and their closing appliances, especially the penetrating parts of air pipes to spaces below the weather decks

(6) Watertight doors, penetrations and stop valves on watertight bulkheads, and closing appliances of openings in superstructure end bulkheads, deckhouses or companions protecting hatchways giving access to spaces below freeboard deck

(7) For ships to be required to indicate the load line, load line mark

(8) Bulwarks and the shutters of bulwarks, freeing ports, hinges and guard rails

(9) Guardrails, gangways, walkways and other means provided for the protection of crew and means for safe passage of crew. Especially, gangways and accommodation ladders (treads or

steps, platform, all support points such as pivots, rollers, all suspension points such as lugs, brackets, stanchions, rigid handrails, hand ropes and turntables including pins, davit structures, wires and sheaves, brake mechanisms, remote control systems and power supply systems as well as other devices for the protection of crew and for the safe passage of crew.

(10) Scuppers, inlets, other discharge, pipes and valves which are possible to examine at the load condition or draft condition at surveys. For ships over 15 years of age, piping in spaces where cargoes are intended to be loaded.

(11) Loading and securing arrangements on deck

(12) Anchoring and mooring arrangements including their accessories as far as can been seen.

(13) Management conditions and general condition of fire extinguishing systems such as the fixed fire extinguishing system, semi-portable and portable fire extinguishers, firefighters' outfits, emergency fire pump, including the validity of semi-portable and portable fire extinguishers, cylinders of breathing apparatus of firefighter's outfit, accessories such as priming pump of emergency fire pump, and stop valves

(14) Fire protection arrangements and means of escape

(15) Towing and mooring fittings and their safe working load markings

(16) Foe ships provided with loading computers and stability computers, management conditions of them

(17) For bow doors, inner doors, side shell doors and stern doors (hereinafter referred as "doors and inner doors"), confirmation that the items specified in the following **(a)** to **(g)** are in good conditions.

(a) Structural members such as plating and stiffeners and related welded parts of the door(s)

(b) Structural members such as plating and stiffeners of the surrounding hull structure and welded parts

(c) Securing devices, supporting devices, locking devices, hinges, bearings and thrust bearings, opening and closing systems, interlock systems for securing and locking devices, sealing arrangements for ensuring watertightness, electric devices for operating the opening/closing systems and securing/locking devices doors and inner doors, drainage systems and their arrangements, hydraulic devices, etc.

(d) In addition to **(c)** above, clearance measurements for the hinges, bearings and thrust bearings of doors are to be carried out in cases where no dismantling is required. If the results of function tests are not satisfactory, dismantling may be required to measure clearances in cases where deemed necessary by the Surveyor. If dismantling is carried out, a visual examination of hinge pins and bearings together with non-destructive testing of the hinge pins are to be carried out. Clearance measurements of securing, supporting and locking devices are to be taken in cases where indicated in operating and maintenance manuals.

(e) Visible indications and audible alarms (hereinafter referred to as indication and alarm system) on navigation bridge panels and on operating panels, lamp test function on navigation bridge panel and on operating panel, mode selecting functions that allow selection between "harbor" and "sea voyage", power supply for the indication and alarm systems, sensors for the indication and alarm systems and any other systems

(f) Where fitted, water leakage detection systems are to be tested including the proper audible alarms on the navigation bridge panels and on the engine control room panels.

(g) Where fitted, television surveillance systems are to be tested including the proper indications on the navigation bridge monitors and on the engine control room monitors.

(18) General conditions of hearing protectors and portable gas detecting systems and confirmation of the calibration records of the portable gas detecting systems

(19) For ships intended to carry flammable liquids or dangerous goods, cargo oil, fuel oil, ballast,

vent pipes including vent masts and headers, inert gas pipes and all other piping in cargo pump room, cargo compressor rooms and on weather decks

(20) For ships provided with refueling systems in which fuels are transferred to or from other ship at seas, the current condition of the refueling system (including piping and drip pans, etc.).

(21) For ships having fin stabilizers, the current conditions of structures for storing stabilizers as far as is visually possible.

3.2.3 Performance Tests

At Annual Surveys, performance tests specified in the following **(1)** to **(12)** are to be carried out for hulls, equipment and fire fighting systems, etc.

(1) Based on the results of general examinations specified in **3.2.2**, hose tests for weather tight hatch covers when deemed necessary by the Surveyor. In case of mechanically operated hatch covers, hatch cover sets within the forward 0.25 L_f and at least one additional set, including hydraulic and power components, wires, chains and link drives are to be checked for satisfactory operation.

(2) Operation tests and hose tests or equivalent tests for closing appliances of watertight door on watertight bulkheads and openings on superstructure end bulkheads, deckhouses or companions protecting hatchways giving access to spaces below freeboard deck. However, hose tests or equivalent tests may be dispensed with at the discretion of the Surveyor based on the satisfactory results of general examination and operation tests.

(3) For appliances related to fire protection and escape, operation tests of systems for opening and closures of skylights, closures of openings in funnels, closures of ventilator dampers, ventilating fans, and systems 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), and systems for closing openings in cargo or vehicle spaces, automatic fire doors. If such systems are able to be operated remotely at locations outside their concerned spaces, remote operation tests are to be carried out.

(4) Fire detection systems and fire alarm systems including manually operated call points (including proper operation of malfunction indicators)

(5) Performance tests of firefighting systems composed of fire pumps (including emergency fire pumps), piping, hydrants, hoses, nozzles etc. For ships with a class notation related to periodically unattended machinery spaces in accordance with the requirement of **1.3.3**, operation tests of the remote control systems or automatic operation systems of a single pump are to be carried out.

(6) Delivery water tests of fixed form systems such as fixed deck form systems

(7) Operation tests of ventilation systems

(8) Performance tests of loading computer and stability computer, if provided.

(9) Performance tests of water level detection and alarm systems selected at random

(10) Performance tests of dewatering arrangements

(11) Operation tests of bow doors, inner doors, side shell doors and stern doors. Hose tests when deemed necessary by the Surveyor based upon the results of general examinations and operation tests.

(12) Performance tests of firefighting arrangements, environment control systems and safety systems in loaded areas for ships intended to carry flammable liquids or dangerous goods

3.2.4 Internal Examinations of Spaces and Tanks

1 Engine rooms and boiler rooms, and superstructures and deck houses are to be examined internally.

2 Spaces installed with pumps for flammable liquids, compressors, etc. are examined internally.

3 For ships over 5 years of age, internal examinations are to be carried out for tanks when such

examinations are required as a consequence of the last Intermediate Survey or Special Survey.
4 For ships over 10 years of age and intended to carry dangerous goods, internal examinations of a single cargo hold selected at random are to be carried out. Internal examinations are also to be carried out for any cargo holds when such examinations are required as a consequence of the last Intermediate Survey or Special Survey.
5 Means of access provided for the internal examinations specified in **-1** to **-4** above are also to be examined.
6 For ships made of aluminium alloys or *FRP* and affixed with the class notation "*CoC*", the internal examinations of ballast tanks need not be carried out.

3.2.5 Close-up Surveys for Structural Members, etc.

1 Close-up surveys of securing, supporting and locking devices, together with welded parts of bow doors, inner doors, side shell doors and stern doors are to be carried out.
2 For ships over 15 years of age and intended to carry dangerous goods, close-up surveys of the lower structures of spaces where such cargoes are intended to be loaded are to be carried out.

3.2.6 Thickness Measurements of Structural Members, etc.

1 Where general corrosion is widely found by the examinations specified in **3.2.4** and **3.2.5**, thickness measurements for structures and equipment are to be carried out subject to the instructions of the Surveyor.
2 Where extensive corrosion is found by the examinations specified in **3.2.4** and **3.2.5**, additional thickness measurements are to be carried out according to the requirements in **Chapter 5**.

3.2.7 Pressure Tests

For piping systems of ships intended to carry flammable liquids, pressure tests are to be carried out when deemed necessary by the Surveyor as in consideration of the results of the general examinations specified in **3.2.4** to **3.2.6**.

3.2.8 Alternative Design and Arrangements

Ships adopting alternative designs and arrangements are to be examined in accordance with the tests, inspections and maintenance requirements, if any, specified in relevant approval documents.

3.3 Annual Surveys for Machinery

3.3.1 General Examinations

1 At Annual Surveys for Machinery, general examinations of all machinery in the engine rooms and the following **(1)** to **(7)** inspections are to be carried out.

(1) It is to be ascertained that the main propulsion machinery, power transmission machinery, shafting systems, prime movers other than main propulsion machinery, boilers, thermal oil heaters, incinerators, pressure vessels, auxiliaries, piping systems, control systems, electrical installations and switchboards are in good working order. In addition, the items specified in the following **(a)** to **(i)** are examined.
  - (a) It is to be confirmed that normal operation of the propulsion machinery can be sustained or restored even when one of the essential auxiliaries becomes inoperative.
  - (b) The means of operation for main and auxiliary machinery essential for ship propulsion and ship safety are to be examined.
  - (c) Arrangements for operating main engines and other machinery from machinery control rooms are to be examined.
  - (d) It is to be confirmed that machinery, boilers and other pressure vessels, associated piping

systems and fittings are installed and protected so as to reduce to a minimum any danger to persons on board, with due to regard being given to moving parts, hot surfaces and other hazards.

(e) It is to be confirmed that means are provided so that the machinery can be brought into operation from the dead ship condition without external aid.

(f) The electrical installations such as main sources of power and lighting systems (including emergency lighting systems) are to be examined.

(g) It is to be verified that precautions provided against shock, fire and other hazards of electrical origin are being maintained.

(h) The conditions of expansion joints in seawater systems are to be visually examined.

(i) Arrangements for remote closing of valves for fuel oil tanks, lubricating oil tanks and other flammable oil tanks are to be examined.

(2) Where controlled atmosphere systems are installed on board, the general examination of gas freeing equipment as well as control, alarm and monitoring equipment of such systems are to be verified in general examinations. Furthermore, where rubber couplings are installed, visual inspections and measurements of surface hardness or permanent deformation of rubber elements are to be conducted.

(3) For ships equipped with electrical distribution systems which include harmonic filters, it is to be ascertained that the filters are in good working order and either of the following **(a)** or **(b)** is to be verified, except in cases where the filters are installed for single application frequency drives such as pump motors.

(a) For harmonic filters provided for electrical distribution systems, records of the Total Harmonic Distortion (*THD*) values are to be verified.

(b) For harmonic filters, correct operation is to be confirmed by verifying that the maximum Total Harmonic Distortion (*THD*) values of main busbars on board ships are measured under typical seagoing conditions as close as possible to the dates of Annual Surveys and that such values do not exceed acceptable limits.

(4) General examinations of machinery and boilers as well as all steam, hydraulic, pneumatic and other systems and their associated fittings located within engine rooms, boiler rooms or means of escape spaces are to be carried out to sea to verify whether they are being properly maintained, with particular attention paid to fire and explosion hazards.

(5) For ships provided with propeller shafts and stern tube shafts which use oil lubricated or freshwater lubricated bearings, and for which lubricating oil or freshwater sampling and analysis are regularly carried out, general examinations of propeller shafts and stern tube shafts are to be carried out in addition to the checking of records for monitoring parameters and confirming maintenance conditions.

(6) For ships provided with waterjet propulsion systems or azimuth thruster systems, the current conditions of propulsion systems are to be confirmed to be in good working order.

(7) For ships provided with anti-rolling systems such as fin stabilizers or other control systems, general examination of these systems, equipment and their associated fittings are to be carried out.

2 At Annual Surveys for ships carrying flammable liquids, the items specified in the following **(1)** to **(4)** are to be examined, in addition to the items specified in **-1**.

(1) Foundations of each pump for flammable liquids, ventilation systems in cargo pump rooms, bunker systems on deck, temperature sensing devices for bulkhead glands and alarms as well as electrical installations (including electrical devices in hazardous areas) and their means of access, the removal of potential sources of ignition in dangerous zones (*e.g.* gear for cargo handling appliances, combustible materials), sealing devices for pumps (*e.g.* bilge pumps, ballast pumps) in dangerous zones, and ventilation systems in dangerous zones.

(2) For portable gas detecting instruments for measuring flammable vapour and oxygen concentrations, it is to be confirmed that at least one portable instrument of each provided, together with a sufficient set of spares and it is also to be confirmed that suitable means are provided for the calibration of these instruments.
(3) Where fixed gas sampling lines are fitted, the current conditions of such lines (including all connections) are to be verified.
(4) Where fixed hydrocarbon gas detection systems are fitted, the current conditions of such systems are to be verified.

3 For ships affixed with the "*M*0" notation to the Characters for main propulsion machinery in accordance with the requirement of **1.3.3**, **Part 1**, safety devices of main propulsion machinery as well as the emergency shutdown devices of main propulsion machinery and controllable pitch propellers, safety devices of boilers and generators provided in remote control rooms, and means of communication on the ship are to be examined.

3.3.2 Performance Tests

1 At Annual Surveys for Machinery, performance tests for the systems and devices specified in the following **(1)** to **(12)** are to be carried out in order to ascertain that they are in good working order.

(1) Operation tests for remote shut-off devices of fuel oil tanks and lubricating oil tanks are to be carried out.
(2) Operation tests for emergency stopping means of fuel oil pumps, cargo pumps, ventilating fans and boiler draught fans are to be carried out.
(3) Operation tests for emergency sources of electrical power and their associated equipment are to be carried out in order to ascertain that the whole systems are in good working order. Automatically operated equipment is to be tested in the automatic mode.
(4) Operation tests for the means of communication between navigation bridges and machinery control positions and between navigation bridges and steering gear compartments are to be carried out.
(5) Operation tests for valves (including ones for emergency use), cocks, strainers, pumps, reach-rods and level alarms of bilge systems are to be carried out
(6) Performance tests specified in the following **(a)** to **(e)** are to be carried out for the main and auxiliary steering gears including their associated equipment and control systems.
    (a) Operation tests for power units including changeover from one to another
    (b) Operation tests for automatic and remote isolation of the power actuating systems for hydraulic steering gear
    (c) Tests for supply of alternative sources of power for steering gear other than hydraulic one.
    (d) Operation tests for the control systems including the changeover systems
    (e) Operation tests for the alarm devices, rudder angle indicators and running indicators of power units
(7) Operation tests for the safety devices, etc. specified in the following **(a)** to **(e)** are to be carried out. However, such tests may be omitted at the discretion of the Surveyor based upon the general examinations, reports of working conditions at sea and inspection records taken by the ship's crew.
    (a) For main propulsion machinery and auxiliary machinery, operation tests of the following safety/alarm devices specified in the following **i)** and **ii)** for prime movers of main propulsion machinery; electric generators; auxiliary machinery essential for propulsion; and auxiliary machinery for maneuvering and crew safety are to be carried out. Where deemed necessary by the Surveyor, maintenance records for the cooling water and lubricating oil are required to be presented for review.

i) Over speed protective devices
ii) Automatic shut-off and alarm devices in case of loss or low pressure of the lubricating oil

(b) For boilers, thermal oil heaters and incinerators, operation tests for safety devices, alarm devices and pressure indicators (including the confirmation of calibration records of the pressure indicators of boilers) are to be carried out, 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 sea prior to the Annual Survey. 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) Operation tests for monitoring devices such as pressure indicators, thermometers, ammeters, voltmeters and revolution meters are to be carried out.
(d) Operation tests for automatic and remote control devices of auxiliary machinery essential for propulsion, maneuvering, and crew safety as well as the means of remotely controlling the propulsion machinery from the navigating bridge (including the control, monitoring, reporting, alert and safety actions) are to be carried out.
(e) It is to be confirmed that the engineer's alarm is clearly audible in the engineers' accommodation.

(8) For ships affixed with the "*M*0" notation to the Characters for main propulsion machinery in accordance with the requirement of **1.3.3**, **Part 1**, performance tests specified in the following **(a)** to **(c)** are to be carried out. However, where deemed necessary by the Surveyor and the maintenance records of the relevant systems are required to be presented for review, some items of the tests may be dispensed with.
(a) Safety device for main propulsion machinery and emergency stopping means of main propulsion machinery and controllable pitch propellers provided in remote control room
(b) Safety devices for boilers
(c) Safety devices for generators

(9) For waterjet propulsion systems, the performance tests specified in the following items are to be carried out.
(a) Performance tests of steering and reversing systems are to be carried out
(b) For ships capable of change-overs of control systems between navigation bridges and auxiliary steering stations, and change-overs between manual steering and automatic steering, tests on the functioning of control devices are to be carried out
(c) Tests on the functioning of alarm and safety devices, and indication devices for deflector positions, reverser positions and impeller speed, and running indicators of electric motors for hydraulic power systems are to be carried out.
(d) Tests for alternative power supply sources of power which are neither used as emergency sources of electric power nor for propulsion, and which are able to supply to propulsion systems from independent sources of power located in steering gear compartments are to be carried out.

(10) For ships provided with azimuth thruster systems, the performance tests specified in the following items are to be carried out.
(a) Performance tests of azimuth steering gears are to be carried out.
(b) Tests on the functioning of alarm and safety devices as well as indication devices for azimuth angles, propeller speeds and direction of rotation and pitch positions, and running indicators of electric motors for azimuth steering gears are to be carried out.
(c) For ships capable of change-overs of control systems between navigation bridges and auxiliary steering stations, and change-overs between manual steering and automatic

steering, tests on the functioning of those control devices are to be carried out.

(d) Tests for alternative power supply sources which are neither used as emergency sources of electric power nor for propulsion, and which are able to supply to propulsion systems from independent sources of power located in steering gear compartments are to be carried out.

(e) Where water detecting systems and fire detecting systems are provided in propeller pods, operation tests of visible and audible alarms are to be carried out

(f) Where ventilation systems for cooling are provided in propeller pods, operation tests of such systems (including shut-off devices) and operation tests of closing appliances for inlet and outlet of ventilation systems are to be carried out.

(11) For ships affixed with the class notation "*RC*", operation tests of fin stabilizers and other relevant systems are to be carried out.

(12) For ships affixed with the class notation "*CoC*" and adopting impressed current protection systems, conditions and operation tests of their systems are to be verified.

2 At Annual Surveys for ships intended to carry flammable liquids with flashpoints of 60 ℃ and below or dangerous goods, performance tests of the installations and systems specified in the following **(1)** to **(6)** are to be carried out.

(1) Operation tests for remote control systems and shut-off devices of the pumps for flammable liquids installed in cargo pump rooms are to be carried out.

(2) Operation tests of bilge systems (including bilge level monitoring devices and alarms) installed in cargo pump rooms are to be carried out.

(3) Operation tests of level indicators used in cargo tanks are to be carried out.

(4) Operation tests of pressure indicators installed in cargo discharge lines are to be carried out.

(5) Operation tests for fixed or portable gas detection systems and alarm systems of associated devices are to be carried out.

(6) Operation test for gauging devices for oxygen density are to be carried out.

3.3.3 Alternative Design and Arrangements

Ships adopting alternative designs and arrangements for machinery and electrical installations are to be examined in accordance with the tests, inspections and maintenance requirements, if any, specified in relevant approval documents.

3.4 Special Requirements for Ships Using Low-flashpoint Fuels

3.4.1 General

For ships affixed with the class notation "*LFF*" in accordance with the requirement of **1.2.12-1**, **Part 1** (Hereinafter referred to as "*LFF* ships"), in addition to the applicable requirements specified in **3.1** to **3.3**, the requirements of **3.4** are to be applied at Annual Surveys of *LFF* ships.

3.4.2 Examinations

At Annual Surveys of *LFF* ships, the examinations of spaces, structures and facilities, etc., specified in The following **(1)** to **(9)** are to be carried out in order to ascertain them being in good order. The extent of the survey may be increased to include additional performance testing, operational testing or open-up examinations in cases where deemed necessary by the attending Surveyor.

(1) On fuel containment systems, the following **(a)** to **(i)** are to be carried out, so far as applicable.

(a) External examination of the storage tanks including secondary barrier if fitted and accessible

(b) General examination of the fuel storage hold place

(c) Internal examination of tank connection space
(d) External examination of tank and relief valves
(e) Verification of satisfactory operation of tank monitoring system
(f) Examination and testing of installed bilge alarms and means of drainage of the compartment
(g) Examination of the general condition of the thermal insulation of fuel storage tanks and secondary barriers as far as accessible
(h) Examination of the general condition of the sealing arrangements for fuel storage tanks or tank covers penetrating decks as far as accessible
(i) At the first Annual Survey after delivery, the examinations specified in **(a)** and **(b)** of **item 1** and **item 2** of **Table B5.29**, **Part B of the Rules for the Survey and Construction of Steel Ships**, as well as an examination of the general condition of the fuel storage tank connection to the hull are to be carried out when deemed necessary by the Surveyor.

(2) Pressure relief valves, vacuum protection systems and safety systems for fuel storage tanks, interbarrier spaces, and fuel storage hold spaces, as well as their associated protection screens and vent piping are to be examined generally as far as accessible. It is to be confirmed that records of sealing of pressure relief valves for fuel storage tanks and their pressure setting are maintained on board.

(3) For bunkering systems, and fuel supply systems for *LFF*, The following **(a)** to **(c)** are to be carried out, so far as applicable.
(a) Examination of bunkering stations and the fuel bunkering system, including liquid level gauges, high level alarms and valves associated with emergency shutdown systems
(b) Examination of the fuel supply system, including fuel heat exchangers, vaporizers, pumps and compressors, during working condition as far as practicable
(c) Examination of automatic and manual stopping devices for fuel pumps and compressors

(4) For fuel handling piping, machinery and equipment, piping and its insulation, hoses, emergency shut-down valves, remote operating valves, relief valves, machinery and equipment for fuel storage, fuel bunkering, and fuel supply such as venting, compressing, refrigerating, liquefying, heating, cooling or otherwise handling the fuel are to be examined, as far as practicable. Stopping of pumps and compressors upon emergency shut-down of the system is to be confirmed as far as practicable.

(5) For control, monitoring and safety systems, general examinations and performance testing of those specified in the following **(a)** to **(h)** are to be carried out. Simulation testing or other suitable methods may be used in cases where it is difficult to carry out testing under actual operating conditions.
(a) Temperature indication equipment and associated alarms
(b) Pressure gauges and associated alarms for fuel tanks, interbarrier spaces and fuel storage hold spaces
(c) Gauging devices for oxygen density
(d) Gas detection equipment, including both fixed and portable instruments, and other leakage detection equipment in compartments containing fuel storage, fuel bunkering, and fuel supply equipment or components or associated systems, including indicators and alarms, is to be confirmed in satisfactory operating condition. Recalibration of the gas detection systems is to be verified in accordance with the manufacturers' recommendations.
(e) Verification of the satisfactory operation of the control, monitoring and shutdown systems, including automatic shutdown systems, of the fuel supply and bunkering systems is to be carried out. General examinations and performance testing, simulation

testing or other suitable methods in cases where it is difficult to carry out performance testing under actual operating conditions for liquid level gauges, high level alarms and valves associated with emergency shutdown systems for bunkering are to be carried out.

(f) Testing of the remote and local closing of the installed main tank valve is to be carried out.

(g) Testing of the remote and local closing of the master fuel valve for each engine compartment and verification of satisfactory operation of the fuel supply system control, monitoring and shut-down systems are to be carried out during working condition as far as practicable.

(h) Operational test, as far as practicable, of the shutdown of *ESD* protected machinery spaces is to be carried out.

(6) For environmental control systems, means for inerting specified in the following **(a)** to **(c)** is to be examined.

(a) Systems for gas freeing and purging and gas sampling devices for fuel storage tanks

(b) Inert gas generators and inert gas storage systems

(c) Pressure control systems, means for preventing backflow of gases and monitoring systems for inert gas associated systems

(7) Examination of the ventilation system, including portable ventilating equipment where fitted, is to be made for spaces containing fuel storage, fuel bunkering, and fuel supply units or components or associated systems, including air locks, tank connection spaces, ESD-protected machinery spaces, fuel preparation rooms including pump rooms and compressor rooms, fuel valve rooms, control rooms and spaces containing gas burning equipment as well as double pipes and ducts. Where alarms, such as differential pressure and loss of pressure alarms, are fitted, these should be operationally tested as far as practicable.

(8) General conditions of fire-fighting systems for enclosed hazardous areas and alarm devices for emergency escape are to be examined.

(9) For other systems, general conditions of those specified in the following **(a)** to **(k)** are to be examined. Checking the contents of items **(i)** to **(k)** and confirmation that they are maintained on board are to be carried out.

(a) Closing appliances for openings such as windows and doors of the wheelhouse, deckhouses and superstructures that are required to be capable of being closed; and the arrangements for the air locks

(b) Portable and fixed drip trays and insulation for the protection of the ship's structure in the event of leakage

(c) Fuel preparation rooms, including fuel pump and compressor rooms, and the sealing of shafts penetrating gas-tight bulkheads

(d) Means for preventing excessive cooling of hull structures

(e) Approved fuel hoses

(f) Electrical bonding arrangements in hazardous areas, such as those between hull structures and fuel piping or fuel storage tanks, including bonding straps where fitted

(g) Equipment specially required depending upon fuel type

(h) Electrical equipment and bulkhead/deck penetrations including access openings in hazardous areas are to be examined for continued suitability for their intended service and installation area.

(i) Bunker delivery notes for *LFF* delivered as well as the operational procedures which the manufacturer/builder instructions and manuals covering the operations, safety and maintenance requirements and occupational health hazards relevant to fuel storage, fuel bunkering, and fuel supply and associated systems for the use of the fuel, and emergency procedures for *LFF* ships.

(j) The *IMO* International Code of Safety for Ships using Gases or Other Low-flashpoint Fuels
(k) Logbooks/Records. Especially, the logbooks and operating records are to be examined with regard to correct functioning of the gas detection systems, fuel supply/gas systems, etc. The hours per day of the reliquefaction plant, gas combustion unit, as applicable, the boil-off rate, and nitrogen consumption (for membrane containment systems) are to be considered together with gas detection records.

3.5 Annual Thorough Surveys for Cargo Handling Appliances

3.5.1 Application

The requirements of **3.5** apply to the cargo handling appliances such as cranes, cargo ramps, cargo lifts, etc., and their accessories of the ship affixed with the class notation "*CHG*".

3.5.2 Survey for Cargo Handling Appliances

1 For cranes, structural members, the connection between the structural members of stationary cranes and hull structures, and rails, buffers and the connection between those members and hull structures for track-mounted cranes, installations of driving system, safety devices and protective devices, and markings of the safe working load, etc., and the effectiveness of the relevant certificates are to be examined. The items specified in the following **(1)** to **(4)** are to be examined where considered necessary by the Surveyor based on the general examination of them.
(1) Checking of plate thickness of the structural members, non-destructive testing and open-up examinations of the bearings
(2) Inside of the posts, their legs and stiffeners of cranes
(3) Open-up examinations of the driving gears
(4) Operation tests of the safety devices and protective devices

2 For cargo ramps, structural members, connection between the structural members and hull structure, water-tight or weather-tight arrangements of cargo ramps that are used as water-tight or weather-tight doors when closed, and driving gears, safety devices and protective devices, and markings of the safe working load and the effectiveness of the relevant certificates are to be examined. The items specified in the following **(1)** to **(4)** are to be examined where considered necessary by the Surveyor based on the general examination of them.
(1) Plate thickness measurements, open-up-inspection of lifting pins, nondestructive tests, etc.
(2) Hose testing or airtight testing for cargo ramps that are used as water-tight or weather-tight doors when closed
(3) Open-up examinations of the driving gears
(4) Operation tests of safety devices and protective devices

3 For cargo lifts, etc., structural members, connection between the holding parts of cargo lifts and hull structure, connection between the lifting/lowering devices of cargo lifts and hull structure, and driving gears, safety devices and protective devices, and markings of the safe working load and the effectiveness of the relevant certificates are to be examined. The items specified in the following **(1)** to **(3)** are to be examined where considered necessary by the Surveyor based on the general examination of them.
(1) Plate thickness measurements, open-up-inspection of lifting pins, nondestructive tests, etc.
(2) Open-up examinations of the driving gears
(3) Operation tests of the safety devices and protective devices

4 The structural members and loose gear in which corrosion, abrasion or other defects whose amount of wear and tear reaches 10 % of the original dimensions are found are, as a rule, to be repaired or renewed.

3.5.3 Surveys for Loose Gears

1 The following items in **(1)** through **(3)** of loose gears are to be visually examined and ascertained to be in good order. However, where considered necessary by the Surveyor, the items in **(2)** are to be opened up and examined.

(1) Wire ropes for their full length

(2) Cargo blocks, chains, rings, hooks, shackles, swivels, lifting beams, cramps, rigging screw, grabs, lifting magnets, spreaders, etc.

(3) Markings of the safe working load and identification symbols, and the effectiveness of the relevant certificates

2 Society may accept an autonomous inspection carried out by ship's master or his representative. In this case, the personnel who carried out an autonomous inspection is to record the following **(1)** through **(6)** for the loose gears renewed in the Inspection Record Book of Loose Gear, and show this Inspection Record Book and the certificates of the loose gears concerned to the Surveyor for his approval at the next Periodical Survey or Occasional Survey.

(1) Names and identification symbols

(2) Locations in service

(3) Safe working loads

(4) Testing loads

(5) Dates of renewal or repairs and dates of commencement of use

(6) Reasons for renewal or repairs

3.6 Annual Surveys for Marine Pollution Prevention Systems, etc.

3.6.1 General

For ships affixed with class notations related to marine pollution prevention systems in accordance with the requirements specified in **1.2.8 (1)** to **(5)**, **Part 1**, the inspections of marine pollution prevention systems, etc. at Annual Surveys, are to be carried out in accordance with the requirements of **3.1**, **Chapter 3**, **Part 2 of the Rules for Marine Pollution Prevention Systems**.

3.7 Annual Surveys for Accommodation and Sanitary Facilities

3.7.1 General

For ships affixed with the class notation "*AAC*" in accordance with the requirement of **1.2.10-4**, **Part 1**, general inspections of accommodation and sanitary facilities are to be carried out at Annual Surveys.

3.8 Annual Surveys for Safety Equipment and Navigational Equipment

3.8.1 General

1 At Annual Surveys Safety Equipment and Navigational Equipment for ships affixed with the class notations "*LSA*" and/or "*SN*" in accordance with the requirements of **1.2.10-1** and/or **-2**, **Part 1**, the following **(1)** to **(12)** plans or documents which are being maintained on board are to be confirmed.

(1) Log books

(2) Training manuals for life-saving appliances

(3) Instructions for on-board maintenance of life-saving appliances and navigational equipment

(4) Procedures for correction of residual deviation of magnetic compass and documents indicating the latest correction results

(5) Drawing showing the shadow fields of navigational radars
(6) Nautical charts and nautical publications (except electronic chart display and information systems and their back-up systems)
(7) International Code of Signals and International Aeronautical and Maritime Search and Rescue Manual
(8) Maintenance records of pilot transfer arrangements
(9) Plans and Procedures for Recovery of Persons from the Water
(10) Muster list
(11) Posters providing instructions for the operation of lifeboats and liferafts provided near lifeboat and liferaft embarkation arrangements
(12) Documents or records of the inspections, tests and maintenance of the equipment and appliances specified in **-2** below carried out by service suppliers deemed appropriate by the Society, which are made by said service suppliers

2 The following equipment or appliances are to be maintained in accordance with maintenance standards specified by the Society in the presence of a surveyor, except where service suppliers deemed appropriate by the Society carry out the maintenance works.
(1) Inflatable liferaft, inflatable appliances and hydrostatic release units
(2) Inflated or combined rescue boat
(3) Marine evacuation systems
(4) Inflatable lifejackets
(5) Boat for inflatable life raft
(6) *NAVTEX* receiver
(7) Enhanced group call receiver
(8) *VHF* digital selective calling equipment
(9) *VHF* digital selective calling watch system
(10) Digital selective calling equipment
(11) Digital selective calling watch system
(12) Float-free satellite emergency position indicating radio beacons (*EPIRBs*) and non float-free *EPIRBs*
(13) Rader transponder and *AIS-SART*
(14) Two way portable and fixed radiotelephone apparatus
(15) Navigation radar
(16) Automatic radar plotting aids
(17) Electronic plotting aids
(18) Automatic tracking aids
(19) Automatic identification system
(20) Voyage data recorders (including simplified *VDR*)
(21) Safety equipment deemed necessary by the Society

3 General examinations of the following **(1)** to **(11)** life-saving equipment and navigational equipment are to be carried out.
(1) Life boat, life raft and rescue boat (including the equipment, the validity of equipment, release system for life boat, hydraulic release system for life boat and life raft)
(2) Life-throwing appliances and the validity of rockets
(3) Rocket parachute signals and their validity
(4) Lifejackets (including whistle, retroreflection and lifejacket lights), immersion suits and anti-exposure suits
(5) Lifebuoy（self-ignition lights, self-activating smoke signals and buoyant lifelines, and the validity of them）
(6) Navigation lights, day shapes, gongs and bells

(7) Magnetic compasses including bowls, gyrocompasses, radars, electronic plotting systems, automatic tracking systems, automatic radar plotting aids, echo sounding devices, devices to indicate speed and distance, rudder angle indicators, propeller speed indicators, propeller rotating angle indicators (pitch angle indicator for controllable pitch propeller), thrust indicators, if any, rate-of-turn indicators, electronic navigational aids, radar reflectors, sound reception systems, heading control systems, universal shipborne automatic identification systems, voyage data recorders, auto pilot systems, bridge navigational watch alarm systems, electronic chart display and information systems, international maritime signal flags, daylight signaling lamps and other navigational equipment. Where the performance of navigational equipment is difficult to confirm at Annual Surveys, the inspection records of such equipment are to be confirmed.
(8) Pilot transfer arrangements
(9) *GMDSS*. Where the performance of *GMDSS* is difficult to confirm at Annual Surveys, the inspection records of *GMDSS* are to be confirmed.
(10) Voyage data recorders (including simplified *VDR*)
(11) Automatic identification systems

4 Performance tests of the following **(1)** to **(7)** safety equipment and navigational equipment are to be carried out in order to ascertain them being in good order.

(1) Onboard communication systems and alarm systems
(2) For emergency lighting systems, especially for emergency lighting arranged at muster stations and embarkation stations as well as corridors, stairways and exits giving access to muster and embarkation stations, it is to be confirmed that such systems powered by emergency generators are in good working order.
(3) For launching appliances of liferafts, dynamic tests of winch brakes at maximum lowering speed using liferafts without any persons on board, upon the completion of examinations made by service suppliers deemed appropriate by the Society and operation tests of automatic release hooks.
(4) For launching appliances of lifeboats, dynamic tests of winch brakes at maximum lowering speed using lifeboats without any persons on board, upon the completion of examinations made by service suppliers deemed appropriate by the Society and operation tests of automatic release hooks, in addition to swinging-out tests.
(5) For launching appliances of free-fall lifeboat, operation tests of release gear, in addition to lowering tests and simulated launching tests.
(6) For launching appliances of rescue boats, lifting and lowering tests of rescue boats, and dynamic tests of winch brakes at maximum lowering speed using rescue boats without any persons on board and operation tests of automatic release hooks
(7) For engines of lifeboats and rescue boats, operation tests for starting of engines and driving forward and afterward are to be carried out and operation tests of lighting supplied by sources of power in the lifeboats or rescue boats.

3.9 Periodical Surveys of Radio Installations

3.9.1 General

For a ship affixed with the class notation "*SR*" in accordance with the requirement of **1.2.10-3**, **Part 1**, the inspection and test records of radio installations made by the radio inspectors are to be confirmed at periodical surveys.

3.10 Annual Surveys of Ballast Water Management Installations

3.10.1 General

For a ship affixed with the class notation "*BWMS*" in accordance with the requirement of **1.2.8 (7)**, **Part 1**, it is to be confirmed that documents related to ballast water management and ballast water record books are being maintained on board and general inspections of the systems are to be carried out in addition to the relevant inspections specified in the requirement of **3.10.2**.

3.10.2 Inspection of Equipment

1 For ships conducting the ballast water exchange specified in *IMO* Resolution *MEPC*.124(53) Guidelines for Ballast Water Exchange (*G*6) (as amended), it is to be confirmed that the ballast piping, ballast pumps, air pipes and sounding pipes for ballast tanks are in good condition. In addition, other inspections deemed necessary by the Society are to be carried out.

2 For ships conducting the ballast water management specified in *IMO* Resolution *MEPC*.174(58) Guidelines for Approval of Ballast Water Management Systems (G8) (as amended) and provided with ballast water management systems approved by the Administration, the following inspections are to be carried out.

(1) Visual inspections and function tests of the ballast water management system, as far as practicable

(2) Confirmation that any consumables such as active substances and preparations necessary for conducting ballast water treatment are provided in sufficient supply on board under approved controls.

(3) Other inspections deemed necessary by the Society

Chapter 4 INTERMEDIATE SURVEYS

4.1 General

4.1.1 General

At Intermediate Surveys, the surveys specified in this Chapter are to be carried out in addition to the Annual Surveys specified in **Chapter 3**.

4.1.2 Surveys Equivalent to Special Surveys

1 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.

2 At Intermediate Surveys for ships over 15 years of age, those surveys consisting of general examinations of hulls, equipment and fire extinguishing systems as well as internal examinations of compartments and tanks, close-up surveys for structural members and thickness measurements that are required to be carried out at the Special Surveys specified in **Chapter 5** are to be carried out. However, the surveys specified in the following **(1)** to **(3)** may not be dispensed with.

(1) Internal examinations of fuel oil, lube oil and fresh water tanks
(2) Examinations (both external and internal) of automatic air pipe heads installed on the exposed deck and of the ventilators and closing appliances for machinery and cargo spaces
(3) Thickness measurements of each bottom plate within the cargo length area including lower turn of bilge

3 At Intermediate Surveys for ships over 15 years of age, among the performance tests of hulls, equipment and fire extinguishing systems, the following **(1)** and **(2)** are to be carried out in accordance with those required at Special Surveys.

(1) Performance tests and operation tests of bilge piping and ballast piping
(2) For doors on watertight bulkheads and closing appliances on superstructure end bulkheads, deckhouses or companions protecting hatchways giving access to spaces below freeboard deck, confirmation that the doors and closing appliances work in order is to be made and hose tests or equivalent tests are to be carried out.

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

4.2.1 General

1 At Intermediate Surveys, the examinations and tests specified in the following **(1)** to **(17)** are to be carried out in addition to those specified in **3.2.1** to **3.2.8**.

(1) General examinations of spare parts for fire extinguishing systems
(2) For ships employing measures to ensure the stability under damage conditions such as cross flooding equipment, general examinations of such systems as well as any other examinations deemed appropriately by the Society.
(3) For ships not over 15 years of age, operation test and hose tests or equivalent tests of doors on watertight bulkheads and closing appliances on superstructure end bulkheads, deckhouses or companions protecting hatchways giving access to spaces below freeboard deck are to be carried out. However, hose tests or equivalent tests may be dispensed with at the discretion of the Surveyor.
(4) Operation tests of drainage, mooring and anchoring arrangements and their accessories are to be carried out. Such tests, however, may be dispensed with at the discretion of the Surveyor.
(5) For fixed dry-chemical powder fire fighting systems, it is to be confirmed that piping is maintained in good condition by delivering air through the pipes. It is also to be confirmed

that monitors and hoses as well as remote control systems and related automatic valves are working properly, and that the quantity of starting or pressuring gases is as required.

(6) For water spray systems, tests made by delivering water through the system are to be carried out. However, the checking of the quantity of delivered water may be dispensed with.

(7) For carbon dioxide extinguishing media, halon extinguishing media and dry chemical powder extinguishing media, the quantity of the media is to be confirmed.

(8) For fixed carbon dioxide firefighting systems and fixed halon firefighting systems, it is to be confirmed that piping is maintained in good condition by delivering air through the pipes and it is to be confirmed that the system alarms are working properly.

(9) For fixed foam firefighting systems and fixed high expansion foam firefighting systems, it is to be confirmed that piping is maintained in good condition is to be carried out by delivering water through the pipes

(10) For fixed pressure water spraying firefighting systems, it is to be confirmed that the system is working properly by delivering water through the system. It is also to be confirmed that system pumps are working properly.

(11) For automatic sprinkler systems, it is to be confirmed that delivery alarms and pumps are working properly while fire detecting systems are in operation.

(12) For fixed local application fire-fighting systems, it is to be confirmed that piping is maintained in good condition by delivering air through the pipes. It is also to be confirmed that system alarms as well as feed water pumps and starting valves are working properly.

(13) For closing appliances of openings related to firefighting in way of cargo holds, it is to be confirmed such appliances are working properly.

(14) For ships over 5 years of age up to 10 years of age, internal examinations of representative ballast tanks are to be carried out. However, such examinations may be dispensed with for ships with the class notation "*CoC*".

(15) For ships over 10 years of age up to 15 years of age, internal examinations of all ballast tanks are to be carried out. However, if external examinations of all the tanks and internal examinations of some of the tanks reveal no visible structural defects, the examination scope may be limited to verification that the corrosion prevention systems remain effective.

(16) For ships over 15 years of age, internal examination of one forward cargo hold and one after cargo hold are to be carried out.

(17) For ballast tanks in which suspicious areas judged from the results of previous internal examinations and internal examinations specified in **(14)** and **(15)** are found, close-up surveys and thickness measurements of such suspicious areas are to be carried out.

2 For ships intended to carry flammable liquids, pressure tests of piping or thickness measurements of pipes or both are to be carried out, where deemed necessary by the Surveyor based on the results of general examinations

4.3 Intermediate Surveys for Machinery

4.3.1 General

At Intermediate Surveys, the examinations and tests specified in the following **(1)** to **(5)** are to be carried out in addition to those specified in **3.3.1** to **3.3.3**.

(1) For diesel engines (main engines, auxiliary machinery essential for main propulsion auxiliary and prime movers of auxiliary machinery for maneuvering and safety), the alignment of crank shafts is to be examined, and the alignment is to be adjusted, if necessary.

(2) Examinations and tests for boilers and thermal oil heaters are to be carried out in accordance with the following **(a)** to **(i)**.

(a) Internal of the boiler

Pressure parts of boilers are to be 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.

(b) Superheaters, economizers and exhaust gas economizers
Internal examinations are to be carried out. 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.

(c) For combustion parts of boilers and thermal oil heaters (only applies to thermal oil heaters heated by fire, combustion gas or exhaust gas from machinery), the furnaces, combustion chambers, combustion gas chambers, etc. are to be internally examined with their doors opened.

(d) For valves and cocks, the principal mountings and their fastening bolts or studs are to be opened up and examined.

(e) Thickness of plates of boilers and thermal oil heaters, and thickness of tubes and size of stays are to be measured where deemed necessary by the Surveyor.

(f) Safety valves and relevant parts of boilers, superheaters and thermal oil heaters
Safety valves are to be adjusted under steam to a pressure not more than 103 % of the approved working pressure after open-up examinations. 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 sea, 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.

(g) Safety devices, alarm devices and automatic combustion control devices
These devices are to be tested in order to ascertain that they are in good working conditions after the examinations specified in **(a)** to **(f)**

(h) Review of logbook records
Review of the following records since last boiler survey is to be carried out.
   i) Operation
   ii) Maintenance
   iii) Repair history
   iv) Quality control of the feed water or thermal oil

(i) When direct visual internal inspections are not feasible due to the limited size of the internal spaces, such as for small boilers and/or narrow internal spaces at the surveys specified in **(a)** to **(c)**, such inspections may be replaced by hydrostatic pressure testa or by alternative verifications as deemed appropriate by the Society.

(3) For electrical installations, generators and switchboards (including emergency generators and switchboards), motors and cables, insulation resistance is to be measured in order to ascertain that they are in good condition. If the values of the measured insulation resistance do not comply with the requirements of **2.18.1**, **Part 8**, adjustments are to be made. However, such measurements may be omitted at the discretion of the Surveyor, if accurate measurement records of insulation resistance are being kept and can be verified

(4) For refrigerating machinery, examination of refrigerant leakage while the machinery is in operation and the general condition of the safety devices are to be carried out. Where controlled atmosphere systems are installed on board, general examinations of gas freeing equipment as well as of the controls, alarms and monitoring equipment of the controlled atmosphere systems are to be carried out.

(5) For ships intended to carry flammable liquids with flashpoints of 60 °C and below or dangerous goods, the following **(a)** to **(c)** are to be examined.
   (a) The earthing between cargo oil tanks/cargo piping systems (cargo oil pipes, vent pipes, tank washing pipelines, etc.) and hull structures is to be examined.
   (b) Electrical installations in hazardous areas are to be examined in detail and confirmation of the maintenance records of explosion-proof electrical equipment is to be carried out. In addition, confirmation that the installations are in good condition is to be made by measuring the insulation resistance. However, such measurements may be omitted at the discretion of the Surveyor, if accurate measurement records of insulation resistance are being kept and can be verified.
   (c) For electrical equipment in hazardous areas, performance tests of interlock devices associated with pressurized protected type electrical equipment and electrical equipment installed in pressurized or ventilated areas are to be carried out.

4.4 Intermediate Surveys for *LFF* ships

4.4.1 General

At Intermediate Surveys, the examinations and tests specified in the following **(1)** to **(7)** are to be carried out in addition to those specified in **3.4.2**.

(1) General examinations of piping of gas detection systems are to be carried out.
(2) In cases where fuel storage tank relief valves with non-metallic membranes are main or pilot valves, it is to be confirmed that such non-metallic membranes are maintained in good condition.
(3) The examinations of electrical installations in hazardous areas are to be carried out in accordance with the requirement of **4.3.1(4)**.
(4) The current condition of the electrical bonding between hull structures and fuel storage tanks or piping is to be verified.
(5) Performance testing of bilge systems for interbarrier spaces, fuel storage hold spaces and tank connection spaces is to be carried out.
(6) Fixed piping of fire-fighting system in enclosed hazardous area is to be tested by passing air through it.
(7) Gas detectors, temperature sensors, pressure sensors, level indicators, and other equipment providing input to the fuel safety system are to be randomly tested to confirm satisfactory operating condition. Proper response of the fuel safety system upon fault conditions is to be verified.

4.5 Intermediate Surveys of Marine Pollution Prevention Systems

4.5.1 General

For ships with class notations related to marine pollution prevention systems in accordance with the requirements specified in **1.2.8 (1)** to **(5)**, **Part 1**, the inspections of marine pollution prevention systems, etc., at Intermediate Surveys, are to be carried out according to the requirements of **3.2**, **Part 2 of the Rules for Marine Pollution Prevention Systems**.

4.6 Intermediate Surveys of Ballast Water Management Installations

4.6.1 General

For a ship with the class notation "*BWMS*" in accordance with the requirement of **1.2.8 (7)**,

Part 1, it is to be confirmed that there are no defects, such as corrosion, wastage and damage, in the ballast water management system, ballast pump and ballast piping, and the ballast water management system is in good working condition, in addition to inspections specified in **3.10**.

Chapter 5 SPECIAL SURVEYS

5.1 General

5.1.1 General

At Special Surveys, the examinations and tests of hull, equipment, fire extinguishing systems, machinery, electrical installations and so on are to be carried out in accordance with the requirement of this Chapter, in addition to the Annual Surveys specified in **Chapter 3**, Intermediate Surveys specified in **Chapter 4** and Docking Survey which examinations are carried out in a dry dock or on a slip way after cleaning the outer shell, and it is to be confirmed that they are complied with the requirements of **Chapter 6**.

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 (5-years validity) of the ship.

5.1.3 Survey Results

Regardless of when Intermediate Surveys and Special Surveys are carried out, the results of surveys and thickness measurements of spaces carried out for Intermediate Surveys are not to be used as the results for Special Surveys and the results of surveys and thickness measurements of spaces carried out for Special Surveys are not to be used as the results for Intermediate Surveys.

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

5.2.1 Examinations of Plans and Documents

At Special Surveys, the management conditions of plans and documents listed in **2.1.6**, **Chapter 2** are to be examined.

5.2.2 General Examinations

1 At Special Surveys, items **(1)** to **(3)** below in addition to hull, equipment, fire extinction, and fittings required at Intermediate Surveys specified in **4.2.2** are to be examined carefully.

(1) All bilge and ballast piping systems

(2) Automatic air pipe heads which are installed on the exposed deck are to be completely examined (both externally and internally) at Special Surveys as specified below. Where the inner parts cannot be properly inspected from the outside, the head is to be removed from the air pipe and examined carefully.

  (a) At Special Survey for ships up to 5 years of age, two air pipe heads located on the exposed decks in the forward 0.25*L* and two air pipe heads located on the exposed decks, serving spaces aft of 0.25*L*, each one port and each one starboard, preferably air pipes serving ballast tanks and which are selected by the attending Surveyor. According to the results of the above inspection, other air pipe heads located on the exposed decks required by the Surveyor.

  (b) At Special Survey for ships over 5 years and up to 10 years of age, all air pipe heads located on the exposed decks in the forward 0.25*L*, and at least 20 % of air pipe heads on the exposed decks serving spaces aft of 0.25*L*, preferably air pipes serving ballast tanks which are selected from each side by the attending Surveyor. According to the results of the above inspection, other air pipe heads located on the exposed decks required by the Surveyor.

  (c) At Special Survey for ships over 10 years, all air pipe heads located on the exposed decks.

However, air pipe heads that show substantiated evidence of replacement within the previous five years may be exempted, the number is not to be less than that required in **(a)**.

(3) Ventilators and their closing appliances for machinery and cargo spaces located on the exposed deck are to be examined carefully and internal examinations specified below are to be carried out.

(a) At Special Survey for ships up to 5 years of age, one ventilator for machinery spaces and one ventilator for cargo spaces which are selected by the attending Surveyor. According to the results of the inspection, other ventilators as required by the Surveyor are to be examined.

(b) At Special Survey for ships over 5 years and up to 10 years of age, all ventilators for machinery spaces, and at least 20 % of the ventilators for cargo spaces which are selected by the attending Surveyor. According to the results of the inspection, other ventilators as required by the Surveyor are to be examined.

(c) At Special Survey for ships over 10 years, all ventilators. However, ventilators that show substantiated evidence of the replacement of closing appliances within the past five years may be exempted, the number is not to be less than that required in **(a)**.

(4) For ships provided with bow doors, inner doors, side shell doors and stern doors, the surveys specified in **(a)** and **(b)** below are to be carried out.

(a) Clearance measurements of hinges, bearings and thrust bearings are to be taken. Unless otherwise specified in operating and maintenance manuals or in manufacturer recommendation, such clearance measurements may be limited to representative bearings in cases where dismantling is necessary in order to perform such measurements. If dismantling is carried out, a visual examination of hinge pins and bearings together with non-destructive testing of the hinge pin is to be carried out.

(b) The non-return valves of the drainage system are to be dismantled and examined.

2 At Special Surveys for ships intended to carry flammable liquids or dangerous goods, 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, in addition to the examinations specified in **-1**.

5.2.3 Performance Tests

1 At Special Surveys, performance tests specified in **4.2.3** are to be carried out. In addition to such performance tests, it is to be confirmed that the loading instrument works in order. Moreover, the performance tests for mooring and anchoring arrangements specified in **4.2.1-4** may not be omitted.

2 In addition to **-1** above, the performance tests and operation tests specified in **(1)** to **(10)** below are to be carried out.

(1) Operation test for all mechanically operated hatch covers, including the testing of all hydraulic and power components, wires, chains and link drives

(2) Hose tests or equivalent, for all weathertight hatch covers

(3) Performance tests for all bilge and ballast piping system and operation tests loaded at design pressure of the piping systems

(4) Hose tests or equivalent, for all bow doors, inner doors, side shell doors and stern doors

(5) The hose tests or equivalent tests, for the doors of watertight bulkheads and the closing appliances of superstructure end bulkheads, deckhouses or companions protecting hatchways giving access to spaces below freeboard deck

(6) For ships intended to carry flammable liquids or dangerous goods, 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.

(7) Operation test for all water level detection and alarm systems.

(8) Performance test for the means of embarkation and disembarkation. The accommodation ladder, gangway and winch are to be operationally tested with the specified maximum operational load. In this case, the tests are to be carried out with the load applied as uniformly as possible along the length of the accommodation ladder or gangway, at an angle of inclination corresponding to the maximum bending moment on the accommodation ladder or gangway. Following satisfactory completion of the applicable test without permanent deformation or damage to the tested item, the load used for that test is to be marked as the maximum operational load on the plate as follows.
  (a) Design loads
  (b) Maximum operational loads, if this is less than the design load

3 After the completion of the examination of the ship in the dry dock or on the slip way, the draft of the ship is to be measured. Where the difference of the draft between the draft at the measurement and draft calculated considering the alteration of equipment and so on are found, stability experiments may be required and correction of stability booklets 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 **(7)** below.

(1) Areas sensitive to corrosion (on parts such as structural members, piping, and hatch covers) 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 coating and corrosion prevention system if applied

(5) Condition of striking plates under sounding pipes

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

(7) 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 specified in the following **(1)** to **(4)** are to be carried out paying attention to the items in **-1** above.

(1) At Special Survey for ships up to 5 years of age
  (a) All tanks and spaces. For *GNS-C* ships and *GNS-D* ships, internal examinations of fuel oil tanks, lubricating oil tanks and fresh water tanks which are not peak tanks may be dispensed with, where deemed appropriately by the Surveyor based on the results of external examination of them.
  (b) General examination of the means of access provided for the examinations specified in **(a)**.
  (c) Coating condition of ballast tanks is to be evaluated.

(2) At Special Survey for ships over 5 years and up to 10 years of age
  (a) All tanks and spaces. For *GNS-C* ships and *GNS-D* ships, internal examinations of fuel oil tanks, lubricating oil tanks and fresh water tanks which are not peak tanks may be dispensed with, where deemed appropriately by the Surveyor based on the results of external examination of them. However, internal examinations of the following tanks for at least the designated numbers of tanks are to be carried out.
    i) Fuel oil tanks fitted within cargo length areas (within cargo areas for tankers): 1 tank
    ii) If no fuel oil tanks are fitted within cargo length areas (within cargo areas for

tankers), fuel oil tanks fitted at locations other than engine rooms (if fitted): 1 tank
iii) Fresh water tanks: 1 tank
(b) General examination of the means of access provided for the examinations specified in **(a)**.
(c) Coating condition of ballast tanks is to be evaluated.

(3) At Special Survey for ships over 10 years and up to 15 years of age
(a) All tanks and spaces. For *GNS-C* ships and *GNS-D* ships, internal examinations of fuel oil tanks, lubricating oil tanks and fresh water tanks which are not peak tanks may be dispensed with, where deemed appropriately by the Surveyor based on the results of external examination of them. However, internal examinations of the following tanks for at least the designated numbers of tanks are to be carried out.
i) Fuel oil tanks fitted within engine rooms: 1 tank
ii) Fuel oil tanks fitted within cargo length areas (within cargo areas for tankers): 2 tanks (In cases where deep fuel oil tanks are provided, one or more deep fuel oil tanks are to be included.)
iii) If no fuel oil tanks are fitted within cargo length areas (within cargo areas for tankers), fuel oil tanks fitted at locations other than engine rooms (if fitted): 1 tank
(b) General examination of the means of access provided for the examinations specified in **(a)**.
(c) Coating condition of ballast tanks is to be evaluated.

(4) At Special Survey for ships over 15 years of age, all tanks and spaces, and items specified in **(3)(b)** and **(c)**.

3 At Special Surveys for ships intended to carry flammable liquids, internal examinations of all cargo tanks and cargo pump room are to be carried out at each Special Survey, in addition to the examinations specified in **-1** and **-2**. Tanks and spaces identified as suspect areas at previous surveys are to be examined. The examination of the coating condition in ballast tanks for the ships is to be based on the coating criteria defined by the Society.

4 At Special Surveys of ships over 10 years of age and subsequent Special Surveys, in addition to **-1** to **-3**, structural downflooding ducts and structural ventilation ducts are to be internally examined.

5 For ships whose structural members made of stainless steels, or aluminium alloys or *FRP* and for ships affixed with the class notation "*CoC*", the application of this requirement may be considered.

5.2.5 Close-up Surveys

1 At Special Surveys, Close-up Surveys are to be carried out for portions **(1)** to **(4)** below.
(1) Lower parts of shell frames, tank side brackets and transverse bulkheads
(2) Lower parts of air pipes and sounding pipes located on top of inner bottom plating
(3) All hatch cover plating, hatch coaming plating, and stiffeners
(4) Securing, supporting and locking devices together with the welded parts of bow doors, inner doors, side shell doors and stern doors

2 At Special Surveys for ships intended to carry flammable liquids or dangerous goods, notwithstanding the provision of **-1** above, Close-up Surveys are to be carried out for structural members specified in the following **(1)** to **(3)**.
(1) Special Survey for ships up to 5 years of age
(a) One web frame in a ballast wing tank, if any, or a cargo wing tank used primarily for water ballast
(b) One deck transverse in a cargo tank or on deck
(c) The lower part of one transverse bulkhead in a ballast tank
(d) The lower part of one transverse bulkhead in two cargo tanks

(2) Special Survey for ships over 5 years and up to 10 years of age
   (a) One web frame in a ballast wing tank, if any, or a cargo wing tank used primarily for water ballast
   (b) One deck transverse in or on each of the remaining ballast tanks, if any
   (c) One deck transverse in or on three cargo tanks
   (d) Both transverse bulkheads in a ballast wing tank, if any, or a cargo wing tank used primarily for water ballast
   (e) The lower part of one transverse bulkhead in each remaining ballast tank
   (f) The lower part of one transverse bulkhead in three cargo tanks
(3) Special Survey for ships over 10 years and up to 15 years of age
   (a) All web frames in all ballast tanks
   (b) All web frames in a cargo wing tank
   (c) A minimum of 30 % of all web frames in each remaining cargo wing tank
   (d) One web frame in each remaining cargo tank
   (e) All transverse bulkheads in all cargo and ballast tanks
   (f) A minimum of 30 % (to be rounded up to the next whole integer) of all deck and bottom transverses in each cargo centre tank

3 Close-up surveys using remote inspection techniques (*RIT*) may be accepted subject to prior special consideration by the Surveyor. In this case, close–up surveys using *RIT* are to be carried out in accordance with the instruction given by the Surveyor or under the attendance of the Surveyor.

4 When thickness measurements of structures subject to close-up surveys using *RIT* are required, temporary means of access for the corresponding thickness measurements is to be provided unless such *RIT* are also able to carry out the required thickness measurements.

5.2.6 Thickness Measurements

1 At Special Surveys, thickness measurements are to be carried out in accordance with **(1)** to **(5)** 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 under the attendance of the Surveyor, as a rule, by the firm approved by the Society under the **Rules for Approval of Manufactures and Service Suppliers** regulated separately. 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.
(5) Thickness measurements of structures in areas where close-up surveys are required are to be carried out simultaneously with close-up surveys.

2 At Special Surveys, thickness measurements are to be carried out according to **-1** above for structural members specified in the following **(1)** to **(4)**.
(1) Special Survey for ships up to 5 years of age
   (a) Structural members subject to close-up surveys specified in **5.2.5** and suspect areas
   (b) All bow doors, inner doors, side shell doors and stern doors when deemed necessary by the Surveyor (plating and stiffeners)
(2) Special Survey for ships over 5 years and up to 10 years of age
   (a) Structural members subject to close-up surveys specified in **5.2.5** and suspect areas
   (b) Each plate in one section of the strength deck plating for the full beam of the midship part of ship
   (c) All bow doors, inner doors, side shell doors and stern doors when deemed necessary by the Surveyor (plating and stiffeners)

(3) Special Survey for ships over 10 years and up to 15 years of age
  (a) Structural members subject to close-up surveys specified in **5.2.5** and suspect areas
  (b) For ships of longitudinal frame system, each plate and member in two transverse sections of midship part of ship, in way of two different cargo spaces. For ships of transverse frame system, each plate and member in three transverse sections of midship part of ship, in way of two different cargo spaces, including adjacent frames and their end connections in way of the transverse section.
  (c) Internals in fore and aft. peak tank
  (d) Both ends and middle part of each hatch side and end coaming (plating and stiffeners)
  (e) All cargo hold hatch covers (plating and stiffeners)
  (f) All bow doors, inner doors, side shell doors and stern doors when deemed necessary by the Surveyor (plating and stiffeners)

(4) Special Survey for ships over 15 years of age
  (a) Structural members subject to close-up surveys specified in **5.2.5** and suspect areas
  (b) Following portions of structural members:
    i) All exposed main deck plates, full length
    ii) Each plate and member in three transverse sections of cargo areas of midship part of ship. 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.
    iii) All wind and water strakes, port and starboard, full length
  (c) Representative exposed superstructure deck plating (poop, bridge and forecastle deck)
  (d) All keel plates, full length, and an appropriate number of bottom plates in way of cofferdams, machinery spaces and aft end of tanks
  (e) Plating of sea chests, and shell plating in way of overboard discharges (as deemed necessary by the Surveyor)
  (f) 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
  (g) Structural members specified in **(3)(c)** to **(f)**

3 Where substantial corrosion is found as a result of such thickness measurements specified in **-2**, additional thickness measurements are to be taken in accordance with the following.

(1) Plating: Suspect areas and adjacent plates; 5 point pattern over 1 square metre
(2) Girders: Suspect area; 5 point pattern over 1 square metre
(3) Stiffeners: Suspect area; each 3 points on web and flange

4 Where local corrosion (pitting corrosion, edge corrosion and grooving corrosion) are found in structural members, additional thickness measurements are to be carried out in order to grasp the corroded conditions.

5 Where the thickness of deck plating of freeboard deck or deck extending on length of ship at midship part of ship is 95 % of average of the original one according to the results of the thickness measurements specified in **-2** and **-3**, additional thickness measurements are to be carried out in order to evaluate the hull girder longitudinal strength (section modulus of cross section of hull) of the ship and the hull girder longitudinal strength of the ship are to be evaluated.

6 For ships under 15 years of age and constructed by stainless steels, aluminium alloys and *FRP* and for ships affixed with the class notation "*CoC*", thickness measurements of structural members may be limited to the parts instructed by the attending Surveyor, based on the results of general and internal examinations. For ships over 15 years of age, thickness measurements of structural members instructed by the attending Surveyor are to be carried out in order to grasp the structural condition and hull girder longitudinal strength of the ship.

5.2.7 Pressure Tests

1 At Special Surveys, pressure tests of tanks are to be carried out according to **(1)** through **(4)** below.

(1) Pressure tests are 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) Where pressure tests of tanks specified in **(a)** are difficult to carry out when the ship in a dry dock or on a slipway, pressure tests of tanks may be carried out when the ship is afloat. Pressure tests 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 pressure tests where deemed appropriate by the Surveyor taking into account the current condition, age and interval from the previous test.

(4) For pressure tests of fresh water tanks, fuel oil tanks and lubricating oil tanks, considering the satisfactory external examinations of tank boundaries and confirmations from Masters stating that all pressure testing has been carried out according to the requirements with satisfactory results, and where deemed appropriately by the Society, pressure tests of these tanks may be specially considered.

2 At Special Surveys, pressure tests of the following tanks are to be carried out in accordance with the requirements specified in **-1**.

(1) Water tanks
(2) Tanks intended to carry liquids
(3) Fuel oil tanks
(4) Lubricating oil tanks
(5) Cargo tank boundaries facing on ballast tanks, void spaces, pipe ducts, fuel oil tanks, pump rooms and cofferdams

3 For watertight compartments not intended to carry liquids, a pressure test may be dispensed with in satisfactory internal and external examinations.

5.2.8 Draught Measurement

1 Measuring the draught of the ship in the test, lightweight of the ship is to be calculated.

2 Regarding the displacement corresponding to the calculated lightweight and longitudinal centre of gravity of the ship, where the deviations of lightweight and longitudinal centre of gravity from those measured at the previous Surveys are not complied with the requirements specified in **2.3.2-4 (1)** to **(3)**, stability experiments specified in **2.3.2** are to be carried out.

5.3 Special Surveys for Machinery

5.3.1 General Examinations

At Special Surveys for Machinery, in addition to the general examination and inspections specified in **3.3.1**, the verification runs specified in **1.1.10-1** and **-3**, the surveys specified in the following **(1)** to **(7)** are to be carried out.

(1) For diesel engines (main propulsion machinery and auxiliary machinery for propulsion, maneuvering and personnel safety), examinations specified in the following **(a)** to **(d)** are to be carried out.
  (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) For boilers and thermal oil heaters, the examination specified in **4.3.1(2)** is to be carried out.

(3) For electrical installations, examinations specified in **(a)** and **(b)** are to be carried out.

(a) The switchboards (including those for emergency), distribution boards, cables, etc. are, as far as practicable, to be generally examined.

(b) Insulation resistance of the generators and switchboards (the both including those for emergency use), the motors and the cables are to be tested to ensure that they are placed in good order, and to be adjusted if it is found not to comply with the requirements of **2.18.1, 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.

(4) For refrigerating machinery, the examinations specified in the following **(a)** and **(b)** are to be carried out.

(a) Safety devices are to be generally examined to ascertain that they are placed in good order. Where controlled atmosphere systems are installed onboard, the general examination of the gas freeing equipment, and control, alarm and monitoring equipment of the controlled atmosphere systems are to be carried out.

(b) The machinery is to be examined while in operation to ascertain that there is no leakage of refrigerant.

(5) For electrical installations in hazardous areas, the examinations specified in the following **(a)** and **(b)** are to be carried out.

(a) Electrical installations in hazardous areas are to be examined in detail and confirmation that they conform to the requirements in **4.2.7, Part 8**, is to be carried out. In addition, confirmation that the installations are in good order is to be made by measuring the insulation resistance. However, this measurement may be omitted at the discretion of the Surveyor, if accurate measurement records of the insulation resistance can be verified.

(b) Performance tests of interlock devices associated with pressurized protected type electrical equipment and electrical equipment installed in pressurized or ventilated areas are to be carried out.

(6) At Special Surveys for water jet propulsion systems, the examinations specified in the following **(a)** to **(f)** are to be carried out.

(a) The examinations specified in **3.3.1-1(7)** are to be carried out.

(b) Waterjet pump units are to be opened up and it is to be confirmed that the principal components are in good working order.

(c) Shafting bearings are to be opened up and the following tests are to be carried out:

i) The principal components of shafting are to be confirmed to be in good order.

ii) Non-destructive tests of contact faces of impeller bosses and main shafts (keyways and flanges), and coupling bolts are to be carried out.

(d) Holding parts and pins of deflectors or reversers are to be opened up and it is to be confirmed that they are in good working order.

(e) Oil piping for lubrication is to be examined.

(f) Sea water piping for lubrication is to be examined.

(7) For azimuth thruster systems, general examinations and performance tests specified in **3.3.1-1(8)** are to be carried out as well as inspections for supporting parts of azimuth steering gears are to be carried out.

5.3.2 Performance Test and Pressure Test

At Special Surveys for machinery, in addition to the performance tests specified in **3.3.2**, the performance tests and pressure tests specified in the following **(1)** to **(7)** are to be carried out.

(1) For 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) For condensers, evaporators, and receivers, for those that use *NH*3 (*R*717) as the refrigerant, the parts exposed to the primary refrigerant are to be tested at a pressure of 90 % of the design pressure (the pressure may be reduced down to 90 % of the setting pressure of the relief valves). However, where the systems satisfy the criteria specified in **(a)** and **(b)** and non-destructive inspections such as ultrasonic tests which can detect cracks of at least 5 *mm* in length on the inside of vessels are carried out, the pressure test may be dispensed with.

(a) Straight flange parts (skirt parts) of receivers are to have been hot formed.

(b) As installed, straight flange parts are to have adequate surface area for an ultrasonic angle beam test.

(3) For all other piped machinery and parts not specified in **(2)** above, pressure tests are to be handled in accordance with the requirements of **2.2.2(2)** where deemed necessary by the Surveyor.

(4) For lighting systems, communication and signaling 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 the general examinations of the following **(a)** or **(b)** are carried out satisfactorily and where deemed necessary by the Surveyor.

(a) For parts exposed to pressure, where wastage such as corrosion or abrasion that affect the strength of those parts is found.

(b) For boilers, pressure vessels or main steam piping, where the condition of internal wastage is impossible to be checked.

(5) For electric generator sets, etc., performance tests of electric generator sets for propulsion and steer of the ship and important auxiliaries are to be carried out.

(a) Where only one electric generating set is normally used, the standby generator, air circuit breakers, and important auxiliary machinery start up automatically when the main source of electrical power is stopped by tripping a circuit breaker.

(b) Where two electric generating sets are normally used, preference tripping of unnecessary loads is performed when the circuit breaker of one of the sets is tripped.

(6) Performance tests of waterjet propulsion systems are to be carried out in accordance with **3.3.2-1(9)**.

(7) Performance tests of azimuth thrusters are to be carried out in accordance with **3.3.2-1(10)**.

5.4 Surveys of Propeller Shafts and Stern Tube Shafts

5.4.1 General Examination

1 Drawing out of the propeller shafts and the stern tube shafts, the applicable examinations such as overhaul inspection specified in **(1)** or **(2)** are to be carried out.

(1) For oil or freshwater lubricated bearings or water lubricated bearings, drawing the propeller shafts and the stern tube shafts and the entire shafts, seals systems and bearings are to be examined.

(2) For oil or freshwater lubricated bearings or water lubricated bearings, drawing the propeller shafts and the stern tube shafts and the entire shafts (including liners, corrosion protection systems and stress reducing features, where provided), inboard seal systems and bearings are

to be examined.

2 For propeller connections, the applicable examinations specified in **(1)** to **(3)** are to be carried out.

(1) For shafts having keyed propeller connections, removing the propeller to expose the forward end of the taper; and performing a non-destructive examination (*NDE*) by an approved surface crack-detection method all around the shaft in way of the forward portion of the taper section, including the keyway. For shaft provided with liners, the *NDE* is to be extended to the after edge of the liner.

(2) For shafts having keyless propeller connections, removing the propeller to expose the forward end of the taper; and performing an *NDE* by an approved surface crack-detection method all around the shaft in way of the forward portion of the taper section. For shafts provided with liners the *NDE* is to be extended to the after edge of the liner. 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 **6.3.1-1, Part 7**.

(3) For shafts having flange connections, whenever the coupling bolts of any type of flange-connected shaft are removed or the flange radius is made accessible in connection with overhaul, repairs or when deemed necessary by the surveyor, the coupling bolts and flange radius are to be examined by means of an approved surface crack detection method.

3 For propeller shaft, stern tube shaft, and coupling bolts, examination of the sleeves, the fillet of the coupling flange to the intermediate shaft or to the stern tube shaft and the coupling bolts with the shaft drawn from the stern tube bearings are to be carried out. 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.

4 For stern tube bearing including shaft bracket bearing, examination of the stern tube bearings is to be carried out.

5 Clearances between the propeller shaft or the stern tube shaft and the after bearing of the stern tube are to be measured and recorded. When the clearance and/or weardown 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) Weardown 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.

(3) Weardown for freshwater lubricated bearings:

Weardown values used as reference for repairs are specified by the manufacturer.

6 For propellers, verification that the propeller is free of damages which may cause the propeller to be out of balance is to be carried out.

7 For stern tube sealing systems including shaft bracket bearing sealing systems, verification of the satisfactory conditions of inboard and outboard seals during the re-installation of the shaft and propeller is to be carried out.

8 For oil lubricated or freshwater lubricated bearings, weardown of the propeller shaft or the stern tube shaft at the after bearing of the stern tube, recording the bearing weardown measurements (after re-installation) is to be carried out.

9 For propeller boss surfaces in contact with the propeller shaft taper, examination of the propeller boss surfaces is to be carried out.

10 For controllable pitch propeller connections, examination of the pitch control gear and working parts as well as, by an efficient crack detection method (*NDE*), the propeller blade fixing bolts are to be carried out.
11 For water lubrication lines, where water lubricated stern tube bearings are adopted, the water piping for lubrication is to be examined.
12 For low oil level alarms of the lubricating oil or lubricating freshwater tanks, lubricating oil or lubricating freshwater temperature measuring devices, oil or freshwater lubrication lines as well as lubricating oil or lubricating freshwater circulation pumps, etc., examination of the systems for verifying whether of stern tube bearings are being maintained in good working condition.
13 Where oil or freshwater lubricated stern tube bearings are adopted, management condition is to be examined the lubricating oil or lubricating freshwater record books.

5.4.2 Partial Surveys

1 At Partial Surveys for propeller shafts of oil or fresh water lubricated stern tube bearings, the examinations specified in the following **(1)** and **(2)** are to be carried out.

(1) Upon the confirmation of the satisfactory surveys specified in the following **(2)**, the surveys are carried out in accordance with the following **(a)** to **(i)**. When the results of verification, recording and examinations specified in the following **(2)** or the following **(a)** to **(i)** are not satisfactory, overhaul inspection specified in **5.4.1** is to be carried out.
- (a) For shafts having keyed propeller connections, examinations specified in **5.4.1-2**
- (b) Measurement and record of weardown
- (c) Visual inspections of all accessible parts of shafting system
- (d) Examinations specified in **5.4.1-6**
- (e) Seal liner found to be or placed in a satisfactory condition
- (f) Verification of the satisfactory conditions of inboard and outboard seals and propeller fitting
- (g) For shafts having keyed propeller connections, examinations specified in **5.4.1-9**
- (h) Examinations specified in **5.4.1-12** and **-13**
- (i) Confirmation of the avoidance of the bared speed range of torsional vibration of shafting

(2) The surveys required in **(1)** are to be carried out in accordance with the following **(a)** to **(e)**.
- (a) Confirmation of service records. However, regarding the temperature of shaft bearings, where the measurement device of temperature of shaft bearings is not required, the confirmation of it may be dispensed with.
- (b) Confirmation specified in the following **i)** and **ii)** is to be carried out.
  - i) For oil lubricated bearings, confirmation that the management criteria for each parameter (upper limit) on the following metallic content, *IR* oxidation and separated water are satisfactory based on the test report of lubricating oil analysis.
    - 1) Metallic content
      Iron (*Fe*): 50 *ppm*
      Tin (*Sn*): 20 *ppm*
      Lead (*Pb*): 20 *ppm*
      Sodium (*Na*): 80 *ppm*
    - 2) *IR* Oxidation and separated water
      IR oxidation @ 5.85 μm: 10 (*Abs.unit/cm*)
      Separated water: 1.0 %
  - ii) For fresh water lubricated bearings, confirmation that the management criteria for each parameter (upper limit) on the following metallic content, *IR* oxidation and separated water are satisfactory, based on the test report of fresh water sample tests.
    - 1) Chloride and sodium content (upper limits) :
      Chloride content: 60 *ppm*

Sodium content (*Na*): 70 *ppm*

pH Value : Lower limit values determined based on the characteristics of the corrosion inhibitors used, but not to be less than 11

2) Bearing particles and other particles :

Metallic contents (upper limits) :

Iron (*Fe*): 25 *ppm*

Chromium (*Cr*): 5 *ppm*

Nickel (*Ni*): 5 *ppm*

Copper (*Cu*): 40 *ppm*

Silicon (*Si*): 30 *ppm*

3) Bearing particles (non-metal content):

No polymer resins are to be found by micro-filter and/or microscopic testing

(c) Lubricating oil analysis for oil lubricated bearings or fresh water sample tests for fresh water lubricated bearings are to be carried out.

(d) Verification of no reported repairs by grinding or welding of shaft and propeller is to be carried out.

(e) Examinations of the contents of "Records for Monitoring System of Stern Tube Bearings and Oil Sealing Devices" prescribed by the Society are to be carried out

(3) Partial surveys for propeller shafts and stern tube shafts made of materials protected effectively against corrosion specified in **5.2.7-1(3), Part 7**, the examinations specified in the following **(a)** to **(d)** are to be carried out. Where abnormality on propeller shafts and stern tube shafts are found at the examinations, overhaul inspection specified in **5.4.1-1** is to be carried out.

(a) At the condition fitted propeller, drawing the propeller shaft so that the essential parts of them such as contact part with stern tube shaft bearings are to be able to examined, the essential parts are to be examined.

(b) Examinations specified in **5.4.1-5** and **-11**

(c) Seal liner found to be or placed in a satisfactory condition

(d) Verification of the satisfactory conditions of inboard and outboard seals

5.4.3 Preventive Maintenance System

Notwithstanding the requirements in **5.4.1** above, where the ship is equipped with oil lubricated stern tube bearings and appropriate stern tube oil sealing devices as approved by the Society, the survey items of **5.4.1-1**, **-3**, **-4**, **-5** and **-7** may be replaced with a general examination of the shafting system and the measurement and record of bearing weardown specified in **5.4.1-8** may be replaced with the measurement at the condition after propeller fitting, provided that all condition monitoring data taken according to the approved preventive maintenance system is found to be within permissible limits. Except for shafts having keyed propeller connections, the examination specified in **5.4.1-2**, **-9** and **-10** may be dispensed with.

(1) Based upon Society approved preventive maintenance systems, at least the following **(a)** to **(d)** are to be properly monitored and recorded for diagnosing lubricating conditions of shafting systems and performing preventive system maintenance. Moreover, the notation *Propeller Shaft Condition Monitoring System* (abbreviated as *PSCM*) is to be affixed to the Classification Characters of ships whose preventive maintenance systems are approved by the Society.

(a) Lubricating oil sampling and analysis is to be carried out regularly at intervals not exceeding 6 months, with at least the following **i)** to **iv)** being analyzed each time:

i) Water content

ii) Salinity (Sodium)

iii) Content of shaft metal and bearing metal particles
iv) Oxidation of oil

(b) Lubricating oil consumption rate

(c) Bearing temperature: to be monitored by either of the following monitoring and recording devices provided for measuring the temperature of the metal at the aft end bottoms of stern tubes

i) Two or more temperature sensors embedded into the metal

ii) An embedded temperature sensor which can be replaced from inside the ship and a spare temperature sensor. In such cases, replacement by the spare sensor is to be demonstrated according to the procedures submitted beforehand.

(d) Weardown of the propeller shaft or the stern tube shaft at the after bearing of the stern tube

(2) Based upon Society approved preventive maintenance systems, at least the following **(a)** to **(e)** are to be properly monitored and recorded for diagnosing lubricating conditions of shafting systems and performing preventive system maintenance. Moreover, the notation *Propeller Shaft Condition Monitoring System・A* (abbreviated as *PSCM・A*) is to be affixed to the Classification Characters of ships whose preventive maintenance systems are approved by the Society.

(a) Lubricating oil sampling and analysis is to be carried out regularly at intervals not exceeding 6 months, with at least the following **i)** to **iv)** being analyzed each time:

i) Water content
ii) Salinity (Sodium)
iii) Content of shaft metal and bearing metal particles
iv) Oxidation of oil

(b) The monthly onboard checking of lubricating oil water content. Such checking, however, may be omitted when the oil sampling and analysis specified in **(a)** above is carried out regularly at intervals not exceeding 3 months.

(c) Lubricating oil consumption rate

(d) Bearing temperature

(e) Weardown of the propeller shaft or the stern tube shaft at the after bearing of the stern tube

5.5 Special Surveys for *LFF* Ships

5.5.1 General

In addition to the applicable requirements of previous sections, the requirements of **5.5** are to be applied at Special Surveys of the *LFF* ships.

5.5.2 Examinations

At Special Surveys for *LFF* ships, the examinations specified in the following **(1)** to **(7)** are to be carried out thoroughly in order to ascertain them being in good order, in addition to the examinations specified in **4.4.1**.

(1) For fuel storage tanks, the following examinations and testing are to be carried out.

(a) Internal examinations of all fuel storage tanks. Vacuum insulated independent fuel storage tanks of type *C* defined by **Part GF, Rules for the Survey and Construction of the Steel Ships**, however, need not be examined internally. Where fitted, the vacuum monitoring system is to be examined, and records are to be reviewed.

(b) Visual examinations of thermal insulation or surfaces of fuel storage tanks without thermal insulation

i) Special attention is to be paid in way of chocks of tank foundations, tank supports, keys, etc. Removal of thermal insulation may be required where deemed necessary by the Surveyor.

ii) Non-destructive testing may be required if conditions raise doubt to the structural integrity.

(c) Thickness measurements for tank plates may be required where deemed necessary by the Surveyor.

(d) Non-destructive testing for independent fuel storage tanks of Type *B* defined by **Part GF, Rules for the Survey and Construction of the Steel Ships**, in accordance with the approved programme is to be carried out. The programme is to be that prepared according to fuel storage tank design. Fuel storage tanks other than independent fuel storage tanks of Type *B* are to be examined by non-destructive testing on welded connections of the tank plates, main structural members and parts where high stress is deemed likely to occur where deemed necessary by the Surveyor

(e) Leakage testing of all fuel storage tanks

(f) Where there is any doubt regarding the integrity of a fuel storage tank as a result of examinations specified in **(a)** to **(e)** above, such a fuel storage tank is to be tested by hydraulic or hydro-pneumatic testing under the pressures specified below

i) Independent fuel storage tanks of Type *C* defined by **Part GF, Rules for the Survey and Construction of the Steel Ships**: a pressure not less than 1.25 times the maximum allowable relief valve setting (hereinafter referred to as *MARVS*); or

ii) For integral tanks and for independent tanks of Type *A* and *B* defined by **Part GF, Rules for the Survey and Construction of the Steel Ships**: an appropriate pressure according to fuel storage tank design, as far as practicable, with the pressure at the top of the tank corresponding at least to the *MARVS*.

(g) For all independent fuel storage tanks of Type *C* defined by **Part GF, Rules for the Survey and Construction of the Steel Ships**, either the following **i)** or **ii)** examination is to be carried out at every second Special Survey in addition to examinations **(a)** to **(e)**.

i) Hydraulic or hydro-pneumatic testing at a pressure not less than 1.25 times *MARVS*, and the non-destructive testing specified in **(d)**

ii) Non-destructive testing according to a programme prepared based upon fuel storage tank design. If an approved non-destructive testing programme does not exist, non-destructive testing of at least 10 % of the length of the welded connections in each highly stressed area given below is to be conducted. This testing is to be carried out from both inside and outside of the tank, as appropriate, with thermal insulation removed, as necessary.

- fuel storage tank supports and anti-rolling/anti-pitching devices
- stiffening rings
- Y-connections between tank plates and longitudinal bulkheads of bilobe tanks
- swash bulkhead boundaries
- dome and sump connections to the tank shell
- foundations for fuel pumps, towers or ladders, etc.
- pipe connections

(h) Where water cannot be tolerated and the fuel storage tank cannot be dried prior to putting the tank into service, the Surveyor may accept alternative testing fluids or alternative means of testing instead of the hydraulic or hydro-pneumatic testing specified in **(g)i)**.

(2) For tank support arrangements, tank fixing arrangements, etc., the following examinations and tests are to be carried out.

(a) Tank support arrangements, anti-rolling or anti-pitching devices, and surrounding hull structures and their thermal insulation are to be visually examined. Non-destructive testing may be required if conditions raise doubt to the structural integrity.

(b) For membrane tanks, it is to be verified that the gas-tightness of secondary barriers is kept on the level of tightness required for system design in accordance with the programme and acceptance criteria approved in advance. Low differential pressure testing, however, is not to be adopted for testing the tightness of secondary barriers. For glued secondary barriers, if the verification results do not satisfy the required level of gas-tightness, an investigation is to be carried out to analyze the causes of failure, and additional testing such as thermographic or acoustic emission testing is to be carried out taking into account the analysis.

(c) For other secondary barriers, gas-tightness is to be verified by pressure or vacuum testing or other proper means in cases where there is any doubt. Appropriate pressure or vacuum testing and examinations for cold spots are to be carried out, where the integrity of thermal insulation is verified by checking the bunker delivery note for the low-flashpoint fuel delivered, however, the examinations for cold spots may be omitted.

(3) For venting systems for fuel containment systems, the following examinations and tests are to be carried out.

(a) The pressure relief valves for the fuel storage tanks are to be opened for examination, adjusted, function tested and sealed. In cases where it is confirmed through the examination of records that the pressure relief valves have been opened for examination, adjusted, function tested and sealed at an interval not exceeding five years, general examinations of the pressure relief valves need only be carried out at Special Surveys. If the tanks are equipped with relief valves with non-metallic membranes in the main or pilot valves, such non-metallic membranes are to be replaced.

(b) The pressure/vacuum relief valves, rupture disc, and other pressure relief devices for interbarrier spaces and fuel storage hold spaces are to be opened, examined, tested and readjusted as necessary, depending on their design. In cases where it is confirmed through the examination of records that the pressure/vacuum relief valves, rupture disc or other pressure relief devices have been opened, examined, tested and readjusted at an interval not exceeding five years, respective general examinations of the pressure/vacuum relief valves, rupture disc or other pressure relief devices need only be carried out.

(c) The vacuum protection systems for fuel storage tanks are to be overhauled and tested appropriately for the design. For systems whose continuous open-up examinations and performance testing since the previous Special Survey have been carried out in the presence of a Surveyor and whose test records are confirmed, visual examinations to the extent as far as practical may be carried out in lieu of the required testing.

(4) For fuel piping and process piping systems, etc., the following examinations and tests are to be carried out.

(a) All piping for fuel storage, fuel bunkering, and fuel supply such as venting, compressing, refrigerating, liquefying, heating, storing, burning or otherwise handling the fuel and liquid nitrogen installations are to be examined. Removal of thermal insulation from the piping and opening for examination may be required where deemed necessary by the Surveyor.

(b) Where deemed suspect by the Surveyor during **(a)** above, a hydrostatic test to 1.25 times the *MARVS* for the pipeline is to be carried out. After reassembly, the complete piping is to be tested for leaks. Where water cannot be tolerated and the piping cannot be dried prior to putting the system into service, the Surveyor may accept alternative testing fluids or alternative means of testing.

(c) A random selection of pressure relief valves for the fuel supply and bunkering piping is to be opened for examination, adjusted, and function tested and sealed. Where a proper record of continuous overhaul and retesting of individually identifiable relief valves is maintained, consideration will be given to acceptance on the basis of opening, internal examination, and testing of a representative sampling of valves, including each size and type of liquefied gas or vapor relief valve in use, provided there is logbook evidence that the remaining valves have been overhauled and tested since crediting of the previous Special Survey.

(d) All emergency shut-down valves, check valves, block and bleed valves, master gas valves, remote operating valves, isolating valves for pressure relief valves in the fuel storage, fuel bunkering, and fuel supply piping systems are to be examined and proven operable. A random selection of valves is to be opened for examination.

(e) Leakage testing of the emergency shut-down valves opened in accordance with **(d)** above is to be carried out.

(5) For components of bunkering systems, fuel containment systems and fuel supply systems for *LFF*, the following examinations and tests are to be carried out.

(a) Fuel pumps and fuel compressors as well as their prime movers are to be overhauled, and performance testing of safety devices is to be carried out. Overhauling of electric motors for prime movers, however, may be omitted. For equipment that is overhauled at Planned Machinery Surveys, overhauling at Special Surveys may be replaced by visual examinations to the extent as far as practical.

(b) Heat exchangers, pressure vessels, including process pressure vessels, evaporators and other components used in connection with fuel handling are to be overhauled. Pressure relief systems are to be performance tested. If an internal examination of the pressure vessels, including process pressure vessels, is impracticable, pressure testing of the vessels and performance testing of pressure relief systems are to be carried out

(c) For equipment specified in **(a)** and **(b)** and that is overhauled at Planned Machinery Surveys, overhauling at Special Surveys may be replaced by visual examinations to the extent as far as practical.

(d) Examinations specified in the following **i)** to **iii)** are to be carried out for refrigerating equipment.

i) Overhauling of pumps and compressors and performance testing of pressure vessels such as condensers, evaporators, inter-coolers and oil separators and the relief systems. For equipment that is overhauled at Planned Machinery Surveys, overhauling at Special Surveys may be replaced by visual examinations to the extent as far as practical.

ii) Leakage testing of pressure vessels and heat exchangers at a pressure not less than 90 % of the setting pressure of their relief systems

iii) Leakage testing of refrigerant piping systems at a pressure of not less than 90 % of the setting pressure of their relief systems

(e) General examinations of inert gas generators are to be carried out.

(f) Overhaul examination of the gas combustion units (*GCU*)

(6) For electrical installations, the following examinations and tests are to be carried out.

(a) Examination of electrical equipment to include the physical condition of electrical cables and supports, intrinsically safe, explosion proof, or increased safety features of electrical equipment.

(b) Testing of systems for de-energizing electrical equipment which is not certified for use in hazardous areas.

(c) An electrical insulation resistance test of the circuits terminating in, or passing through, the hazardous zones and spaces is to be carried out. However, this test may be omitted at the discretion of the Surveyor, if accurate test records of the insulation resistance can be verified.

(d) The earthing between fuel storage tanks or fuel piping systems (fuel pipes, vent pipes, etc.) and hull structures is to be examined.

(e) Electrical installations in hazardous areas are to be examined in detail and confirmation that they conform to the requirements in **4.2.7, Part 8** is to be carried out.

(f) Performance tests of interlock devices associated with pressurized protected type electrical equipment and electrical equipment installed in pressurized or ventilated areas are to be carried out. In addition, functional testing of pressurized equipment and associated alarms is to be carried out.

(7) For safety systems such as gas detectors, temperature sensors, pressure sensors, level indicators, and other equipment providing input to the fuel safety system are to be tested to confirm satisfactory operating condition.

(a) Proper response of the fuel safety system upon fault conditions is to be verified.

(b) Pressure, temperature and level indicating equipment are to be calibrated in accordance with the manufacturer s requirements.

5.6 Special Surveys for Cargo Handling Appliances

5.6.1 General

At Special Surveys for cargo handling appliances of ships affixed with the class notation "*CHG*", the examinations specified in **3.5** are to be carried out.

5.6.2 Load Tests

1 At load tests for cargo handling appliances of ships affixed with the class notation "*CHG*", cargo handling appliances are to be examined by applying movable weights or loads at least equal to the test loads as specified in **-2** and in the manners specified in **-3** or **-4** depending on the types of cargo handling appliances and ascertained that they are in good order. However, Load Tests of loose gears may be omitted provided that the certificates with testing records of them are examined.

2 The test loads used for Load Tests are to comply with the requirements of the following **(1)** through **(3)** depending on the types of cargo handling appliances

(1) The test loads for cargo gears and cargo ramps are to be as given in **Table 2.5.1** according to the safe working loads.

Table 2.5.1 Test Load for Cargo Gear and Cargo Ramps

Safe working load SWL (*t*)	Test load (*t*)
SWL < 20	$1.25 \times W$
20≤SWL < 50	$W+5$
50≤SWL < 100	$1.1 \times W$
100≤SWL	Load as considered appropriate by the Society

(2) The test loads for loose gears except for ropes are to be as given in **Table 2.5.2** according to the safe working loads;

Table 2.5.2 Test Loads for Loose Gears

Article of Gear			Safe Working Load (SWL) (t)	Test Load (t)
Pulley blocks	Single-sheave block	without becket	—	$4W$
		with becket	—	$6W$
	Multi-sheave block		SWL≤25	$2W$
			25 < SWL≤160	$0.933W+27$
			160 < SWL	$1.1W$
Chain hook, shackle, ring, link, swivel, clamp and similar gear			SWL≤25	$2W$
			25 < SWL	$1.22W+20$
Lifting beam, Lifting magnet, spreader and similar gear			SWL≤10	$2W$
			10 < SWL≤160	$1.04W+9.6$
			160 < SWL	$1.1W$

(3) The test loads for ropes are to satisfy the following formula:

$T \geq W \cdot f$

where,

T: Test loads for ropes (t)

W: Safe working loads of ropes (t)

f: For Safety working load is less than 160 (t), safety factor is calculated the formula (10,000/(8.85W+1910)) . However, the safety factor of the wire ropes for running rigging may not exceed 5, and those for standing rigging, For synthetic fibre ropes, the safety factor is taken the value deemed appropriately by the Society.

3 For cargo handling appliances of which the safe working loads, etc. are assigned for the first time, the methods of load tests are to comply with the following requirements in **(1)** through **(4)**.

(1) Cranes

(a) In case of a jib crane, the test weight is to be slewed throughout the working range at the maximum slewing radius and then lifted/lowered at some position of the working range. Further, jib is to be luffed at some position of the working range.

(b) In case of a track-mounted crane, the crane with the test weight suspended is to be transversed throughout the working range and test weight is to be lifted / lowered at some position.

(c) In case of a track-mounted hoisting gear, the hoisting gear with suspending the test weight is to be traversed from one end of the bridge span to the other and the test weight is to be lifted / lowered at some position.

(2) Cargo ramps

In case of a cargo ramp, the test weight is to be placed on the severest position of loading in the designed loading conditions, and the deflection is to be measured. As far as practicable, a vehicle with the mass corresponding to the safe working load is to run on the cargo ramp.

(3) Cargo lifts

In case of a cargo lift, the test weight is to be so spaced that the most severe working condition is available taking into account one side loading, and the cargo lift is to be moved between each stop position, and to be lifted or lowered within the entire stroke of motion.

(4) In case of loose gear, the test load is to be loaded in the method considered as appropriate by the Society.

4 For the cargo handling appliances other than described in **-3**, the methods of load tests are to comply with the following requirements in **(1)** or **(2)**.

(1) The load test specified in **-3(1)**, **(2)**, **(3)**, or **(4)** is to be carried out.

(2) The load test may be carried out using a spring or hydraulic weighing machine anchored suitably and safely in accordance with the method considered appropriate by the Society.
   (a) Accuracy of the load weighing machine is to be within the range of ±2.5 %.
   (b) Load applying position is to be selected in such a way that the stress generated in the structural members be the most severe within the approved operating range.
   (c) The load is to be sustained for a period of 5 *minutes* or more being sufficient to ensure the load indicator remains constant.

5.7 Special Surveys for Marine Pollution Prevention Systems, etc.

5.7.1 General

For ships affixed class notations related to marine pollution prevention systems in accordance with the requirements specified in **1.2.8 (1)** to **(5), Part 1**, the inspections of marine pollution prevention systems, etc., at Special Surveys, are to be carried out according to the requirements of **3.3, Chapter 3, Part 2 of the Rules for Marine Pollution Prevention Systems**.

5.8 Special Surveys for Safety Equipment and Navigational Equipment

5.8.1 General

At Special Surveys for safety equipment and navigational equipment of a ship affixed with the class notation "*LSA*" and/or "*SN*" in accordance with the requirements of **1.2.10-1** and/or **-2, Part 1**, the following examinations are to be carried out in addition to the examinations specified in **3.8.1**.

(1) For launching appliances of lifeboat, rescue boat and liferaft, the dynamic tests of winch brake at the maximum lowering speed using the lifeboat, rescue boat and liferaft without any persons but loaded 1.1 times mass which corresponds to the mass of maximum number of persons and full equipment, are to be carried out, after the completion of the examination specified in **3.8.1-2** under the attendance of the Surveyor.
(2) For automatic release hook of davit type launching appliances for liferaft and release gears for life boat including free-fall lifeboat, operation tests of automatic release hook and release gears using lifeboat and liferaft without any persons but loaded 1.1 times mass which corresponds to the mass of maximum number of persons and full equipment, are to be carried out, after the completion of the examination specified in **3.8.1-2** under the attendance of the Surveyor.
(3) For operation tests of automatic release hook of free-fall lifeboat, free-fall tests of the lifeboat which the operator is in the boat or simulation test are carried out, after the completion of overhaul inspection of automatic release hook and release gears under the attending Surveyor.

Chapter 6 DOCKING SURVEYS

6.1 Docking Surveys

6.1.1 Surveys in Dry Dock or on Slipway

At Docking Surveys, the examinations specified in the following **(1)** to **(15)** are to be carried out on a docking block of sufficient height in a dry dock or on a slipway after cleaning the outer shell.

(1) Shell plating including keel plates, stem and stern frames
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) Rudders
(a) Rudders are to be lifted or removed and visible parts of the rudder, rudder pintles, gudgeons, rudder stocks and couplings, and the stern frame are to be examined. In addition, rudder bearing clearance is to be measured. The rudder may not require lifting or removal, however, in cases where the Surveyor is satisfied with the condition of the rudder based upon measurements of said clearance.
(b) Where applicable, pressure tests of rudders may be required as deemed necessary by the Surveyor.

(3) Scuppers, overboard discharges and sea inlets (including distance pieces) as well as valves and cocks on shell plating, sea chests or distance pieces
The main parts of valves and cocks are to be opened up and examined. In addition, 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.

(4) Side thrusters
Side thrusters are to be visually examined for any damage which may affect the hull structure.

(5) Fin stabilizers
Fin stabilizers are to be expanded as far as possible and examined visually.

(6) Propeller shafts
Clearances between propeller shafts and the stern tube shafts, or the wear down of propeller shafts or stern tube shafts are to be measured.

(7) Sealing devices for stern tubes and shaft bracket bearings
In the case of oil or freshwater lubricated stern tube bearings, the efficiency of the oil or freshwater gland is to be checked.

(8) Propellers
Propellers are to be examined. Furthermore, where controllable pitch propellers are fitted, pitch control devices are to be examined without dismantling.

(9) Anchors, anchor chains, ropes, hose pipes, chain lockers and cable clenches
Anchors and anchor chains are to be arranged at suitable locations and all chains and chain related equipment is to be verified and externally examined. The conditions of hose pipes, chain lockers and cable clenches are to be confirmed to be in good working order as far as possible.

(10) At Special Survey No.2 and subsequent Special Surveys, the diameter of an anchor chain that refers to the average of the smallest diameter (the diameter measured in the direction with the most wear) found in one cross-section of a link and the diameter measured perpendicular to it in the same cross-section) is to be measured. A link is to be replaced if the mean diameter at its most worn part is reduced by 10 % or more from its required nominal diameter for *GNS-A*

ships and *GNS-B* ships and by 12 % or more for *GNS-C* ships and *GNS-D* ships.

(11) Tanks and spaces

Internal examinations, close-up surveys and thickness measurements (if applicable and not already carried out) are to be carried out as stipulated below.

(a) At Docking Surveys in a dry dock or on a slipway carried out in conjunction with Special Surveys or at Intermediate Surveys for ships over 15 years of age, at least the portions below the light ballast waterline of the cargo holds or cargo tanks and water ballast tanks.

(b) At Docking Surveys for ships less than 15 years of age and at Intermediate Surveys of ships less than 15 years of age carried out simultaneously, internal examinations of tanks and spaces as far as possible.

(12) For ships approved to carry out In-water Surveys in lieu of Docking Surveys conducted in a dry dock or on a slipway, it is to be verified that the items specified in **6.1.2-2** are being maintained in good order at the Docking Surveys for such ships.

(13) For ships adopting the impressed current protection systems, general examinations and operation tests of such systems are to be carried out. In addition, for ships adopting anodes, general examinations of anodes fitted to hull structures under load waterlines are to be carried out. Where deemed necessary by the attending Surveyor, the dimensions and weights of anodes are also to be measured.

(14) For waterjet propulsion systems, the examinations specified in the following **(a)** to **(c)** are to be carried out.

(a) In cases where water-lubricated bearings for waterjet pump units are adopted, bearing wear down is to be measured.

(b) The mountings of waterjet pump units to hull structures (including flanges and bolts) are to be examined.

(c) Water intake ducts are to be confirmed to be in good working order.

(15) For azimuth thrusters, the examinations specified in the following **(a)** to **(c)** are to be carried out.

(a) Visual inspections of steering columns, propeller pods and propellers (including bolt locking and other fastening arrangements) are to be carried out.

(b) Examinations on sealing devices for azimuth steering gear, propeller shafts and propeller blades are to be carried out.

(c) Measurements of the wear down of the bearings are to be carried out. (Except when roller bearings are used as bearings for propeller shafts)

6.1.2 In-water Surveys

1 For ships with the class notation "*IWS*" (an application on In-water Survey in lieu of Docking Surveys specified in **6.1.1** is submitted to the Society by the applicant, and is approved by the Society), In-water Surveys may be accepted in lieu of Surveys in a dry dock or on a slipway subject to prior approval by the Society, however, surveys in a dry dock or on a slipway to be carried out at the times specified in **(1)** or **(2)** are not to be replaced with In-water Surveys.

(1) Docking Surveys required to be carried out at the times of Special Surveys

(2) Docking Surveys for ships over 15 years of age

2 For ships intended to be subjected to In-water Surveys, the following measures are to taken prior to the survey being conducted.

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

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

(3) For water lubricated stern tube bearings, a means of measuring the clearances between propeller shafts and their bearings is to be provided.

(4) For oil or freshwater lubricated stern tube bearings, a suitable means of ascertaining the

performance of the stern tube bearings, including oil sealing devices, is to be provided.
(5) A suitable means of ascertaining the positions and identities of each propeller blade is to be provided.
(6) Valves provided at ship bottoms are to be constructed so as to facilitate opening from the insides of ships in the case of surveys or repairs and their openings are to be constructed so as to facilitate secure closing from the outsides of ships; moreover, hinged gratings are to be installed on all sea chests and constructed so as to facilitate opening and closing by divers.
(7) Markings indicating the positions of longitudinal bulkheads, transverse bulkheads and transverses as well as the names of interior spaces on the hull below the load waterline are to be provided so that divers are able to orientate their positions relative to ships being surveyed.
(8) For ships adopting the impressed current protection systems, general examinations and operation tests of such systems are to be carried out. In addition, for the ships adopting anodes, general examinations of anodes fitted to hull structures under load waterlines are to be carried out. Where deemed necessary by the attending surveyor, the dimensions and weights of anodes are also to be measured.

3 In-water Surveys are to be carried out under the following conditions in **(1)** through **(5)** to ensure that the information such as conditions of shell plating, appendages and welds obtained is as reliable as that obtained by surveys in a dry dock or on a slipway.
(1) At calm weather and sea state conditions and a ship being at sea being in-water visibility is to be good enough to permit a meaningful examination.
(2) The ship is at its lightest possible draught and the cleanliness of the hull below the waterline is to be good enough to permit a meaningful examination
(3) 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.
(4) 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.
(5) Means for taking colour photographs are to be provided.

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

Chapter 7 PLANNED MACHINERY SURVEYS

7.1 Planned Machinery Surveys

7.1.1 Application

1 The requirements in this Chapter is to apply, in principle, to *GNS-C* ships and *GNS-D* ships.

2 Planned Machinery Surveys, in principle, only apply to machinery and equipment with established service histories, and are to only be carried out in accordance with the applicable requirements prescribed in **7.2** to **7.4** or some combination thereto. However, Planned Machinery Surveys cannot be carried out for the machinery, equipment and survey items specified in the following **(1)** to **(7)**.

(1) Propellers and propeller shafts
(2) Sea valves below load waterlines
(3) Boilers
(4) Machinery and equipment (cargo handling appliances, refrigerating installations, bilge separators, pumps for bilge separators, etc.) for which open-up surveys are required by **3.4** to **3.10**.
(5) Measurements 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 as well as 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 scope of application of Planned Machinery Survey for the following reasons:
  (a) Newly developed machinery and equipment that are not considered appropriate for the application of Planned Machinery Surveys; or
  (b) Machinery and equipment to which Planned Machinery Surveys apply, but which are not considered appropriate for further application of Planned Machinery Surveys due to frequent occurrences of damage.

3 In cases where a Planned Machinery Survey is intended to be adopted, the shipowner or the agent is to submit the following documents together with an application for Planned Machinery Surveys to the Society for approval before the first survey after the Classification Survey or the previous Special Survey. Upon approval by the Society, the Planned Machinery Survey is to be carried out.

(1) In case of Continuous Machinery Surveys (*CMS*), *CMS* program which is to satisfy the following items.
  (a) All the survey items applicable to *CMS*
  (b) The intervals between open-up examinations of identical items are not to exceed 5 years.
  (c) 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.
  (d) When there are identical sets of machinery or equipment, the examinations are to be conducted on an alternate set each time as far as practicable.
(2) In the case of Planned Machinery Maintenance Schemes (*PMS*), the machinery maintenance scheme, the survey schedule table and the function descriptions for maintenance management systems specified in **7.3.2**.
(3) In the case of Condition Based Maintenance Schemes (*CBM*), the documents described in the following items in addition to a machinery maintenance scheme for *CBM* and the survey schedule table specified in **7.4.2**.

(a) List of the machinery, etc. subject to the scheme
(b) List of equipment comprising the condition monitoring system as well as function descriptions and maintenance instructions for the condition monitoring system
(c) List of sensors
(d) Kinds and contents of output information from the condition monitoring system (kinds of abnormalities, maintenance recommendations, remaining years of service life, etc.)
(e) List of limiting parameters used in condition monitoring (alarms and warnings determined from manufacturer recommendations or international standards)
(f) Procedures for changes to software systems and limiting parameters
(g) Function descriptions for maintenance management system

4 Where the survey schemes, planned machinery maintenance schemes or machinery maintenance schemes for *CBM* specified in **-3** above are intended to be modified, the modified documents are to be submitted to the Society for approval.

7.2 Continuous Machinery Surveys (*CMS*)

7.2.1 General

1 In *CMS*, every item of machinery and equipment specified in the following **(1)** to **(5)** is to be surveyed systematically, continuously and sequentially in accordance with a survey schedule table approved by the Society so that each survey interval for all *CMS* items does not exceed 5 years.

(1) Open-up surveys of 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) Open-up surveys of power transmission systems and shafting systems
(a) 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.
(b) The essential parts of flexible couplings are to be opened up.
(c) Thrust shafts, intermediate shafts and their bearings (excluding stern tube bearings and shaft bracket bearings) are to be examined by either removing the upper bearing halves or their bearing metals (including their thrust pads), and then turning the shafts.
(d) The essential parts of other power transmission gears are to be subjected to open-up examinations to the Surveyor's satisfaction. During the *CMS*, when any defect or damage is found, similar machinery and equipment, or some parts of them, may be required to be opened up for further examination as deemed necessary by the Surveyor, and all defective items or failures found are to be repaired to the Surveyor's satisfaction.

(3) Open-up surveys of auxiliary engines
Auxiliary engines driving generators (including emergency generators), auxiliary machinery essential for main propulsion and auxiliary machinery for maneuvering and personnel safety are to be handled in accordance with the requirements applicable to main engines.

(4) Open-up surveys of auxiliary machinery
(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 maximum evaporation rates of 3 *tons*/*hr* or less)
(b) Cooling pumps
Circulating pumps for main steam turbines, piston cooling fresh water or oil pumps,

cylinder jacket cooling fresh water or sea water pumps, turbocharger cooling fresh water or sea water pumps, fuel valve cooling fresh water or oil pumps, cooling sea water pumps for *L.O.* cooler, cooling sea water pumps for fresh water coolers, and cooling fresh water or sea water pumps for generator engines

(c) Fuel oil pumps
F.O. supply pumps, *F.O.* service pumps, boiler burning pumps (excluding those with maximum evaporation rates of 3 *tons/hr* or less), and *F.O.* transfer pumps

(d) Lubricating oil pumps
L.O. pumps for main engines, *L.O.* pumps for camshafts, *L.O.* pumps for reduction gears, *L.O.* pumps for controllable pitch propellers (*C.P.P.*), stern tube *L.O.* pumps (excluding those where the lubricating oil can be supplied and circulated under a 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, condensing pumps (for main steam turbines, generator turbines, cargo oil pump turbines, and ballast pump turbines), 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
Main condensers, 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 or 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 capacities of 10 *kW* or less)

(j) *F.O.* tanks (having capacities of more than 1 m^3 which do not form parts of the hull structures)
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) Cargo handling appliances (including cargo handling appliances, cooling and reliquefaction equipment for bulk liquid cargoes as necessary)
Cargo pumps (including chemical pumps, liquefied gas pumps), stripping pumps, tank cleaning pumps, gas compressors, gas blowers, heat exchangers, pressure vessels, vaporisers, tank cleaning heaters and drain coolers, drain coolers for cargo oil heaters, refrigerating equipment (refrigerant pumps and compressors), and inert gas systems

(m) Deck machinery
Steering gears, windlasses and mooring winches (including their hydraulic pumps)

(n) Distilling plants (for boilers used for driving steam turbines necessary for main propulsion or maneuvering and personnel safety)

(o) Other machinery and equipment which the Society considers to be covered by the

Planned Machinery Survey

(5) Waterjet propulsion systems

(a) Open-up examinations of hydraulic pumps for hydraulic power systems

(b) Open-up examinations of lubricating oil pumps

(c) Open-up examinations of coolers

(d) Open-up examinations of other items considered to be necessary by the Society

(6) Azimuth thrusters

(a) Open-up examinations of gears, gear shafts, shaft couplings, bearings and clutches for propulsion
These items are to be opened up as deemed necessary by the Surveyor so that they can be inspected.

(b) Open-up examinations of gears, gear shafts, shaft couplings and bearings for steering
These items are to be opened up as deemed necessary by the Surveyor so that they can be inspected.

(c) Open-up examinations of hydraulic pumps and hydraulic motors for azimuth steering gears

(d) Open-up examinations of lubricating oil pumps

(e) Open-up examinations of coolers

(f) Open-up examinations of any other items considered to be necessary by the Society

2 During the *CMS*, when any defect or damage is found, similar machinery and equipment, or some parts 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.

3 Survey items deemed appropriate by the Society may be delegated to overhaul inspections by the shipowner (or the ship management company). In such cases, 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.

7.3 Planned Machinery Maintenance Schemes (*PMS*)

7.3.1 General

1 A shipowner (or ship management company) that has an established maintenance systems may apply to adopt a planned maintenance method in which the shipowner is permitted to carry out planned overhaul inspections and maintenance as specified in **-2** to **-5** in place of the open-up surveys specified in **7.2.1-1**.

2 The *PMS* is to be implemented in accordance with the machinery maintenance scheme and the survey schedule table approved by the Society.

3 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.

(1) Date of maintenance work

(2) Names and signatures of the persons responsible for maintenance (e.g. the chief engineer)

(3) Details of maintenance work and results

(4) Total running hours (parts replacement intervals and overhaul intervals)

(5) Names of parts replaced

(6) Measuring data (including original design dimensions and allowable tolerances)

(7) The condition of damage and repair method

(8) 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)

4 Where it is regarded that satisfactory maintenance has not been carried out for any of the machinery and equipment by the results of the survey specified in **-3**, an open-up examinations of such items in the presence of the Surveyor may be required.

5 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 tables based upon the machinery maintenance schemes.

7.3.2 Documents for Machinery Maintenance Schemes and Survey Schedule Tables

1 Machinery maintenance schemes for *PMS* are to specify maintenance works such as overhaul inspections, replacements of parts and general inspections with their time schedules and/or running hours for each item of machinery and equipment including their parts.

2 In specifying the contents in **-1**, schemes are to be prepared based upon the inspection and maintenance intervals recommended by manufacturers of machinery and equipment with input also from shipowners (ship management companies) based upon their experience and knowledge.

3 The inspection intervals for all items covered by *PMS* are, in principle, to be scheduled so as not to exceed 5 years. However, for items whose overhaul intervals are specified on the basis of their running hours, longer intervals may be accepted as long as said intervals are based upon manufacturer recommendations.

4 Survey schedule tables are to be so made that the survey intervals of survey items do not exceed those specified in machinery maintenance schemes, in addition, the following items are, in principle, to be opened up and examined in the presence of the Surveyor.

(1) Rotors, casings, main bearings, couplings between turbines and reduction gears, nozzle valves and manoeuvring valves for main steam turbines
(2) Auxiliary steam turbines for main generators
(3) Reduction gears for main propulsion
(4) Flexible couplings for main propulsion shafting systems
(5) Other machinery, equipment and components deemed necessary by the Society

7.3.3 Computers Used for Maintenance Management Systems

Computers used for maintenance management systems are to satisfy the following **(1)** through **(6)**.

(1) Computers are to be configured so that the effects of a system failure in part of the circuits or in some devices can be kept limited to a certain degree as far as possible.
(2) Each system component is to be protected against any overvoltages (electrical noise) likely to enter through input/output terminals.
(3) Central processing units and important peripheral devices are to possess self-monitoring capability.
(4) Important programmes and data are not to be deleted in the event of temporary failures of the external sources of power supply.
(5) Spare parts for important system components that require specialist services for repairs are to be supplied in readily replaceable part units.
(6) The software is to be approved by the Society in accordance with the requirements in **9.1.3, Part B of the Rules for the Survey and Construction of Steel Ships**.

7.4 Condition Based Maintenance Schemes (*CBM*)

7.4.1 General

1 A shipowner (or ship management company) that has an established maintenance system may apply to adopt the method in which maintenance of machinery is carried out according to the results of condition monitoring and diagnosis, as specified in the following **(1)** to **(6)**, in place of the open-up surveys specified in **7.3.2-1**.

(1) The condition based maintenance method is to be implemented in accordance with a machinery maintenance scheme for *CBM* approved by the Society based on the requirements in **7.4.2**.

(2) In cases where no abnormality is found in the results of condition monitoring and diagnosis, a general examination may be carried out as an alternative to the open-up examinations specified in **7.3.2-1** based upon manufacturer recommendations regarding maintenance. In cases where an abnormality is found, 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 for *CBM*.

(3) The condition monitoring system is to be approved by the Society.

(4) The condition monitoring and diagnosis is not to replace routine surveillance or the chief engineer's responsibility for making decisions in accordance with his judgment.

(5) The Society confirms on a yearly basis that the condition monitoring system works effectively and is in good condition; this includes inspection of condition monitoring records and machinery maintenance records subject to the scheme so as to confirm said machinery is in good condition, and that maintenance was carried out in cases where monitoring parameter of the machinery exceeded its limiting value.

(6) Where it is regarded that satisfactory maintenance has not been carried out for any of the machinery and equipment by the results of the survey specified in **(5)**, an open-up examination of the item in the presence of the Surveyor may be required.

2 The Society is to carry out the survey the investigate the condition monitoring record described in the followings in addition to the confirm the their conditions of mac every year to verify that machinery, equipment or associated components whose condition monitoring are found in good order and diagnosis results were abnormal since the last survey has been carried out.

(1) Condition monitoring data, including all data since last open-up inspection, the original baseline data at the implementation survey and relevant maintenance data

(2) Names and signatures of the responsible persons for monitoring

(3) Contents and results of condition monitoring and diagnosis (including criteria for judgment)

(4) Records of the modification of software and parameters

(5) Calibration records, certificates and conditions of sensors

(6) Maintenance records specified in **7.3.1-3**

7.4.2 Documents for Machinery Maintenance Schemes for *CBM* and Survey Schedule Tables

1 Survey schedule tables are to be given in **7.3.2-4**. The machinery maintenance schemes for *CBM* are to be described the items specified in the following **(1)** to **(4)** in addition to the management of maintenance of the machinery, equipment or associated components subject to the scheme and their maintenance records

(1) The functions of the condition monitoring system

(2) Procedures related to condition monitoring and diagnosis

(3) Handling procedures in cases where an abnormality is found (including procedures for creating maintenance records and reporting to the Society)

(4) Procedures for identifying defects and failures that were not prevented by condition

monitoring and diagnosis and for modifying the machinery maintenance scheme for *CBM* accordingly

2 The condition monitoring systems specified in **-1** are to comply with the requirements specified in the following **(1)** to **(8)**.

(1) Computers collect data from sensors or centralized machinery monitoring and control systems. These sensors are to be tested in accordance with the relevant requirements of **Part 7**.

(2) Computer hardware and software are to comply with requirements in **7.3.3 (1)** to **(5)** and the requirements in **18.1.1, Part D of the Rules for the Survey and Construction of Steel Ships**.

(3) In addition to **(2)**, the software is to have condition monitoring function specified in **9.1.3-4, Part B of the Rules for the Survey and Construction of Steel Ships** and be suited to diagnosing any deterioration of machinery, equipment or associated components on the basis of the data from the sensors or centralized machinery monitoring and control systems specified in **(1)**. The software is to be suitable for diagnosing the condition of equipment or its components on the basis of independent or coalesced data, or their trends.

(4) The condition monitoring systems are to produce condition monitoring records.

(5) In cases where condition monitoring and diagnosis are conducted on board ships, the condition monitoring systems are to be such that no specialized knowledge of data analysis is required to use the system.

(6) In cases where remote condition monitoring and diagnosis are conducted (i.e. the data sent from the ship is analyzed remotely), the condition monitoring systems are to include a communication function to transfer the data collected by the sensors or centralized machinery monitoring and control systems specified in **(1)**. Particular attention is to be paid to the cyber safety and security of said communication function. The system equipped on board is to be arranged to store the condition monitoring data in the event of loss of the communication function and transfer the data after the communication function is restored.

(7) In cases where limiting parameters are modified, such modifications are to be identified.

(8) The condition monitoring systems are to include a method for backing up data at regular intervals.

3 The maintenance management systems are to have the maintenance records function specified in **9.1.3-4, Part B of Rules for the Survey and Construction of Steel Ships**. This function may be incorporated into the condition monitoring system specified in **-2**.

7.4.3 Surveys of *CBM*

(1) Installation survey

It is to be confirmed in the presence of the Surveyor that the equipment necessary for condition monitoring and diagnosis, e.g. sensors, are installed and available in accordance with the machinery maintenance scheme for *CBM*. In addition, a set of baseline readings is to be taken.

(2) Implementation survey

An implementation survey is to be carried out no earlier than 6 months after the installation survey and no later than the first periodical survey (i.e. the Annual Survey, Intermediate Survey or Special Survey specified in **1.1.3-1, Part B of the Rules for the Survey and Construction of the Steel Ships**). At the implementation survey the following **(a)** to **(f)** are to be verified. At this implementation survey, a report which specifies the implementation status of these items is to be submitted to the Society. The baseline data are to be approved by the Society prior to the implementation survey.

(a) Baseline data are incorporated in the condition monitoring system.

(b) Condition monitoring and maintenance are conducted in accordance with the machinery maintenance schemes for *CBM* (including a comparison of condition monitoring results to the baseline data).

(c) Condition monitoring records and machinery maintenance records are available on board the ship and the contents of said records are sufficient as an alternative to the open-up surveys specified in **7.2.1-1**.

(d) The familiarity of the chief engineer and other designated personnel with the operation of the machinery maintenance scheme for *CBM*.

(e) Records of any limiting parameters that have been modified.

(f) In cases where there is any failure on machinery, equipment or associated components subject to the scheme, appropriate modification of the machinery maintenance scheme for *CBM* has been undertaken to address said failure.

(3) Annual survey

An annual survey is to be carried out to verify that the scheme is being correctly operated and maintenance of machinery, equipment or associated components whose condition monitoring and diagnosis results were abnormal since the last survey has been carried out. At the annual survey the following **(a)** to **(g)** are to be verified. In cases where it is deemed necessary by the Surveyor (in consideration of the results of this verification) open-up examinations, function tests, confirmatory tests and readings of condition monitoring parameters may be required as far as practicable. In addition, condition monitoring records and maintenance records are to be available on board ships.

(a) The results of condition monitoring and diagnosis (including confirmation of maintenance records and general inspections) of machinery, equipment and associated components subject to the scheme are good.

(b) Condition monitoring systems and maintenance management systems work effectively and are in good condition.

(c) Records of any limiting parameters that have been modified since the last survey

(d) Written details of breakdowns or malfunctions

(e) The familiarity of the chief engineer and other designated personnel with the operation of the machinery maintenance scheme for *CBM*.

(f) In cases where there is a failure of machinery, equipment or associated components subject to the scheme, appropriate modification of the machinery maintenance scheme for *CBM* has been undertaken based to address said failure.

(g) The following documents are available on board ships

i) Documents specified in **7.4.2-1**.

ii) Maintenance instructions issued by manufacturers or shipyards

iii) Condition monitoring records and initial obtained baseline data specified in **7.4.2-1(4)**.

iv) Machinery maintenance records specified in **7.4.2-2(3)**.

v) Reference documents (trend investigation procedures, etc.)

7.5 Periodical Surveys

7.5.1 General

In place of the Planned Machinery Surveys prescribed in **7.2** to **7.4**, the surveys specified in **7.5.2** and **7.5.3** may be carried out at Intermediate Surveys and Special Surveys prescribed in **1.1.3** to ascertain that all the machinery is placed in good order. Where the machineries, etc. are overhauled for their maintenance by the shipowner voluntarily at the period other than that specified in **1.1.3**, the Surveyor may carry out the survey where deemed necessary.

7.5.2 Intermediate Survey

1 The surveys specified in the following **(1)** to **(4)** may be carried out at Intermediate Surveys.

(1) Diesel engines (Main)

(a) Internal inspection of the cylinders and internal and external inspection of the cylinder covers. However, the pistons are need not to overhaul except where deemed necessary by the Surveyor.

(b) Overhauling one third crank pins and crank shaft is inspected by rotating it.

(c) Rotors of exhaust gas turbocharger and their bearings are inspected.

(2) Power transmission systems and shafting systems

(a) Reduction gears, reversing gears and clutch gears are inspected through the inspection hole.

(b) 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

Auxiliary engines driving generators (including emergency generators), auxiliary machinery essential for main propulsion and auxiliary machinery for maneuvering and personnel safety are to be handled in accordance with the requirements applicable to main engines.

(4) Auxiliary machinery

The surveys specified in **7.2.1-1 (4)**

2 For the internal combustion engine less than 11 years age, the following items instead of the survey specified in **-1** may be measured and may carry out the performance tests (sea trial) in order to ascertain that they are found in order, where deemed appropriately by the Surveyor, considering the results of the confirmation of inspection and maintenance record and the inquiry.

(1) Loads (%)

(2) Rotational speed

(3) Power output

(4) Fuel oil pump rack

(5) Maximum pressure in the cylinder

(6) Temperature of exhaust gas (Maximum and average value)

(7) Pressure of cooling water (Maximum and average value)

(8) Temperature of cooling water (Maximum and average value)

(9) Pressure of lubricating oil (Maximum and average value)

(10) Temperature of lubricating oil (Maximum and average value)

(11) Angle of controllable pitch propeller

(12) Room temperature

(13) Running time for operation

3 Where the machinery or equipment consists of duplicate systems, surveys for either of the machinery may be carried out. However, for internal combustion engine less than 11 years age, the performance test (sea trial) instead of the survey specified in **-1** may be accepted where deemed appropriately by the Surveyor, considering the results of the confirmation of inspection and maintenance record and the inquiry.

7.5.3 Special Surveys

1 At Special Surveys, the surveys specified in **7.2.1** are to be carried out and are to be confirmed that the conditions of the survey items are found in order.

2 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.

3 Where the surveys specified in **7.5.2** for the internal combustion engine less than 11 years age are carried out at Intermediate Survey or Occasional survey after the Classification Survey during Construction or the previous Special Survey, and where deemed appropriately by the Surveyor, considering the results of the confirmation of inspection and maintenance record and the inquiry., whole or part of the surveys specified in **7.2.1** may be dispensed with.

Part 3 MATERIALS AND WELDING

Chapter 1 GENERAL

1.1 General

1.1.1 Application

1 The requirements in this Part apply to rolled steels, aluminium alloys and fibre reinforced plastics (hereinafter referred to as "*FRP*") which are intended to be used for hull structures, and castings, steel forgings, copper and copper alloys, and their welding or moulding.

2 Materials not specified in this Part may be used when the manufacturing procedures, manufacturing controls and quality controls adopted by manufacturers as well as detailed design data (including material characteristics) are specially approved by the Society. In such cases, detailed data relating to manufacturing processes and designs as well as examinations and tests carried out are to be submitted to the Society for approval.

1.1.2 Limitation of Using Materials

1 Magnesium alloys are not used in places installed with machinery, workshops, or hazardous areas defined in **2.4.24, Part 1** as well as in locations where they may come into contact with the primary refrigerants of refrigeration units

2 Paints and coatings whose dry films have aluminium contents greater than 10 % by weight as well as aluminum pipes and pipes whose surfaces are anodized are not to be used in the hazardous areas (as defined in **2.4.24, Part 1**), of ships intended to carry crude oil and petroleum products having flashpoints not exceeding 60 °C and Reid vapour pressures below atmospheric pressure or of ships intended to carry other liquid cargoes having similar fire hazards or where such paints and coatings may come into contact with the primary refrigerants of refrigeration units.

Chapter 2 MATERIALS

2.1 Hull Structural Materials

2.1.1 General

1 In principle, rolled steels and aluminium alloys intended to be used for hull structures are to comply with the requirements in **Part K of the Rules for the Survey and Construction of Steel Ships**.

2 Materials whose standards for mechanical properties are not specified in **Part K of the Rules for the Survey and Construction of Steel Ships**, are to be of approved in accordance with the requirements in **Chapter 1**, **Part K of the Rules for the Survey and Construction of Steel Ships**.

3 *FRP* is to comply with the requirements of **the Rules for the Survey and Construction of Ships of Fibreglass Reinforced Plastics**.

2.1.2 Rolled Steels

1 In principle, rolled steels intended to be used for hull structures are to comply with the requirements in **3.1** and **3.10** to **3.12**, **Part K of the Rules for the Survey and Construction of Steel Ships**.

2 The high strength quenched and tempered rolled steels specified in **Table 3.2.1** are considered to be equivalent to the high strength rolled steels for offshore structures specified in **3.8**, **Part K of the Rules for the Survey and Construction of Steel Ships**, and may be used for hull structures when the heat treatments methods used applied are thermo mechanical controlled process (*TMCP*) or quenched and tempered (*QT*), and when their designs effects of corrosion diminution and enlargements of deflections, etc. are taken into account with respect to structural strength, fatigue strength and ultimate strength) and manufacturing processes as well as any examinations and tests carried out are approved by the Society.

3 Where stainless clad steels specified in **3.9**, **Part K of the Rules for the Survey and Construction of Steel Ships** are intended to be used for structural members that come in contact with sea water, such steels may only be used where detailed data on compatibility of use in sea water and splash zones are approved by the Society.

4 The characteristics of major materials in the requirements for hull structure strength are to be as given in **Table 3.2.1**.

Table 3.2.1 Characteristics of mild steels, high tensile steels, etc.

Kinds of materials		Proof strength (σ_Y) (N/mm^2)	Tensile strength (σ_T) (N/mm^2)	Material coefficient (K)	Modulus of tensile elasticity (Young's modulus) (E) (N/mm^2)	Poisson's ratio (ν)
Mild Steels		235	400	1.0	206,000	0.3
High tensile steels[*1]	*HT*32	315	440	0.78		
	*HT*36	355	490	0.72		
	*HT*40	390	510	0.68 [*2]		
	*HT*47	460	570	0.62 [*3]		
High strength quenched and tempered rolled steels[*1]	*HHT*550	550	640	[*4]		
	*HHT*690	690	770	[*4]	203,000	0.3
Stainless clad steels		[*5]	[*5]	[*5]	[*5]	0.3

(Notes)

*1 High tensile steels whose minimum proof strength are 315 N/mm^2, 355 N/mm^2, 390 N/mm^2 and 460 N/mm^2 refer to *HT*32, *HT*36, *HT*40 and *HT*47, respectively, and high strength quenched and tempered rolled steels refer to *HHT* with minimum proof strength.

*2 Where this material is used for hull structures and direct strength calculation and fatigue strength assessment of the locations instructed by the Society are carried out in accordance with the requirements in **Part 5**, material coefficient 0.66 for hull girder strength assessment may be used.

*3 Where this material is used for hull structures and direct strength calculation and fatigue strength assessment of the locations instructed by the Society are carried out in accordance with the requirements in **Part 5**, this material coefficient for hull girder strength assessment may be used.

*4 Material coefficients of materials having the minimum proof strength equal to *HHT* 550 or higher are to be at the discretion of the Society.

*5 The values are obtained by driving the required values of base steels and stainless steels proportionally to their thicknesses, respectively.

2.1.3 Aluminium Alloys

1 In principle, aluminium alloys intended to be used for hull structures are to comply with the requirements in **Chapter 8**, **Part K of the Rules for the Survey and Construction of Steel Ships**.

2 Where hull structures are intended to be constructed by aluminium alloys complying with the requirements in **Chapter 8**, **Part K of the Rules for the Survey and Construction of Steel Ships**, aluminium alloys may be used when the heat treatment, weldability, strength of welded butt joints, design, manufacturing processes as well as any examinations and tests carried out are approved by the Society.

3 Strength characteristics of aluminium alloys used in the requirements for hull structure strength are to take into account the welding efficiency of joints. The material characteristics of major aluminium alloys are given in **Table 3.2.2**. When alminium alloys are welded to different types of aluminium alloys, the lower material characteristics among the two types of aluminium alloys are to be used for the structural strength assessments of structures.

4 Plating of extruded shapes is to be arranged so that their direction is parallel to the same direction of the principal stresses of stiffeners.

5 Aluminium alloys of kinds 6005*AS*, 6061*P* and 6061*S* that do not possess suitable anti-corrosion characteristics against sea water are, in principle, not to be used when such alloys are likely to come into contact with sea water during normal operations. Such aluminium alloys, however, may be used for parts likely to contact with sea water during normal operations in cases where suitable corrosion protection measures such as surface treatments are provided and the

effectiveness of said corrosion protection is deemed appropriate by the Society,
6 In principle, the use of plating of extruded shapes is to be limited to decks, bulkheads, superstructures and deck houses.

Table 3.2.2 Material characteristics of aluminum alloys

Kinds of materials	Temper condition	Proof strength (σ_Y) *1 (N/mm^2)	Tensile strength (σ_T) *1 (N/mm^2)	Modulus of tensile elasticity (Young's modulus) E (N/mm^2)	Poisson's ratio (ν)
5083*P*	*O*, *H*112	125	275	72,000	0.33
5083*P*	*H*116, *H*321	190	285		
5083*S*	*O*, *H*112	110	270		
5086*P*	*O*	95	240	70,600	0.33
5086*P*	*H*112	105*1	240		
5086*P*	*H*116	165	275		
5086*S*	*O*, *H*116	95	240		
6061*P*	*T*6	115	295	68,600	0.33
6061*S*	*T*6	115	260	68,600	0.33

* 1 The proof strength and tensile strength of aluminium alloys are taken as the minimum strength of welded parts.
* 2 Where plate thickness is less than 12.5 *mm*, proof strength is to be taken as 125 N/mm^2.

2.1.4 *FRP*

1 *FRP* used for hull structures is to be moulded using fibreglass reinforcements (*e.g.* glass chopped strand mats (hereinafter referred to as "chopped mats"), glass roving cloths (hereinafter referred to as "roving cloth") and glass roving) and unsaturated polyester resins, epoxy resins or phenol resins, in addition *FRP* and raw materials are to be of *FRP* specified in **Chapter 4 of the Rules for the Surveys and Construction of Ships of Fibreglass Reinforced Plastics**.
2 The mechanical properties of *FRP*, excluding gel coats are as given by **Table 3.2.3**.

Table 3.2.3 Characteristics of *FRP*

Tensile strength (σ_T) (N/mm^2)	Modulus of tensile elasticity (Young's modulus) E (N/mm^2)	Bending strength(σ_B) (N/mm^2)	Modulus of bending elasticity B_M $B_{\rm M}$ (N/mm^2)
98	6,860	150	6,860

3 Where are constructed using *FRP* whose strength is stronger than those specified in **-2,** the values for tensile strength and bending strength given in **Table 3.2.3** which are corrected based upon the results of the testing specified in **Chapter 4 of the Rules for the Survey and Construction of Ships of Fibreglass Reinforced Plastics** may be used.
4 For, the manufacturers, material characteristics and moulding procedures for reinforced plastic materials using materials other than fibreglass for reinforcement (*e.g.* carbon fibre reinforcements) are to be approved by the Society based upon the requirements in **Chapters 3**, **4** and **5 of the Rules for the Survey and Construction of Ships of Fibreglass Reinforced Plastics**.

2.2 Materials of Machinery, Equipment, etc.

2.2.1 General

1 Materials used for the primary parts of machinery and main structures of cranes, cargo lifts and cargo ramps are to be selected the materials suitable for their purposes and service conditions from the materials complied with the relevant requirements in **Part K of the Rules for the Survey and Construction of Steel Ships**.

2 Materials other than those specified in **-1** are to be in accordance with the following **(1)** to **(4)**.

(1) All materials used for the main propulsion machinery, power transmission systems, shafting systems, propellers, boilers, pressure vessels and control systems as well as those used for auxiliary machinery essential for main propulsion, maneuvering and safety and cargo handling are to comply with *JIS* or any other standards deemed appropriate by the Society.

(2) All materials used for auxiliaries for propulsion, maneuvering and safety and cargo handling, driving systems, loose gears and synthetic fibre ropes used for cargo handling appliances, and their associated power transmission systems, shafting systems, piping systems and control systems are to be selected with consideration given to their purpose and conditions of service.

(3) Wire ropes used for cargo handling appliances and ropes used for towing and mooring are to be complied with the requirements in **Part L of the Rules for the Survey and Construction of Steel Ships**.

(4) In principle, gray irons specified in **5.5, Part K of the Rules for the Survey and Construction of Steel Ships** are not to be used.

3 Materials of pipes passing through collision bulkheads and valves being operable from above the bulkhead deck are to be of copper, bronze or ductile materials deemed appropriately by the Society.

2.2.2 Materials for Machinery

1 Materials intended for the principal components of diesel engines specified in the following **(1)** to **(18)** are to conform to the requirements in **Part K of the Rules for the Survey and Construction of Steel Ships**. 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.

(1) Welded bedplate and welded frame box

(2) Bearing transverse girders (cast steel)

(3) For crosshead diesel engines, welded cylinder frames and crosshead

(4) Engine block (spheroidal graphite cast iron. However, for *GNS-C* ships and *GNS-D* ships and for engine power exceeding 400 *kW/cyl*, materials are applied. Also for *GNS-C* ships and *GNS-D* ships, chemical composition analysis may be omitted.

(5) Cylinder liner. However, for *GNS-C* ships and *GNS-D* ships and for cylinder bore not more than 300 *mm*, materials are to comply with *ISO*, *JIS* or any other standards deemed appropriate by the Society.

(6) Cylinder head (cast steel or forged steel). However, for *GNS-C* ships and *GNS-D* ships and for cylinder bore not more than 300 *mm*, materials are to comply with *ISO*, *JIS* or any other standards deemed appropriate by the Society.

(7) Piston crown (cast steel or forged steel) and piston rod. However, for *GNS-C* ships and *GNS-D* ships and for cylinder bore not more than 400 *mm*, materials are to comply with *ISO*, *JIS* or any other standards deemed appropriate by the Society.

(8) Crankshaft（One piece types, Web, pin and journal for all built-up and semi-built-up types and others (including coupling bolts)）

(9) Crosshead for crosshead type diesel engines

(10) Connecting rods together with connecting rod bearing caps

(11) Bolts and studs (for cylinder heads, connecting rods, main bearings)
(12) Tie rod for crosshead type diesel engines
(13) High pressure fuel injection pipes including common fuel rail, high pressure common servo oil system and heat exchanger, both sides (the water side of charge air coolers). However, for *GNS-C* ships and *GNS-D* ships and for cylinder bore not more than 300 *mm*, materials need not comply with the requirements in **Part K of the Rules for the Survey and Construction of Steel Ships**.
(14) Accumulator of common rail fuel or servo oil system. For *GNS-C* ships and *GNS-D* ships and for the capacity exceeding 0.5 *l*, materials are applied.
(15) Piping, pumps, actuators, etc. for hydraulic drive of valves. However, for *GNS-C* ships and *GNS-D* ships and for engine power exceeding 800 *kW/cyl*, materials are applied.
(16) Pipes, valves and fittings attached to engines classified as either Group I or Group II in the requirements on pipings.
(17) Bearings for main, crosshead, and crankpin. However, for *GNS-C* ships and *GNS-D* ships, submission of a test report which compiles all test and inspection results in an acceptance protocol issued by the manufacturer may be accepted.
(18) Turbine discs, blades, blower impellers and rotor shafts of exhaust driven turbochargers. However, for *GNS-C* ships and *GNS-D* ships, in cases where the manufacturer has a quality system deemed appropriate by the Society, materials and non-destructive tests as well as surface inspections and dimension inspections for categories *A* and *B* turbochargers may be substituted for by tests deemed necessary by the manufacturer. In such cases, the submission or presentation of test records may be required by the Society.

2 Materials of the components of gas turbine specified in the following **(1)** to **(8)** (hereinafter referred to as "the principal components of gas turbine") are to comply with the requirements in **Part K of the Rules for the Survey and Construction of Steel Ships**. However, for *GNS-C* ships and *GNS-D* ships, bolts, pipes, valves and fittings need not be subjected to the non-destructive tests specified in **Part K of the Rules for the Survey and Construction of Steel Ships**. The materials used in high temperature parts are to have properties suitable for the design, performance and service life against corrosions, thermal stresses, creeps and relaxations. In case where the base material is coated with corrosion-resistant surfacing, the coating material is to have such properties that it is hard to detach from the base material as well as not to impair the strength of the base material.
(1) Discs (or rotor), stationary blades and moving blades of turbine
(2) Discs, stationary blades and moving blades of compressor
(3) Turbine and compressor casings
(4) Combustion chambers
(5) Turbine output shaft
(6) Connecting bolts for main components of turbine
(7) Shaft coupling and bolts
(8) Pipes, valves and fittings attached to gas turbine classified as either Group I or II in the requirements on pipings

3 Materials used for components specified in the following **(1)** to **(4)** (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**. For *GNS-C* ships and *GNS-D* ships, coupling bolts, clutch discs and the like need not be subjected to the non-destructive tests specified 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

4 Materials used for the components specified in the following **(1)** to **(7)** (hereinafter referred to as the principal components of shafting) are to comply with the requirements in **Part K of the Rules for the Survey and Construction of Steel Ships**. For *GNS-C* ships and *GNS-D* ships, coupling bolts, clutch discs and the like need not be subjected to the non-destructive tests specified 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

5 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**.

6 The materials of boilers and boiler fittings are to comply with the requirements specified in the following **(1)** to **(3)**.

(1) The materials used for the construction of the pressure parts of boilers specified in the following **(a)** to **(e)** and boiler fittings are to comply with the requirements in **Part K of the Rules for the Survey and Construction of Steel Ships**, according to respective conditions of service.
  (a) Shells of boilers
  (b) Nozzles welded to the boiler drum
  (c) Manhole rings, stiffeners (except for those used for screwing fittings)
  (d) Flanges attached to nozzles (except for those used for connecting piping) or distance pieces
  (e) Manhole covers, cleaning hole covers, inspection hole covers, etc.

(2) The material of valve boxes or the nozzles, flanges or distance pieces that attach directly to a boiler drum (including tube headers) other than those specified in **(1)** are to be of steel which is suitable for the working temperatures. However, the following cases are excluded.
  (a) Copper alloy castings may be used in cases where the maximum working temperature does not exceed 210 °C.
  (b) Special cast irons such as malleable iron castings and spherical graphite iron castings (those irons specified in *ISO*, *JIS* or appropriate standards recognized by the Society) made by approved manufacturers may be used in cases where the maximum working temperature does not exceed 350 °C and the approved design pressure does not exceed 2.5 *MPa*.

(3) For *GNS-C* ships and *GNS-D* ships, boiler fittings such as valves and nozzles, etc., whose dimensions and conditions of service have been approved by the Society, may use materials specified in *ISO*, *JIS* or appropriate standards recognized by the Society.

7 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) All materials of pressure vessels, Group I (*PV*-1) are to comply with the requirements in **Part K of the Rules for the Survey and Construction of Steel Ships**. For *GNS-C* ships and *GNS-D* ships, the materials for fittings such as valves, nozzles, etc. that are to be fitted to*PV*-1 complying with the requirements specified in *ISO*, *JIS* or the appropriate standards recognized

by the Society may be used, where approved by the Society with consideration given to their dimensions and service conditions.

(2) Materials of pressure vessels, Group 2 (*PV*-2) are to comply with the requirements specified in the following **(a)** to **(c)**.

(a) For *GNS-A* ships and *GNS-B* ships, materials are to comply with the requirements in **Part K of the Rules for the Survey and Construction of Steel Ships**.

(b) For *GNS-C* ships and *GNS-D* ships, materials of the pressure vessels with the design pressure more than 0.7 *MPa* or the design pressure exceeding 2 *MPa*, a maximum working temperature exceeding 150 °C and an internal capacity exceeding 500 *litres*, are to comply with the requirements in **Part K of the Rules for the Survey and Construction of Steel Ships**.

(c) For *GNS-C* ships and *GNS-D* ships, materials of pressure vessels and their attachments other than those specified in **(b)** and the attachments with the design pressure less than 3 *MPa* or nominal diameter less than 100 *A*, complying with the requirements specified in *ISO*, *JIS* or the appropriate standards recognized by the Society may be used.

(3) Materials of pressure vessels, Group 3 (*PV*-3) are to comply with the requirements specified in the following **(a)** and **(b)**.

(a) For *GNS-A* ships and *GNS-B* ships, materials are to comply with the requirements in **Part K of the Rules for the Survey and Construction of Steel Ships**.

(b) For *GNS-C* ships and *GNS-D* ships, materials complying with the requirements specified in *ISO*, *JIS* or the appropriate standards recognized by the Society may be used.

(4) Special cast irons such as malleable iron castings and spherical graphite iron castings (those irons specified in *ISO*, *JIS* or appropriate standards recognized by the Society) made by approved manufacturers may be used in cases where the maximum working temperature does not exceed 350 °C and the approved design pressure does not exceed 1.8 *MPa*.

(5) Gray cast iron is not to be used for the shells of the pressure vessels and their fittings that contain or handle flammable or toxic substances.

(6) 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**.

(7) 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 Materials used for auxiliary machinery are to be adequate for their service conditions. Materials of essential parts of auxiliary machinery are to comply with the requirements specified in the following **(1)** and **(2)**.

(1) For *GNS-A* ships and *GNS-B* ships, materials of essential components of prime mover with not less than 100 *kW* are to comply with the requirements in **Part K of the Rules for the Survey and Construction of Steel Ships**. Materials of essential components of prime mover with an output less than 100 *kW* are to comply with *ISO*, *JIS* or other standards recognized by the Society.

(2) For *GNS-C* ships and *GNS-D* ships, materials of essential components of prime mover with an output not less than 375 *kW* are to comply with the requirements in **Part K of the Rules for the Survey and Construction of Steel Ships**. Materials of essential components of prime mover with an output less than 375 *kW* are to comply with *ISO*, *JIS* or other standards recognized by the Society.

9 Materials for pipes are to be adequate for their service conditions and are to comply with the

following requirements:
(1) Materials for distance piece, valves, seats and pipe fittings directly fitted to the shell plating or sea chest and collision bulkhead are to comply with the requirements in **Part K of the Rules for the Survey and Construction of Steel Ships**.
(2) Materials for pipes belonging to Group 1 or 2 are to comply with the requirements in **Part K of the Rules for the Survey and Construction of Steel Ships**.
(3) Materials for valves and pipe fittings used for the pipes belonging to Group 1 or 2 are to comply with the requirements in **Part K of the Rules for the Survey and Construction of Steel Ships**. However, For *GNS-C* ships and *GNS-D* ships, materials for pipe and valves specified in the following **(a)** to **(d)**, except for those specified in **(1)** are to comply with *ISO*, *JIS* or other standard recognized by the Society.
    (a) Pipes with a design pressure less than 1 *MPa* and a design temperature less than 230 °C.
    (b) Valves and pipe fittings used for the pipes with a nominal diameter less than 100 *A*.
    (c) Valves and pipe fittings used for the pipes with a design pressure less than 3 *MPa* and a design temperature less than 230 °C.
    (d) Pipe flanges
(4) Materials for pipes belonging to Group 3 and valves and pipe fittings used for the pipes are to comply with *ISO*, *JIS* or other standard recognized by the Society.
(5) 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 Pipes are, as a rule, to be made of steel, copper, copper alloy or cast iron and the material is to meet the requirements for the service limitations listed below according to design temperature, classification, service, etc., unless otherwise specified.
(1) Steel pipes are not to be used for any of the following pipes. However, for pipes which have an opening and are classed in Group 3 regardless of design temperature, these service limitations regarding temperature do not apply.
    (a) Any pipes specified as Grade 1 and Grade 2 in **4.2**, **Part K of the Rules for the Survey and Construction of Steel Ships** that have a design temperature over 350 °C. However, steel pipes may be used up to 400 °C if an allowable stress value is guaranteed.
    (b) Any pipes specified as Grade 3, No.2 and No.3 in 4.2, **Part K of the Rules for the Survey and Construction of Steel Ships** that have a design temperature over 450 °C.
    (c) Any pipes specified as Grade 3, No.4 in **4.2**, **Part K of the Rules for the Survey and Construction of Steel Ships** that have a design temperature over 425 °C.
    (d) Any pipes specified as Grade 4, No.12 in **4.2**, **Part K of the Rules for the Survey and Construction of Steel Ships** that have a design temperature over 500 °C.
    (e) Any pipes specified as Grade 4, No.22, No.23 and No.24 in **4.2**, **Part K of the Rules for the Survey and Construction of Steel Ships** that have a design temperature over 550 °C.
    (f) Any carbon steel pipes for ordinary piping specified in **4.2**, **Part K of the Rules for the Survey and Construction of Steel Ships** that are pipes of Group 1, pipes with a design pressure over 1.0 *MPa* or pipes with a design temperature over 230 °C.
    (g) All other steel pipes as to be deemed appropriate by the Society.
(2) Copper pipes and copper alloy pipes are not to be used for any of the following pipes:
    (a) Any pipes used for phosphorous-deoxidized-copper seamless pipes and brass seamless pipes and tubes for condensers that have a design temperature over 200 °C.
    (b) Any pipes used for cupro-nickel seamless pipes and tubes for condensers that have a design temperature exceeding 300 °C.
    (c) Section of pipes which penetrate partitions of Class *A* or Class *B* for copper alloy pipes

except in cases where the Society has given special approval.
(d) All service limitations regarding temperature for other copper pipes and copper alloy pipes are to be as deemed appropriate by the Society.
(3) Cast iron pipes are not to be used for the following pipes:
(a) Pipes of Group 1 and Group 2 for cast iron pipes that have an elongation that is less than 12 %.
(b) Pipes of Group 1 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.
(4) In addition to **(2)** and **(3)**, copper pipes, copper alloy pipes and cast iron pipes are not used for the place or location specified in the following **(a)** and **(b)**.
(a) Fuel oil pipes, lubricating oil pipes in machinery spaces, hydraulic oil pipes in machinery spaces, thermal oil pipes in machinery spaces, cargo oil pipes, air pipes and sounding pipes outside of sounding areas, except the followings.
i) The portion of pipes which is inside a tank is usable.
ii) Copper and copper alloys for control oil piping used to control each valve in machinery spaces.
iii) Copper pipes and copper alloy pipes for instrumentation piping for saturated steam piping with a design pressure of 1.6 *MPa* or less.
iv) Copper pipes and copper alloy pipes for thermal oil piping used for heat tracing of *F.O.* piping in machinery spaces, which are provided with appropriate protection,
v) Copper pipes used for air pipes for the remote closing of tank suction stop valves and for air pipes for the remote control of auxiliaries, valves, etc. used during a fire.
(b) Overflow pipes, bilge pipes, ballast pipes, drain pipes opening outboard and sanitary pipes, 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

11 Where pipes of aluminium alloys are used for fuel pipes and process pipes of LFF ships, aluminium alloys are to comply with the requirements in **8.2, Part K of the Rules for the Survey and Construction of Steel Ships**.

12 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** regulated separately, are to be used:
(1) Pipes of Group 1 or Group 2
(2) Pipes likely to cause fire or flooding in cases where they rupture.

13 In cases where plastic pipes are used, the requirements specified in **the Annex D12.1.6-2 "GUIDANCE FOR THE SURVEY AND CONSTRUCTION OF PLASTIC PIPES" of Guidance for the Survey and Construction of Steel Ships** regulated separately, are to be complied with.

14 Valves and pipe fittings are, as a rule, to be made of steel, copper alloy or cast iron and, except where otherwise specified, they are to conform to the requirements below for service limitations according to their design temperature, class, application, etc. However, for valves and pipe fittings which have an opening and are classified as Group 3 notwithstanding their design temperature, the service limitations regarding temperature do not apply.
(1) Cast steel products and forged steel products are not to be used for the following valves and pipe fittings
(a) Valves and pipe fittings with a design temperature over 425 ℃ for cast carbon steel products and forged carbon steel products specified in **5.1** and **6.1**, **Part K of the Rules for the Survey and Construction of Steel Ships**.
(b) Valves and pipe fittings with a design temperature over 550 ℃ for cast low alloy steel

products and forged low alloy products specified in **5.1** and **6.1**, **Part K of the Rules for the Survey and Construction of Steel Ships**.

(c) Other cast steel products and forged steel products when deemed appropriate by the Society.

(2) 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.

(3) 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 1 and Group 2 (except steam pipes of Grade 2)

(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 and pipe fittings of clean ballast piping systems which penetrate cargo oil tanks and reach the forepeak tank.

(i) Valves and pipe fittings of cargo oil piping systems with a design pressure over 1.6 *MPa*.

(j) Valves provided at the ship/shore connection of a flammable liquid cargo line.

(4) Cast iron products with an elongation of 12% or above are not to be used for valves and pipe fittings for pipes of Group 1.

(5) 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 divisions required to be install the fire protection measures by the requirements in **Part 9**.

(c) Piping in which the use of copper alloy pipes is prohibited by the requirements of **-10(2)**.

15 Materials used for steering gears are to comply with the requirement specified in **(1)** to **(3)**.

(1) Materials of the components specified in the following **(a)** and **(b)** are to comply with the requirements in **Part K of the Rules for the Survey and Construction of Steel Ships**.

(a) Tillers and bosses and vanes of rotary vane type rudder actuators.

(b) Bolts for assembling split type tillers and bolts for securing vanes to the bosses of rotary vane type rudder actuators.

(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.

(3) Materials of components other than those specified in **(1)** and **(2)** are to comply with *ISO*, *JIS* or other standard recognized by the Society.

16 Materials used in construction of torque-transmitting and load-bearing components of windlasses are to comply with the requirements specified in the following **(1)** or **(2)**.

(1) The materials are to be approved by the Society in accordance with the requirements in **Part K of the Rules for the Survey and Construction of Steel Ships**.

(2) The materials complying with *ISO*, *JIS* and other standards recognized by the Society are to be certified by the material manufacturers and are to be traceable to the manufacturers' certificates.

17 Materials for shaft of motors of important use are to comply with the requirements in **Part K**

of the Rules for the Survey and Construction of Steel Ships. For *GNS-C* ships and *GNS-D* ships, however, the materials of motors with an output less than 375 *kW* and motors driving the auxiliary machinery of cargo handling appliances specified in **Part 6**, are to comply with *ISO*, *JIS* and other standards recognized by the Society.

Chapter 3 WELDING AND MOULDING

3.1 General

3.1.1 General Requirements for Welding

1 Welding consumables used for welding of rolled steels for hull, equipment, machinery are to comply with the requirements in **Chapter 6 of Part M of the Rules for the Survey and Construction of Steel Ships**.

2 Where the hull, equipment, machinery, etc. are constructed by welding, welding are to be carried out by the welders having certification and passing qualification tests required by **Chapter 5 of Part M of the Rules for the Survey and Construction of Steel Ships**.

3 The manufacture is to be obtained the approval of the welding procedures and welding procedure specifications in accordance with the requirements in **Chapter 4 of Part M** or **11.2 of Part D of the Rules for the Survey and Construction of Steel Ships**.

3.1.2 Moulding of *FRP*

Workshops and facilities intending to manufacture *FRP* ships are to be approved by the Society in accordance with the requirements in **Chapter 3 of the Rules for the Survey and Construction of Ships of Fibreglass Reinforced Plastics**.

3.2 Welding of Hull Structures

3.2.1 General

1 The manufacture is to submit the welding application plan and welding procedure specifications including the welding condition and repairs, made in accordance with the requirements in **2.2.1** and **2.2.2 of Part M of the Rules for the Survey and Construction of Steel Ships** to the Society for approval, prior to welding works.

2 Shipbuilding quality standards such as survey standards including accuracy of fitting, welding works, etc., are to be agreed by the manufacturer and owner. The agreed shipbuilding quality controls us to be submitted to the Society for reference.

3.2.2 Welding Preparation and Welding Process for Rolled Steels for Hull

1 Welding preparation is to be in accordance with the requirements in **2.3 of Part M of the Rules for the Survey and Construction of Steel Ships**.

2 Welding process is to be in accordance with the requirements in **2.4 of Part M of the Rules for the Survey and Construction of Steel Ships**.

3 Where rolled steels are welded to steel forgings, carbon content of steel forgings is to be not more than 0.23 % and carbon equivalent is to be not more than 0.45 %.

3.2.3 Welding for Aluminium Alloys

1 The joint part of base material is to be mad sufficiently clean by using appropriate methods directly before welding as far as possible so that the oxide or other extraneous matter of surface does not become source of weld defects.

2 Since aluminium alloys have a larger solidifying shrinkage and the coefficient of expansion is 2 times of steels, and therefore the welding distortion or crack is easily generated in aluminium alloys, the following attentions are to be paid for welding.

(1) Jig, fixing device, etc., are to be used.

(2) Non-magnetic materials are to be used for the materials of jig and fixing device when there is a possibility of magnetic arc blow.

(3) Welding is to be carried out in symmetrical order to avoid twisting and bending.

(4) Care is to be taken to be free from ununiformity of restraint to a weld line.
(5) When the plates are different in thickness, restraint is to be strengthened.
(6) To prevent the welding distortion such as angular deformation, restraint or preset distortion by an appropriate method is to be adopted.
(7) The allowance for shrinkage is to be considered preliminarily.

3 Where the backing metals or backing are used for bull welding, the following attentions are to be paid.

(1) Non-magnetic materials such as follower metal and copper, or stainless steel are to be used for backing.
(2) Backing is to be clean and to have appropriate grooves as required.
(3) The same material as the base material in quality is in principle to be used for backing metal to be left as it is after completion of welding.

4 Where tack weld for temporally fixing or tack weld for fitting to structural members are used, the following attentions are to be paid.

(1) An appropriate root gap by the use of fixing device, spacer, etc., is to be kept to avoid stagger of plates at the time of regular welding.
(2) The length of bead and the thickness of throat are to be appropriate in order to avoid producing the weld defects such as crack.
(3) The tack welding is to be as little as possible in principle. The tack welding is to be avoided at corners, end parts and other important places where stress concentrate.
(4) The adhering matters such as black powder, oxide film, etc., which have been produced by the tack welding, are to be removed sufficiently before the regular welding.
(5) Harmful defects are to be completely removed when those have been produced in the tack welding.

5 Preheating and control of interpass temperature in welding for aluminium alloys are to be in accordance with the followings.

(1) In the case of aluminium alloys, preheating is not carried out as a rule. However, when it is necessary to execute welding of a thick plate with a relatively small current, preheating may be executed in order to facilitate the penetration and reduce the generation of weld cracks and blow holes by decreasing the cooling speed. In this case, the standard preheating is to be made below 200 °C for general cases, while below 100 °C to 150 °C in the case of the strain-hardened or heat-treated aluminium alloys.
(2) The interpass temperature is to be kept lower as far as possible.
(3) If the interpass temperature is high in the multi-layer welding, the preceding bead is excessively heat-affected, often causing generation of minor cracks due to the local intergranular fusion or coarsening of the base material in the vicinity of the bead.

6 The end tabs having the same material as that of the base metal should be fitted at both ends of welding butt joints, and the starts and ends of welding beads should be placed on the tabs, since the blowholes, cracks or the like might be generated at both ends of the welding joints. The starts and ends of welding without end tabs, joint of beads, or the like are to be welded particularly with care by deliberating of the position of arc starts, or by the method of the crater filler or the like, or an appropriate countermeasure are to be taken such as continuing the welding beads by fully removing the craters, and the welding beads are to be examined as found necessary.

7 When the fillet welding is carried out on only one side, the end part is in principle to be welded with boxing. The length of boxing is to be about 20 *mm*.

8 The back chipping is to be carried out until weld defects at the first layer are removed when the back chipping is necessary. Lubricant is not to be used in this case. When foreign matter such as black powder, impurities, etc., exists, those are to be removed sufficiently by brushing, chipping and other appropriate methods.

9 The generated welding distortion is to be corrected by an appropriate mechanical method (which is a method giving no damage on the surface of the base material) and a point or linear heating method. Attention is to be paid to maximum heating temperature when the removal of welding distortion by quenching or hot working after heating is carried out.
10 The welds are to be subjected to visual examination and non-destructive examination specified in the requirements of **2.1.6**, **Part 2**.
11 The welds are to be sound and free from defects such as crack, excessive reinforcement or underfill, harmful undercut or overlap, lack of fusion, lack of penetration, porosity and so on.
12 The surfaces of welds are to be reasonably smooth. The flank angle at the toe of bead made by base material and bead surface is to be sufficiently large.
13 Welded joints are to be reasonably free from excessive mis-alignment and welding distortion.
14 The welding defects found in visual examinations, non-destructive examinations or other examinations by the Surveyor are to be removed, corrected and re-examined.

3.2.4 Moulding of *FRP*

Moulding of *FRP* is to be in accordance with the requirements in **Chapter 5 of the Rules for the Survey and Construction of Ships of Fibreglass Reinforced Plastics**.

3.3 Welding for Machinery Installations

3.3.1 General

1 The requirements in this Section apply to welding for machinery installations. 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.
2 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.

3.3.2 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 $220\times25/t$ (°C/*hr*), but under any circumstances not more than 220 (°C/*hr*)
  - ii) The cooling rate $275\times25/t$ (°C/*hr*), but under any circumstances not more than 275 (°C/*hr*)

    t: Maximum weld thickness (*mm*)
- (c) The holding temperature of the furnace for carbon steel, carbon manganese steel, etc. is to be 600 °C and for 21/4*Cr*1*Mo* steel and 5*Cr*0.5*Mo* is to be 680 °C, and 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 the approved temperature.
- (d) During heating and cooling periods, temperature variation throughout the portion being heated shall not be a greater than 130 °C within any 4,500 *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 specified in **(1)(b)**.

(d) The holding temperature and the period of the post weld heat treatment are to conform to the requirements specified 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.

3 For post weld heat treatment procedures on materials (2-2.5*Ni* steels, 3.5*Ni* steels) other than those specified in **-1**, the requirements are to be specially considered by the Society according to the type of base metal, the welding materials and the welding procedures.

4 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.

3.3.3 Temperature Measurements and Recordings during Post Weld Heat Treatment

1 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.

2 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

3.3.4 Welding of Boilers

1 For the alignment of butt welded joints at portions subject to the pressure of boilers, 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.

3 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

4 In cases where minor fillet welding is carried out for the following items **(1)** and **(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.

5 For welded joints of boiler shells, production weld tests are to be carried out. *FRP* the welded joints of furnace plates, a guided bend test, a roller bend test, or a radiographic test may be tested as production weld tests. 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.

6 Tests for the welded joints of test plates specified in **-5**, such as tensile test for joint (1 tensile test specimen), bending tests (each 1 test specimen for a face bend test and a root bend test or 1 test specimen for a side bend test), and a macro-etching test (1 test specimen) are to be carried out. Guided bend tests or roller bend tests may be accepted as the bend test. Test specimens are to comply with the requirements in **Part M of the Rules for the Survey and Construction of Steel Ships**.

7 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.

8 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.

9 For boiler shells (including headers), the entire length of both the longitudinal and the circumferential welded joints are to be subjected to radiographic testing. 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: For thickness of base metal not more than 12 *mm*, allowable height of reinforcement is to be not more than 1.5 *mm*, for thickness of base metal more than 12 *mm* but not more than 25 *mm*, allowable height of reinforcement is to be not more than 2.5*mm*, and for thickness of base metal more than 25 *mm*, allowable height of reinforcement is to be not more than 3.0 *mm*.

(2) Single-welded butt joints: To be 1.5 *mm* or less, regardless of the plate thickness

10 In cases where there are defects such as crack, lack of fusion, incomplete penetration, etc., are found as a result of radiographic test, the defective parts are to be chipped off and rewelded. In cases where defects such as blow-holes and slag-inclusions found as a result of radiographic test, the defective parts 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. In cases where repairs are carried out on welded joints, the repaired part of the joint is to be subjected to a radiographic testing once again.

11 Notwithstanding the requirements in **-9**, other appropriate non-destructive testing may be conducted in lieu of the radiographic testing using a radiograph film in cases where the Society specifically grants approval.

12 For important welds other than longitudinal joints and circumferential joints, appropriate non-destructive tests such as a radiographic testing, ultrasonic testing are to be carried out.

3.3.5 Welding of Pressure Vessels

1 For the alignment of the butt welded joints, the maximum offset is not to exceed the following limits.

(1) Alignment of the butt welded joints

 (a) For longitudinal joints, joints in end plates and joints between hemispherical end plates and shells

  i) $t/4$ for plates with an actual thickness (t) of 50 *mm* or less (maximum: 3.2 *mm*)

  ii) $t/16$ for plates with an actual thickness (t) of more than 50 *mm* (maximum: 9 *mm*)

 (b) For circumferential joints

  i) $t/4$ for plates with an actual thickness (t) of 40 *mm* or less (maximum: 5 *mm*)

  ii) $t/8$ for plates with an actual thickness (t) of more than 40 *mm* (maximum: 19 *mm*)

 (c) 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 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.

(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.

2 Pressure vessels of Group 1 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.

3 Pressure vessels of Group 2 installed on *GNS-A* ships and *GNS-B* ships, 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. Pressure vessels of Group 2 installed on *GNS-C* ships and *GNS-D* ships, corresponding to the following **(1)** or **(2)** are to be subjected to spot weld heat treatment for stress relieving after all fittings, such as flanges, nozzles and reinforcement plates, have been welded in place.
(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 formula (T_n = (Inside diameter of shell (*mm*)) /120 + 10).

4 Notwithstanding the requirements in **-2** and **-3**, 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.

5 In cases where materials having superior notch toughness complying with the following requirements are used, stress relieving may be omitted if approved by the Society.
(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 specified in **Part K of the Rules for the Survey and Construction of Steel Ships** at a temperature of 0 °C.
(2) The impact test value of welds in the production weld tests specified in **3.3.5-6** 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.

6 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.

7 In cases where pressure vessels of Group I are of welded construction, production weld tests 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 are to be a tensile test for joints (1 tensile test specimen), a bend test (I face bend test specimen and 1 root bend test specimen or 1 side bend test specimen for test plate thickness more than 20 *mm*) and a Charpy impact test (1 set of test specimen) are to be carried out. Guided bend tests or roller bend tests may be accepted as the bend test.

(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 **3.3.4-7 (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.

8 Production weld tests of pressure vessels of Group 2 of welded construction are to be conducted in accordance with the requirements in **-6**. For *GNS-C* ships and *GNS-D* ships, however, the guided bend tests or roller bend tests specified in **-6(2)** may be omitted.

9 Where the production tests specified in **-6** and **-7** fail, retest specified in the following **(1)** and **(2)** are to be carried out.

(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.

10 Non-destructive testing for welded joints of pressure vessels specified in the following **(1)** to **(5)** are to be carried out.

(1) The entire length of butt weld joints corresponding to the following **(a)** or **(b)** are to be subjected full radiographic testing. Ultrasonic testing may be conducted in lieu of the radiographic testing in cases where the Society specifically grants approval.

(a) Longitudinal and circumferential weld joints of pressure vessels of Group I

(b) 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. Ultrasonic testing may be conducted in lieu of the radiographic testing in cases where the Society specifically grants approval.

(a) 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.

(b) 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 **3.3.4-9** and **-10**.

(4) 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. 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 according to the sampling method.

3.3.6 Welding of Piping

1 The welding, preheating of welds and post weld heat treatment of pipes, valves and pipe fittings belonging to Group 1 and 2 are to comply with the requirements specified in the following **(1)** to **(3)**.

(1) Allowable alignment of Joints are to be in accordance with the following **(a)** to **(d)**.

(a) In cases where a backing strip is used; 0.5 *mm*, regardless of the thickness of pipes

(b) In cases where no backing strip is used, and 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.

(c) In cases where no backing strip is used, and 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.

(d) In cases where no backing strip is used, and 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.

(2) Preheating for pipes is to be carried out at the minimum preheating temperature specified in **Table 3.3.1** according to the grade of the materials and their thickness.

(3) After any welding, pipes of a thickness specified in **Table 3.3.2** are to be subject to post weld heat treatment for relieving any residual stress according to the grade of the material used. Regarding the post weld heat treatment of pipes and piping systems that are made of materials other than those given in **Table 3.3.2**, 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.

Table3.3.1 Minimum Preheating Temperature

Grade of Material		Thickness of weld (*t*) (*mm*)	Minimum preheating temperature (℃)
Grade 1, Grade 2 and Grade 3 specified in **4.2 of Part K of the Rules for the Survey and Construction of Steel Ships**	*C* + *Mn*/6 t K	*t* ≥20 *1	50
	C + *Mn*/6 >0.4	*t* ≥20 *1	100
Grade 4 specified in **4.2 of Part K of the Rules for the Survey and Construction of Steel Ships**	No. 12	*t* ≥ 13 *1	100
	No. 22 and No. 23	*t* < 13 *2	100
		t ≥ 13	150
	No. 24	*t* < 13 *2	150
		t ≥ 13	200

(Note)

*1 In cases where welding is carried out at an ambient temperature less than 0 ℃, 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.

*2 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.

Table3.3.2 Pipes Requiring Post Weld Heat Treatment

Grade of Material		Kind of Steels	Thickness of weld *t* (*mm*)
Grade 1, Grade 2 and Grade 3 specified in **4.2 of Part K of the Rules for the Survey and Construction of Steel Ships**		Carbon steel, Carbon manganese steel, 0.5*Mo*steel, 0.5*Cr*0.5*Mo* steel, 1*Cr*0.5*Mo* steel, 11/4*Cr*0.5*Mo* steel	*t* ≥ 15
Grade 4 specified in **4.2 of Part K of the Rules for the Survey and Construction of Steel Ships**	No.12		
	No. 22 and No.23		*t* > 8
	No. 24	21/4*Cr*1*Mo* steel, 5*Cr*0.5*Mo* steel	All *1

(Note)

*1: For *GNS-C* ships and *GNS-D* ships, and where the thickness is 8 *mm* or less, the outside diameter is 100 *mm* or less and the design temperature is 450 ℃ or less, this treatment may be omitted.

2 Non-destructive testing for weld of pipes are to comply with the requirements specified in the following **(1)** to **(5)**.

(1) Butt weld joints of Group 1 pipes having nominal diameters exceeding 65*A* are to be subjected to full radiographic testing.

(2) For *GNS-A* ships and *GNS-B* ships, butt weld joints of Group 1 pipes having nominal diameters not more than 65*A* and Group 2 pipes having nominal diameters exceeding 90*A* are to be subjected to full radiographic testing.

(3) For *GNS-A* ships and *GNS-B* ships, butt weld joints of Group 2 pipes having a nominal diameter not more than 90*A* and for *GNS-C* ships and *GNS-D* ships, butt weld joints of Group 1 pipes having a nominal diameters not more than 65*A* and Group 2 pipes having a nominal diameters more than 90*A*, are to be subjected to a radiographic testing by sampling in accordance with the instructions of the Surveyor.

(4) The Society may approve other appropriate non-destructive testing in lieu of a radiographic testing.

(5) With respect to the fillet welding of Group 1 or Group 2 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.

3.3.7 Welding of Principal Components of Prime Movers, etc.

1 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.
2 In butt weldings between plates of different thickness, the end of the thicker plate is to be smoothly tapered up to 1/4 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 Where the principal components of prime movers are welded, 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*
5 In cases where fillet welding is carried out in areas subjected to bending stress, toe parts are to have a smooth finished.
6 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. 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.
7 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.
8 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 4 PAINTINGS

4.1 General

4.1.1 General

1 All steel works are to be coated with a suitable dry paint. Special requirements may be additionally made by the Society in accordance with the kind of ship, purpose of spaces, etc. However, where it is recognised by the Society that the spaces are effectively protected against the corrosion by means other than painting or due to the properties of the cargoes, etc., painting may be omitted.
2 Surfaces of steelworks are to be thoroughly cleaned and loose rust, oil and other harmful adhesives are to be removed before being painted. At least the outer surfaces of shell plating below the load line are to be sufficiently free from rust and mill scale before painting.
3 Structural members of aluminium alloys works are recommended to be coated with suitable paints.
4 Outer shell of *FRP* craft are to be coated with suitable gelcoats or compositions having the property of low water absorption.
5 Where two or more kinds of different metallic materials (for example, steel and aluminium alloy) are used for structural members of a craft, different metals are to be insulated by electrical insulation having the property of anti-water absorption against galvanic corrosion. Where two or more kinds of different metallic materials (for example, steel and aluminium alloy) are used for structural members of a ship and such different metals are closed to each other in salt water, suitable methods against galvanic corrosion are to be applied.
6 For chlorinated rubber paint, a chlorinated rubber paint product not containing carbon tetrachloride is to be used.

4.1.2 Protective Coatings in Dedicated Seawater Ballast Tanks

1 For painting for dedicated seawater ballast tanks, the requirements are to be complied with **PERFORMANCE STANDARD FOR PROTECTIVE COATINGS FOR DEDICATED SEAWATER BALLAST TANKS IN ALL TYPE OF SHIPS AND DOUBLE-SIDE SKIN SPACES OF BULK CARRIERS** (*IMO* Performance Standard for Protective Coatings for Seawater Ballast Tanks, etc. / *IMO* resolution *MSC*. **215(82)** as may be amended).
2 For painting for dedicated seawater ballast tanks, the following attentions are to be paid.
(1) Applicable paints are to be an epoxy type or a type that is as durable and effective against corrosion.
(2) The surfaces of steels are to be properly prepared before coating and the thickness of the coating is to be adequate.
(3) It is recommended that cathodic protection is applied together with the coatings as a backup.
(4) The coatings are recommended to be of a light colour, *i.e.* a colour easily distinguishable from rust which facilitates inspection.

4.1.3 Painting of Fresh Water Tanks

Fresh water tanks are to be painted using a suitable paint such as a polyurethane resin pain after surface preparation and painting by anti-corrosive paint.

4.1.4 Painting of Tanks Intended to Carry Flammable Liquids

Corrosion protection in accordance with the following **(1)** or **(2)** is to be applied to the cargo oil tanks.
(1) Coatings in accordance with the **PERFORMANCE STANDARD FOR PROTECTIVE COATINGS FOR CARGO OIL TANKS OF CRUDE OIL TANKERS** (*IMO* Performance

Standard for Protective Coatings for Cargo Oil Tanks / *IMO* resolution *MSC*. 288(87) as may be amended); or

(2) Alternative means in accordance with the **PERFORMANCE STANDARD FOR ALTERNATIVE MEANS OF CORROSION PROTECTION FOR CARGO OIL TANKS OF CRUDE OIL TANKERS** (*IMO* Performance Standard for Alternative Means of Corrosion Protection for Cargo Oil Tanks / *IMO* resolution *MSC*. 289(87) as may be amended).

4.1.5 Painting of Other Spaces and Piping, etc.

1 Paints used for painting the inside of the accommodation spaces, service spaces and control stations are to be of a suitable one deemed appropriate by the Society, taking into account the characteristics of flame spread, combustibility, calorific value, smoke production, etc.

2 Principal components of machinery and equipment are to be coated with suitable paints or are to be protected against corrosion by other suitable measures.

3 Inside of pipes are to be protected by the anti-corrosive measures such as galvanization. However, for pipes having a thicker thickness with larger corrosion margin than that required by the relevant requirements or for pipes made of steel casting, paint of inside of pipes may be dispensed with.

4 An access to the steering gear, each space of hull, machinery installations and control units in machinery space and working spaces are to be painted by non-slip type paint.

5 Pipes located in spaces where deemed necessary for safety are to be marked with distinctive colours to avoid any mishandling.

6 All valves which are used for fire extinguishing are to be painted red.

7 Inside of the compartment for storage of battery including a shelf is to be painted by anti-corrosive paint.

8 Inside of ventilation duct and impellers of ventilation fan made of materials except anti-corrosive ones, are to be painted by anti-corrosive paint.

9 All components of release hook, handle for release, control cable or mechanical link system for operation provided to launching appliances for life boat, life raft and rescue boat and joint parts with structure for securing life boat are to be of anti-corrosive materials in marine environment which are not necessary to painting or galvanizing.

10 Inside of the box for navigation lights is to be painted by the frosted black paint.

4.2 Anti-fouling Systems

4.2.1 Ships Affixed with the Class Notation "*AFS*"

1 Anti-fouling systems on ships are to be controlled so as to limit any substances deemed harmful to the marine environment.

2 Paints used for anti-fouling systems are not to contain organization compounds. However, paints containing organization compounds of 2,500 *mg* total tin per 1 *kg* of dry paint may be accepted.

4.3 Cathodic Protection System

4.3.1 Ships Affixed with the Class Notation "*CoC*"

1 For ships affixed with the class notation "*CoC*", cathodic protection systems or impressed current protection systems are to be provided for parts exposed to sea water, in addition to the compliance with the requirements specified in **4.1** and **4.2**.

2 Where sacrifice anodes are provided as cathodic protection systems, they are to comply with the requirements specified in the following **(1)** to **(7)**.

(1) Anodes are to be of zinc or aluminium alloys. Anodes of magnesium or magnesium alloy are not permitted.

(2) The dimensions, weights, shapes and arrangements of anodes are to be designed so that the environment condition (seawater or fresh water, temperature, change over the years of water quality such as *pH* value, and so on), electric potential and electric current density, etc. are considered appropriately.

(3) The anodes are to have steel cores and these are to be sufficiently rigid to avoid resonance in the anode support and be designed so that the anode does not come free when the surroundings become wasted.

(4) The anode is to be provided in accordance with **(a)** or **(b)**. When anode inserts and/or supports are welded to the structure, they are to be arranged so that the welds are clear of stress raisers. The supports at each end of an anode are not to be attached to separate structures which are likely to move independently.

(a) The steel inserts are to be attached to the structure by means of a continuous weld of adequate section.

(b) The steel inserts are to be attached to separate supports which are attached to the structure by means of a continuous weld of adequate section, by bolting, provided a minimum two bolts with locknuts are used or by appropriate mechanical means of clamping deemed as equivalent by the Society.

(5) Where inserts or supports of anodes are welded to local supporting members or primary supporting members, the welds for end parts of supporting members and end parts of brackets as well as stress concentration parts are to be avoided.

(6) Where anodes are welded to asymmetric structural members, the anodes are to be welded at least 25 *mm* apart from the end of the web. For the symmetric face plate of stiffener or girder, the anodes may be welded on the center line of the web or the face plate, but it is sufficiently apart from the free edge.

(7) In principle, anodes are not to be fitted to the face plate of high tensile steels. Where anodes fit to the face plate of high tensile steels, the details for their fitting are to be approved by the Society.

3 Plates of impressed current protection systems are to be of insoluble and durable base metals such as titanium.

4 Where cathodic protection systems are adopted to cargo tanks and their adjacent tanks in ships intended to carry crude oil and petroleum products having a flash point not exceeding 60 ˚C and Reid vapour pressure below atmospheric pressure or other liquid cargoes having similar fire hazards, cathodic protection systems are to be in accordance with the following requirements.

(1) Where anodes of aluminum or aluminium alloys are used, the anodes are to comply with the requirements specified in the following **(a)** and **(b)**.

(a) Anodes are to be located such that their potential energy does not exceed 274.68 *N-m*. The heights of anodes are to be measured from the bottom of the tank to the centre of the anodes, and their weights are to be taken as the weight of the anodes fitted, including the fitting devices and inserts. Where width of anodes are not less than 1 *m* and where the anodes are fitted to horizontal structural members with upstanding flanges or face flats projecting not less than 75 *mm* above their horizontal surfaces, however, the heights of anodes may be measured from the surfaces of the horizontal structural members.

(b) Anodes are not to be located under tank hatches or butterworth openings, unless protected from any objects falling on the fitted anodes by an adjacent structure.

(2) Where impressed current protection systems are adopted, plates of magnesium or magnesium alloy are also not permitted.

Part 4 SUBDIVISIONS AND STSBILITY

Chapter 1 GENERAL

1.1 General

1.1.1 Application

The requirements in this Part apply to arrangements of compartments, determination of draught and stability of ships.

1.1.2 General Requirements

1 Ships are to have sufficient buoyancy, stability and characteristics of stability under intact condition at all stages of the voyage and under damage condition expected during operations of ships.

2 Sufficient buoyancy is to be ensured, provided that appropriate size and number of watertight compartments that have sufficient strength and scantlings of structural members in order to ensure the watertight integrity are arranged in the ship. Measures for protection of openings, piping, pipe and duct penetrations in order to ensure the integrity of watertight compartments are to be taken.

3 Ships are to have sufficient buoyancy and stability in case of failure or malfunction or misoperation of equipment, etc.

1.1.3 Limitation of Arrangement of Accommodation Spaces, etc.

1 Accommodation spaces are not to be arranged forward of the collision bulkhead specified in **1.2.2**.

2 In principle, accommodation spaces are not to be arranged in adjacent to compartments carrying flammable liquids or dangerous goods, bulkheads or top of fuel oil tanks. Cofferdams having clear spaces for personnel access and having sufficient ventilation system are to be provided between accommodation spaces and such compartments.

3 Regardless of the requirement in **-2**, where compartments carrying flammable liquids or dangerous goods and the top of fuel oil tank have no opening and their boundaries are covered by coating materials deemed appropriate by the Society, or ventilation systems for accommodation spaces are enhanced than those required by **10.2 of Part 6**, accommodation spaces may be arranged without cofferdams.

4 Equipment or systems for propulsion, emergency generators, etc. are not to be arranged forward of the collision bulkhead.

1.1.4 Limitation of Carriage of Oils

Oils or other flammable liquids are not to be carried in tanks forward of the collision bulkhead specified in **1.2.2**.

1.2 Arrangement of Watertight Bulkheads

1.2.1 General

1 All ships are to have the transverse watertight bulkheads specified in the followings.

(1) Collision bulkhead

(2) After peak bulkhead

(3) Bulkheads provided at forward and aft end of machinery spaces

2 Ships are to have the transverse watertight bulkheads at reasonable intervals in order to ensure sufficient transverse strength of hull and to satisfy with the damage stability requirements specified in **Chapter 3**, in addition to those required in **-1**.

3 The transverse watertight bulkheads are generally to be extended from port side to starboard side of the ship and from the bottom to bulkhead deck. Where ships have a damage control deck, however, the transverse watertight bulkheads may be extended to the damage control deck instead of bulkhead deck.

4 Openings arranged in the transverse watertight bulkheads and penetrations for pipes, ventilation ducts and electric cables are to be watertight.

1.2.2 Collision Bulkheads

1 All ships are to have a collision bulkhead, at a position not less than 0.05 L_f or 10 m, whichever is less, from the forward terminal of L_f defined in **2.3.2, Part 1**, but not more than 0.08 L_f or 0.05 L_f + 3.0 (m), whichever is greater, However, where any part of the ship below the waterline at 85 % of the least moulded depth extends forward beyond the forward terminal of L_f, 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 0.015 L_f forward from the above-mentioned forward terminal

(3) A distance 3 m forward from the forward terminal

2 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 line are to be submitted to the Society and approved by the Society, the collision bulkhead may be arranged at a position aftward 0.08 L_f or 0.05 L_f + 3.0 (m), whichever is greater, from the forward terminal of L_f.

3 The bulkhead may have steps or recesses within the limits specified in **-1** and **-2**.

4 Any access openings, doors, manholes or ducts for ventilation, etc. are not to be cut in to the collision bulkhead below the bulkhead deck (the damage control deck where damage control deck is arranged). Where a forward superstructure having openings without closing appliances leads to a space below the freeboard deck, or a forward superstructure with length of 0.25 L_f and more is provided, a collision bulkhead is to extend up to a deck above the freeboard deck and is to be weathertight. In this case, the number of openings in the extension of the collision bulkhead is to be kept to a necessary minimum and all such openings are to be provided with weathertight means of closing.

5 Where a ship has a damage control deck and where openings such as door are provided in the collision bulkhead between the part above damage control deck and below bulkhead deck, the number of openings in this part is to be kept to a necessary minimum and all such openings are to be provided with weathertight means of closing.

6 In ships with bow doors, the collision bulkhead under the deck just above the freeboard deck is to comply with the requirements mentioned in **-1** to **-4**. However, where a sloping ramp forms a part of the collision bulkhead above the bulkhead, the part of the ramp which is more than 2.3 m above the bulkhead deck may extend forward of the limit specified in **-1** above. In this case, the ramp is to be weathertight over its complete length. However, ramps not meeting the above requirement are to be disregarded as an extension of the collision bulkhead.

7 Bulkheads not complying with the requirements specified in **-1** to **-6** are regarded as neither the collision bulkhead nor effective transverse watertight bulkheads.

1.2.3 After Peak Bulkheads

1 All ships are to have an after peak bulkhead situated 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 by taking measures to minimize the danger of water penetrating into the ship in case of damage to stern tube arrangements.

3 Where a watertight deck arranged below freeboard deck and above the maximum load water line or a damage control deck is arranged and the deck from the after peak bulkhead up to the end of ship are watertight, the after peak bulkhead may be extended to this bulkhead. In this case, extension part is to be complied with the requirements specified in **1.2.2-5**.

1.2.4 Machinery Space Bulkheads

1 At the forward end and aft end of machinery space, watertight machinery space bulkheads which extend to the bulkhead deck are to be arranged.
2 Where accommodation spaces are arranged above the machinery space, the deck consisting of the upper structure of the machinery space is to be airtight. Where openings are provided in the deck, all openings are to be provided with closing appliances with gasket.
3 The bulkhead arranged aft end of the machinery space may be considered as the after peak bulkhead specified in **1.2.3**.

1.2.5 Other Transverse Watertight Bulkheads

1 For ships whose L is less than 186 m, the number of transverse watertight bulkhead is to be not less than that specified in **Table 4.1.1** corresponding to the ship's length, in addition to the transverse watertight bulkhead required by **1.2.1** to **1.2.4**. However, where the distance between two neighbouring bulkheads is less than $0.7\sqrt{L}$ or 0.05 L_f (m), whichever is lesser, these two bulkheads are not counted as two bulkheads.

Table 4.1.1 Total number of transverse watertight bulkheads

Length of ship L	Total number of transverse watertight bulkheads
$L < 87m$	4
$87\ m <= L < 102\ m$	5
$102\ m <= L < 123m$	6
$123\ m <= L < 143\ m$	7
$143\ m <= L < 165\ m$	8
$165\ m <= L < 186\ m$	9

2 The total number of transverse watertight bulkhead for ships whose L is not less than 186 m may be accepted to the number complied with the requirements on transverse strength of hull and strength under flooding condition specified in **Part 5** and the requirements on damage stability specified in **Chapter 3** of this Part.
3 Regardless of length of a ship, where the ships comply with the requirements on transverse strength of hull and strength under flooding condition specified in **Part 5** and the requirements on damage stability specified in **Chapter 3**, the total number of transverse watertight bulkheads different from that specified in **-1** may be accepted.

1.2.6 Chain Lockers

1 Where chain lockers are arranged aft of the collision bulkhead or in the fore peak tank, chain lockers including spurling pipes are to be watertight up to the weather deck and to be provided with a means for drainage.
2 Chain lockers are to be subdivided by centre line screen walls.

1.3 Watertight Doors, etc.

1.3.1 Watertight Doors, etc.

1 All openings in the watertight bulkheads and the part of the deck which forms the step of the bulkheads are to be closed by watertight closing appliances (referred to as watertight doors in this chapter) in accordance with the requirements in **4.3.2, Part 6**.

2 Watertight doors as specified in **-1** above are to be normally closed at sea, except where deemed necessary for the ships operation by the Society. Watertight doors or ramps fitted to internally subdivided cargo spaces are to be permanently closed at sea.

3 Where openings are arranged in walls required being watertight by the requirements in **Chapters 2** and **3** of this Part, which are located above freeboard deck, the openings are to be complied with the requirement in **-1**.

4 Manholes and flush deck openings in exposed positions on the freeboard deck, damage control deck and superstructure decks or within superstructures other than enclosed superstructures are to be closed by steel covers capable of being made watertight. These covers are to be secured by closely spaced bolts or to be permanently fitted.

5 Watertight doors located above the bulkhead deck are to also comply with the requirements for doors provided for means of escape specified in **Chapter 11, Part 9**.

1.3.2 Weathertight Doors, etc.

1 Access doors in the end bulkhead of enclosed superstructures, access openings giving access to a space below the freeboard deck or a space within an enclosed superstructure and access openings of deckhouses in order to protect the access openings are to comply with the requirements specified in the following **(1)** to **(5)**.

(1) The doors are to be made of steel or other equivalent materials and to be permanently and rigidly fitted to the bulkheads.

(2) The doors are to be rigidly constructed, to be of equivalent strength to that of intact bulkhead and to be weathertight when closed.

(3) The means for securing weather-tightness are to consist of gaskets and clamping devices or other equivalent devices and to be permanently fitted to the bulkhead or the door itself.

(4) The doors are to be operated from both sides of the bulkheads.

(5) Hinged doors are, as a rule, to open outward.

2 The height of sills of access openings specified in **-1** is not to be less than 380 *mm* above the upper surface of the deck. Where the assumption is made that sea water is down flooded from this access opening in applying the requirements specified in **Chapter 2** and **3** or the access openings are to be watertight in accordance with the requirements in **1.3.1**, the height of sills deemed appropriate by the Society may be accepted. However, in principle, portable sills are not permitted.

1.4 Draught

1.4.1 General

1 Designed maximum load lines and the distances between the designed maximum load lines and freeboard decks of ships are to be so determined that ships comply with the intact stability requirements specified in **Chapter 2** and the damage stability requirements specified in **Chapter 3**.

2 For *GNS-A* ships, draughts and hull forms are to be so designed to reduce the heaving and pitching motions of ship and relative motions to waves.

(1) Natural periods of heaving and pitching motions of the ships is to be avoided their resonant periods to the average wave periods. Especially, for high speed ships defined in **1.2.5, Part 1** and for other ships whose speed is relatively high, it is recommended that the ratio of the length of ship to displacement be as large possible.

(2) Water plane areas are to be large in comparison to displacement.

(3) Taking into account relative water heights at the forward ends and aft ends of ships, the distance between the deck in question and the waterline is to be sufficiently ensured so as to avoid any immersion of the deck in question.

(4) Forecastle structures are to be provided or sufficient height from the deck at the forward end to the waterline is to be ensured so as to reduce the impact of green seas.
(5) Draughts at the forward ends of ships are to be not less than 0.037*L*, except in cases where the bottom structures of forward parts of ships are sufficiently reinforced.
(6) Draughts of the ends of ships and the shapes of stern structures are so determined to prevent any considerable reduction of the propeller efficiency caused by the exposure of the bottoms of stern structures.

3 For *GNS-B* ships, the requirements in **-1** and **-2** are to be applied as far as possible.

4 For *GNS-C* ships and *GNS-D* ships, load lines and freeboards may be determined based on the International Conventions on Load Lines, instead of the requirements in **-1** and **-2**.

1.4.2 Marking of Draughts

1 Ships are to have scales for draughts marked clearly at their bows and sterns as well as at mishap.

2 Ships whose draught marks are not located where they are easily readable, or whose hull shapes or equipment, etc. Make it difficult to read their draught marks are to also be fitted with reliable draught indicating systems by which bow and stern draughts can be determined.

3 All ships need not mark their freeboards. In addition, this provision also applies to ships whose load lines and freeboards are determined based upon the International Conventions on Load Lines in accordance with the requirements in **1.4.1-4**.

Chapter 2 INTACT STABILITY

2.1 General

2.1.1 General Requirements

1 Stability curves and heeling moment curves taking into account of the effects of changes in trim during heeling are to be prepared by methods deemed appropriate by the Society for all design loading conditions and are to be verified to comply with the requirements in **2.2** and **2.3**.

2 Free surface effects are to be accounted for in all conditions of loading.

3 In cases where anti-rolling devices such as fin stabilizers, anti-rolling tanks, are installed in a ship, the requirements given in **2.2** and **2.3** 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 devices.

4 Where influences such as the icing of topsides, water trapped on deck, etc. are expected to affect stability adversely, such effects are to be appropriately considered, so far as is deemed necessary.

5 Provisions are to be made for safe margins of stability at all stages of voyages, with 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 the 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 Part are to be satisfied whether the devices are in operation or not.

(4) Where ships have well-docks or similar structures in their hulls, such spaces are either not to be included in stability calculations or are to take into account the most severe condition for stability.

(5) In calculation of stability curves, the following portions may be included in addition to hull below upper deck.

  (a) Superstructures of first and second tiers above freeboard deck complying with the requirements in (10)(b) of Regulation 3, Annex I of Attachment 1 of International Convention on Load line, 1966 (hereinafter referred to as *ILLC* in this Part).

  (b) Deckhouses of first tier above freeboard deck complying with the requirements in (10)(b) of Regulation 3, *ILLC*.

  (c) Trunks

  (d) Hatchways with effective closing means

  (e) Portion of superstructures or deckhouses up to an angle above which seawater will flow-in through openings, even though the superstructure or deckhouse is not regarded as enclosed. In a heeled condition exceeding the angle above, the flooded space is to be considered to have no buoyancy.

(6) In calculation of stability curves, all openings within any deckhouses may be regarded as closed. However, such openings within the deckhouse, of which the doors do not comply with the requirements in Regulation 12, *ILLC* are to be fitted with closing devices complying with the requirements in Regulations 15, 17 and 18, *ILLC*.

2.2 General Stability Requirements

2.2.1 Stability Curve

1 The stability curves are to comply with the following requirements in **Fig. 4.2.1**.

(1) A_1 is not to be less than 0.055 $m \cdot rad$.

(2) A_2 is not to be less than 0.03 $m \cdot rad$.

(3) ($A_1 + A_2$) is not to be less than 0.09 $m \cdot rad$.

(4) GZ is to be at least 0.20 m at an angle of heel equal to or greater than 30°.

(5) θ_{MAX} is not to be less than 25°. For ships with B_{WL}/D more than 2.5, θ_{MAX} may be taken not to be less than 25°.

(6) G_0M is not to be less than 0.15 m.

where

A_1: Area under stability curve between 0° and 30° ($m \cdot rad$).

A_2: Area under stability curve between 30° and θ_u ($m \cdot rad$).

θ_u: Heeling angle (*degree*) to be taken of whichever is less, downflooding angle in the relevant loading condition or 40°.

Where, downflooding angle refers to the angle of heel at which openings in the hull, superstructures or deckhouses which cannot be closed weathertight, immerse.

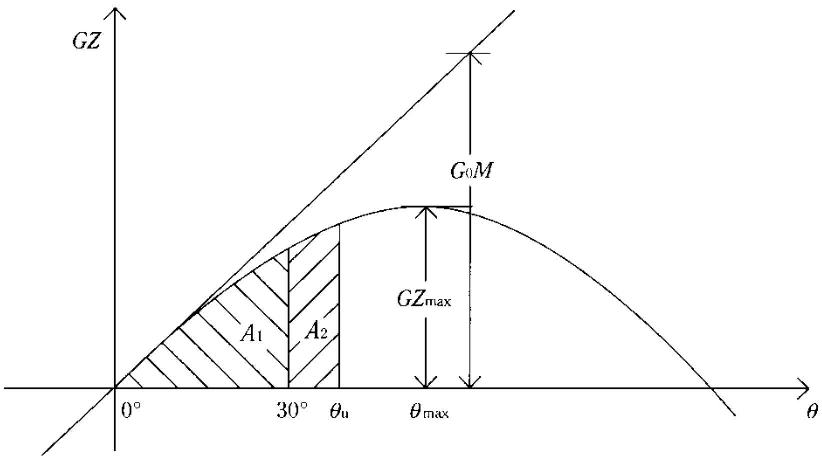
GZ_{max}: Maximum righting lever (m).

θ_{MAX}: Heeling angle at which the righting arm reaches maximum (*degree*).

G_0M: Initial metacentric height corrected by free surface effect (m).

For ships with B_{WL}/D *more than 2.5, area under stability curve between 0° and* θ_{MAX} in **Fig. 4.2.1** may be taken as $0.055 + 0.001(30 - \theta_{MAX})$

Fig. 4.2.1 Stability Curve (General Stability Requirements)



2 For high speed ship navigating in threat sea area, the stability curves are to comply with the requirements specified in the following **(1)** to **(6)**.

(1) The area under the righting lever curve (GZ-curve) is not to be less than 0.07 *m-rad* up to $\theta = 15°$ when the maximum righting lever (GZ_{MAX}) occurs at $\theta = 15°$ and 0.055 *m-rad* up to $\theta = 30°$ when GZ_{MAX} occurs at $\theta = 30°$ or above.

(2) Where GZ_{MAX} occurs at angles of between $\theta = 15°$ and $\theta = 30°$, the corresponding area under the righting lever curve is not to be less than that obtained from the following formula:

$A = 0.055 + 0.001(30° - \theta_{MAX})$ (*m-rad*)

where:

θ_{MAX} : The angle of heel in degrees at which the righting lever curve reaches its maximum;

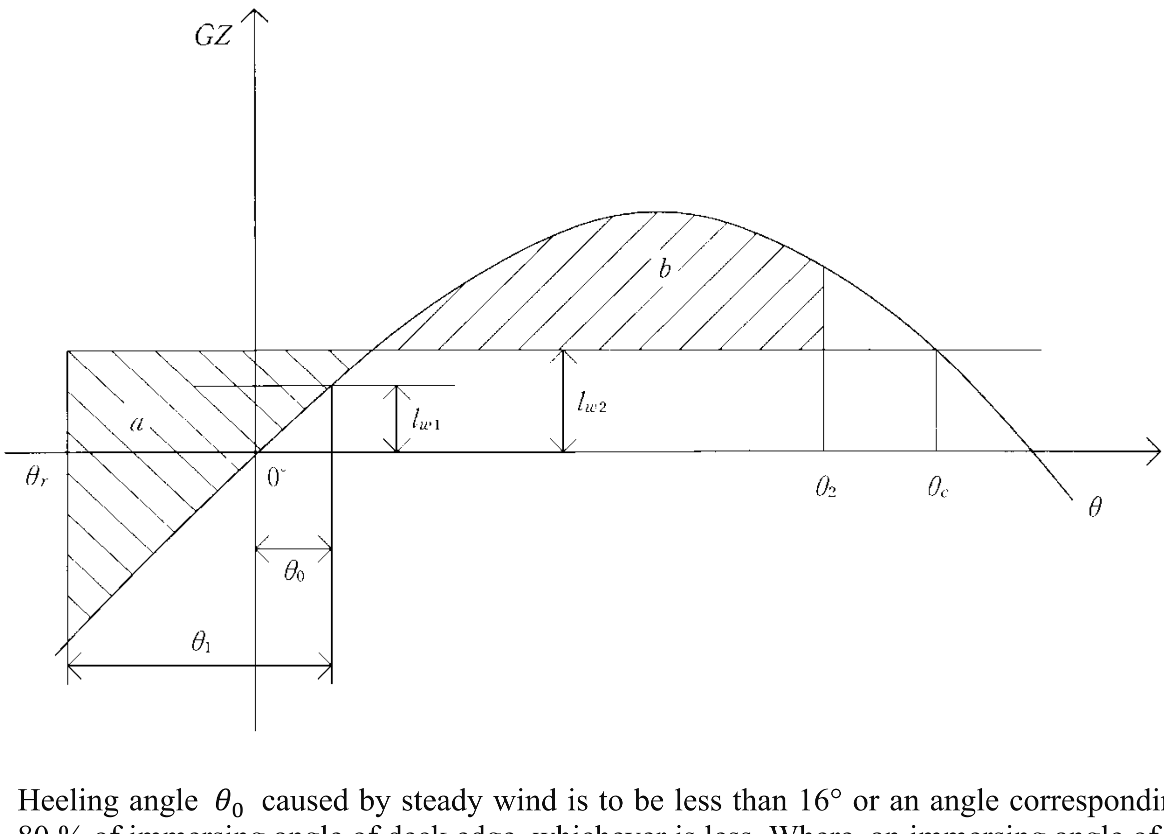
(3) The area under the righting lever curve between $\theta = 30°$ and $\theta = 40°$ or between $\theta = 30°$ and the angle of flooding θ_f*, if this angle is less than 40 *degrees*, is not to be less than 0.03 *m-rad.*
(* : Small openings, which are not causing more flooding, may be ignored.)
(4) The righting lever (*GZ*) is to be at least 0.20 *m* at an angle of heel equal to or greater than 30 *degrees*;
(5) GZ_{MAX} is to occur at an angle of heel not less than 15 *degrees*; and
(6) The initial metacentric height (G_0M) is not to be less than 0.15 *m*.

2.3 Stability Requirements in Wind and Waves

2.3.1 Stability Curves and Wind-heeling Moment Lever Curves

1 Stability curves and wind-heeling moment lever curves of ships are to comply with the following requirements in **Fig. 4.2.2**.

Fig.4.2.2 Stability and Wind-heeling Moment Lever Curve (Stability Requirements in Wind and Waves)



(1) Heeling angle θ_0 caused by steady wind is to be less than 16° or an angle corresponding to 80 % of immersing angle of deck edge, whichever is less. Where, an immersing angle of deck edge is to be of the angle between the waterline in un-inclined condition of ship and the line linked deck edge to the point of intersection between the centre line and waterline in un-inclined condition of ship.
(2) Area "*b*" is not to be less than area "*a*".
where
l_{w1}: Heeling moment lever caused by steady wind (*m*) given by the following formula
$\frac{0.0514\,AZ}{W'}$ (m)
A: Projected lateral area of hull and cargoes on deck above waterline at each draught

condition (m^2).

Z: Vertical distance between the centre of "A" and the centre of underwater projected lateral area of hull (m).

W': Displacement at each draught condition (t).

l_{w2}: Heeling moment lever caused by gust (m) given by the formula $1.5l_{w1}$

a: Area encircled by stability curve, l_{w2} and θ_r ($m \cdot rad$).

b: Area encircled by stability curve, l_{w2} and θ_2 ($m \cdot rad$).

θ_r: Angle of rolling stop motion (*degree*). In general, it may be given by the formula $(\theta_0 - \theta_1)$.

θ_C: Heeling angle at the second intersection between heeling moment lever and stability curve (*degree*).

θ_2: Heeling angle (*degree*) to be taken of whichever is the least, downflooding angle, θ_C or 50°.

θ_0: Angle of heel under action of steady wind (*degree*).

θ_1: Angle of roll to windward due to wave action (*degree*) given by the following formula:

$109x_1x_2k\sqrt{rs}$ (*degree*)

x_1: Values obtained from **Table 4.2.1** according to the value of B'_{WL}/d'. In case the value of B'_{WL}/d' becomes intermediate, values are to be determined by interpolation.

Table 4.2.1 Value of x_1

B'_{WL}/d'	≤ 2.4	2.5	2.6	2.7	2.8	2.9
x_1	1.0	0.98	0.96	0.95	0.93	0.91
B'_{WL}/d'	3.0	3.1	3.2	3.3	3.4	≥ 3.5
x_1	0.90	0.88	0.86	0.84	0.82	0.80

B'_{WL}: Moulded waterline breadth of the ship at each draught condition (m).

d': Mean moulded draught of the ship (m).

x_2: Values obtained from **Table 4.2.2** according to C_b at each draught condition. In case C'_b becomes intermediate, values are to be determined by interpolation.

Table 4.2.2 Value of x_2

C'_b	≤ 0.45	0.50	0.55	0.60	0.65	≥ 0.70
x_2	0.75	0.82	0.89	0.95	0.97	1.0

C'_b: Block coefficient given by the following formula at each draught condition:

$\frac{W'}{1.025L'_{WL}B'_{WL}d'}$

L'_{WL}: Length of the ship at waterline at each draught condition (m)

k: Values determined according to the shapes of bilge part and bilge keels are provided or not, are as follows;

(a) For round-bilged ships having neither bilge keels nor bar keels: 1.0

(b) For ships with sharp bilges: 0.7

(c) For ships with bilge keel and/or bar keels: Values obtained from **Table 4.2.3** according to the value of $100A_k/L_{WL}B_{WL}$. In case $100A_k/L_{WL}B_{WL}$ becomes intermediate, values are to be determined by interpolation.

Table4.2.3 Value of k (Ships with bilge keels, bar keels or both)

$100A_k/L_{WL}B_{WL}$	0	1.0	1.5	2.0	2.5	3.0	3.5	≥ 4.0
k	1.0	0.98	0.95	0.88	0.79	0.74	0.72	0.70

A_k: Total area of bilge keels, projected lateral area of bar keels or sum of those areas (m^2).

r: Coefficient determined by the formula $0.73 + 0.6\frac{OG}{d'}$

OG: Distance between the centre of gravity and the waterline (m), and is taken as positive when the centre of gravity is above waterline.

s: Values obtained from **Table 4.2.4** according to the value of T. In case T becomes intermediate, values are to be determined by interpolation.

Table 4.2.4 Value of s

T	≤ 6	7	8	12	14	16	18	≥ 20
s	0.100	0.098	0.093	0.065	0.053	0.044	0.038	0.035

T : Rolling period (seconds) obtained from the following formula..

$\frac{2B'_{WL}}{\sqrt{G_0M}}(0.373 + 0.023\frac{B'_{WL}}{d'} - 0.043\frac{L'_{WL}}{100})$

G_0M : As specified in **2.2.1**

2 In applying the requirement in **-1**, deck edge means the point of intersection between the continuation of top of freeboard deck at ship's side of lowest point of freeboard deck and the outside of side shell, in general. However, in cases where there are any openings under the deck edge, the lower edge of the opening is to be treated as the deck edge. In addition, in case of ships having superstructure decks of entire length, deck edge may be either of the points specified in the following **(1)** or **(2)**.

(1) Where side shells in way of superstructures have no openings or all openings are kept watertight closing devices, the point of intersection between the continuation of top of superstructure deck at ship's side of lowest point of superstructure deck and the outside of side shell

(2) Where side shells in way of superstructures have openings with weathertight covers, the lowest point of such openings

3 Concerning the area between the stability curve and l_{w1} in **Fig. 4.2.2**, where portions within the range of $\pm\theta_1$ on both sides of θ_0 are significantly different from each other, angle of rolling stop motion is to be determined so that both areas will be equal. Even in this case, full rolling angle is to be kept to $2\theta_1$.

4 For *GNS-A* ships, *GNS-B* ships and *GNS-C* ships whose L is not less than 100 m, regardless of the requirements in **-1(2)**, stability curves and wind-heeling moment lever curves of ships are to comply with the following requirements.

(1) Area *b'* is taken as area encircled by stability curve, l_{W2} and θ_c, θ_2 or 70°, whichever is the less ($m \cdot rad$), instead of area b in **Fig. 4.2.2**.

(2) Area *b'* is to be not less than 1.4 times area a.

5 For *GNS-A* ships, *GNS-B* ships and *GNS-C* ships whose L is not less than 100 m, intact stability in storm condition is to be considered as follows, in addition to complying with the requirements in **-4**.

(1) Wind speed V (*m/s*) in storm condition is to be obtained by the instantaneous wing speed specified in **Table 1.3.4, Part 1** divided by the gust factor 1.17.

(2) Heeling moment lever l_{storm} (m) in storm condition is given by the following formula.

$$l_{storm} = 0.76 \times 10^{-4} \times V^2 \frac{AZ}{W'} cos^2\theta \quad (m)$$

(3) Heeling moment lever at the first intersection between heeling moment levers and stability curves for stability curves in storm conditions are to be not less than 60 % of the maximum heeling moment lever (GZ_{MAX}).

2.3.2 Alternative methods

Where equivalency of the safety level regarding the intact stability of ships required by this Part is verified by the appropriate methods specified in the following **(1)** to **(3)**, the following appropriate measures may be taken, instead of those specified in this Part.

(1) Numerical simulations of dynamic behaviours

(2) Model tests

(3) Large scaled experiments by using the real ships

2.4 Other Requirements on Stability of Ships

2.4.1 General

1 Ship stability during turning is to be determined by taking into account the relationship between angles of inclination and rudder angles at the maximum speed of the ship (speed at the draught condition when the speed of the ship becomes maximum) or the maximum speed of the ship under sea trial conditions, and confirmation results at sea trials are to be included in document for sea trial results.

2 For ships having rudders with maximum rudder angles of 35°, inclined angles at maximum speed of the ships with rudder angles of 35° are to be not more than 15°, except for the following ships.

(1) High speed ships

(2) Ships having rudders with maximum rudder angles of more than 35° .

(3) Ships having azimuth thruster systems

(4) Ships so designed that the ships turn by using rudders and thrusters

(5) Ships having waterjet propulsion systems

(6) Ships having flap rudders, high lifting rudders, fishtail rudders, or other rudders so designed that the diameter of the turning circle is less than 4 times L.

3 With respect to ship stability, consideration is to be given to the dynamic stability phenomena effect in waves such as parametric rolling, broaching, etc.

Chapter 3 DAMAGE STABILITY

3.1 General

3.1.1 Application

1 *GNS-A* ships and *GNS-B* ships are to comply with the requirement in **3.2** under the damaged conditions.

2 *GNS-C* ships and *GNS-D* ships whose L_f is not less than 80 *m* are to comply with the requirements in **Chapter 4** of either **Part C** or **Part CS of the Rules for the Survey and Construction of Steel Ships** or are to comply with the following requirements on the final waterline after flooding assumed in accordance with the requirements in **3.3**. In such cases, the requirements in **Chapter 4** of either **Part C** or **Part CS of the Rules for the Survey and Construction of Steel Ships** need not be applied.

(1) The final waterline after flooding (taking into account sinking, heel, and trim) is to be below the lower edge of any opening through which progressive flooding may take place. Such openings are to include air pipes, ventilators and openings which are closed by means of weathertight doors or hatch covers. Openings closed by means of manhole hatch covers and flush scuttles, watertight hatch covers, remotely operated sliding watertight doors and side scuttles of the non- opening type, may be excluded.

(2) Where pipes, ducts or tunnels are situated within the assumed extent of damage penetration, arrangements are to be made so that progressive flooding does not extend to compartments other than those assumed to be flooded.

(3) The metacentric height in the flooded condition is to be positive.

(4) Righting lever curves are to have a minimum range of 20 *degrees* beyond the position of equilibrium and a maximum righting lever of at least 0.1 *m* within this range. Areas under the righting lever curve within this range are to be not less than 0.0175 *m-radian*. Unprotected openings are not to be immersed within this range except where the corresponding compartments are assumed to be flooded.

3 *GNS-C* ships and *GNS-D* ships whose L_f is less than 80 *m* are to comply with the requirements in **-2** assuming flooding of any one compartment.

3.2 Extent of Damage

3.2.1 Extent of Side Damage

1 For ships navigating in threat sea area, the extent of side damage is to be determined based on the expected accident scenarios.

2 Extend of side damage is to be $1/3L_f^{2/3}$ or 14.5 *m*, whichever is less, for longitudinal extent, $B_f/5$ or 11.5 *m*, whichever is less, for transverse extent, and vertical extent from the moulded line of the bottom shell plating at centreline, upwards without limit. Permeability of various spaces is to be given in **Table 4.3.1**. Where the permeability taken is different from that given in **Table 4.3.1**, the value may be taken deemed appropriate by the Society considering the purpose of the spaces.

3 The distance between transverse watertight bulkheads is greater than the longitudinal extent of damage specified in **-2**, the forward or aft spaces of the transverse bulkhead in question are to be assumed to be flooded. The distance of transverse watertight bulkheads is smaller than the longitudinal extent of damage specified in **-2**, the transverse bulkhead located in the longitudinal extent of damage are to be assumed to be ignored.

4 Where two or more longitudinal bulkheads are arranged at the location within $B_f/5$ or 11.5 *m*, whichever is the less from the ship's side, the longitudinal bulkhead arranged at the location of the nearest to the ship's side which are assumed the side damage, is to be ignored.

5 For *GNS-A* ships and *GNS-B* ships, assuming the explosion in the compartment assumed the side damage, the forward and the aft transverse bulkheads and side longitudinal bulkheads or side shells constituting the compartment in question are to be assumed the damage caused by the explosion.

Table 4.3.1 Permeability of various spaces

Space	Permeability
Accommodation space including service spaces, spaces arranged in important equipment such as central control room and void space	0.95
Machinery spaces, boiler room and auxiliary machinery room	0.80
Magazine room or storage room for necessary goods equipped with the ship including dangerous goods and warehouse other than provision stores	0.80
Provision stores and chain lockers	0.70
Various tanks	0.97 or 0

3.2.2 Extent of Bottom Damage

1 For *GNS-A* ships and *GNS-B* ships, extent of bottom damage is to be $1/3L_f^{2/3}$ or 14.5 *m*, whichever is less for longitudinal extent, $B_f/6$ or 10 *m*, whichever is less for transverse extent and $B_f/15$ or 6 *m*, whichever is less , for vertical extent. Permeability of various spaces is to be given in **Table 4.3.1**. Where the permeability taken is different from that given in **Table 4.3.1**, the value may be taken deemed appropriate by the Society considering the purpose of the spaces.
2 Extent of bottom damage for *GNS-C* ships and *GNS-D* ships whose L_f is not less than 80 *m* is to be given in **Table 4.3.2**.
3 The distance between transverse watertight bulkheads is greater than the longitudinal extent of damage specified in **-1**, the forward or aft spaces of the transverse bulkhead in question are to be assumed to be flooded. The distance of transverse watertight bulkheads is smaller than the longitudinal extent of damage specified in **-1**, the transverse bulkhead located in the longitudinal extent of damage are to be assumed to be ignored.
4 Where a ship has a double bottom structure and the distance between the bottom shell and top of the double bottom is less than the vertical extent of bottom damage, the top of the double bottom is to be assumed to be ignored.

Table 4.3.2 Extent of Bottom Damage of *GNS-C* Ships and *GNS-D* Ships whose L_f is not less than 80 *m*

	Extent of side damage	
Direction	Bow part	Any other part of ship
Longitudinal extent	$1/3\ L_f^{2/3}$ or 14.5 *m*, whichever is less	$1/3\ L_f^{2/3}$ or 5 *m*, whichever is less
Transverse extent	$B_f/6$ or 10 *m*, whichever is less	$B_f/6$ or 5 *m*, whichever is less
Vertical extent	$B_f/15$ or 6 *m*, whichever is less,	$B_f/15$ or 6 *m*, whichever is less,

3.2.3 Damage Extent of High Speed Ships

1 The assumed extent of damages for high speed ships navigating in threat sea area is to be according to **(1)** to **(5)**:
(1) The assumed maximum extent of side damage is to be in accordance with **Table 4.3.3** and following **(a)** to **(b)**.

(a) Where side plating is inclined, the damages above the design waterline are to be assumed to have the shape of a parallelepiped. The inboard face at its mid-length is to be tangential to, or otherwise touching in a least 2 places, the surface corresponding to the specified transverse extent of penetration.

(b) Side damage may not to be transversely penetrating a greater distance than the extent of $0.2\nabla^{1/3}$ (m^3) at the design waterline, except where a lesser extent is provided for in **Table 4.3.3** is volume of displacement corresponding to the design water line.

(2) The assumed maximum extent of bottom damage is to be in accordance with **Table 4.3.4**. The shape of damage is to be assumed to be rectangular in the transverse plane.

(3) Extent of bottom damage in areas vulnerable to raking damage is to be in accordance with **Table 4.3.5**. However these requirements may not need to apply at that same time as that stipulated in **(1)** or **(2)** above. The shape of damage is to be assumed to be rectangular in the transverse plane.

(4) Extent of bow and stern damage is to be in accordance with **Table 4.3.6**.

(5) Any damage of a lesser extent than that postulated in **(1)** to **(4)** above, as applicable, which would result in a more severe condition, is to be also investigated.

2 For high speed ships navigating in no threat sea area, notwithstanding of the requirements in **-1**, possibilities of collision, grounding, etc., in ships intended to navigate in sea area are to be assessed in accordance with the requirement specified in **Part 12** and the extent of damage may be determined based on the assessment results.

Table 4.3.3 Extent of Side Damage

Direction	Extent of Damage
Longitudinal extent	$0.75\nabla^{1/3}$, (3 m+$0.225\nabla^{1/3}$) or 11 m, whichever is the least.
Transverse extent	$0.2\nabla^{1/3}$ However, where the craft is fitted with inflated skirts or with non-buoyant side structures, the transverse extent of penetration are to be at least $0.12\nabla^{1/3}$ into the main buoyancy hull or tank structure
Vertical extent	the full vertical extent of the craft

Table 4.3.4 Extent of Bottom Damage

Direction	Extent of Damage
Longitudinal extent	$0.75\nabla^{1/3}$, (3 m+$0.225\nabla^{1/3}$) or 11 m, whichever is the least.
Athwartship girth extent	the athwartship girth of damage is to be $0.2\nabla^{1/3}$
Normal extent to the shell	the depth of penetration normal to the shell is to be $0.02\nabla^{1/3}$

Table 4.3.5 Extent of Bottom Damage in Areas Not Vulnerable to Raking Damage

Direction	Extent of Damage
Longitudinal extent	55 % of the length L, measured from the most forward point of the underwater buoyant volume of each hull
	a percentage of the length L, applied anywhere in the length of the craft, is as follows. Where L is 50 m and over, equal to 35 % for craft Where L is less than 50 m, equal to $(L/2+10)$% for craft
Athwartship girth extent	The athwartship girth of damage is to be $0.1\nabla^{1/3}$
Normal extent to the shell	the depth of penetration normal to the shell is to be $0.04\nabla^{1/3}$ or 0.5 m, whichever is lesser

Table 4.3.6 Extent of Bow and Stern Damage

Damage Parts	Extent of Damage
Bow part	at the fore end, damage to the area defined as A_{bow}, the aft limit of which being a transverse vertical plane, provided that this area need not extend further aft from the forward extremity of the crafts watertight envelope than the longitudinal distance of side damage.
Stern part	at the aft end, damage to the area aft of a transverse vertical plane at a distance $0.2\nabla^{1/3}$ forward of the aft extremity of the watertight envelope of the hull.

Note:

$A_{bow} = 0.0035AmfV$, however never less than $0.04A$

Where:

A_{bow}: the plan projected area (m^2) of craft energy-absorbing structure forward of the transverse plane

A: the plan projected area (m^2) of craft

m: material factor $0.95/M$

M: Appropriate hull material factor, for high-tensile steel: 1.3, for aluminium alloy: 1.0, for mild steel: 0.95, and for *FRP*: 0.8. Where materials are mixed, the material factor is to be taken as a weighted mean, weighted according to the mass of material in the area defined by A_{bow}.

f: framing factor as follows

(a) longitudinal deck and shell stiffening : 0.8

(b) mixed longitudinal and transverse : 0.9

(c) transverse deck and shell stiffening : 1.0

V: 90% of maximum speed

∇: volume of displacement(m^3) corresponding to the design water line

3.3 Damage Stability

3.3.1 Damage Stability

1 Ships are to have the sufficient buoyancy and the positive stability after flooding assumed caused by the damage specified in **3.2**.

2 For ships other than high speed ships, the watertight bulkheads are to be arranged so that the draught after flooding is lower than the margin line which is determined as a line parallel to the freeboard deck and is located below freeboard deck, which is based on the flooding calculations carried out by assuming the flooding of compartments in extend of damage specified in **3.2**. The distance between the margin line and freeboard deck is to be of the value deemed appropriate by the Society.

3 At the final equilibrium stage after flooding, the following conditions are to be maintained.

(1) The embarkation stations of lifeboat or liferaft are not to be arranged below the final equilibrium waterline.

(2) The emergency equipment, emergency radio installations, emergency sources of power and addressing systems and other essential equipment or systems are to be arranged at the places to be able to access easily and are to be maintained to be of continuous operation.

4 The openings below the final equilibrium waterline or the margin line are to be watertight.

5 High speed ships navigating in threat sea area are to comply with the requirements specified in **(1)** and **(2)**.

(1) After flooding has ceased and a state of equilibrium has been reached, the final waterline it to be 150 *mm* below the level of any opening through which further flooding could take place.

(2) Angles of inclination of such ships from the horizontal are to not normally exceed 15 *degrees* in any direction. However, where this is clearly impractical, angles of inclination up to 20 *degrees* immediately after damage may be permitted provided that such ships are to comply with the following requirements;

(a) Means to reduce the angle of inclination to 15 degrees within 15 *minutes* are to be provided, and

(b) Efficient non-slip deck surfaces and suitable holding points (*e.g.* holes, bars) are to be provided.

6 Damage stability for high speed ships navigating in no-threat sea area is to be as deemed appropriate by the Society.

Part 5 HULL CONSTRUCTION

Chapter 1 GENERAL

1.1 General

1.1.1 Application

1 The requirements in this Part apply to ships whose main hull structures are constructed of steels or aluminium alloys.

2 Ships whose main hull structures are constructed of *FRP* are to comply with the requirements of the **Rules for the Survey and Construction of Ships of fibreglass Reinforced Plastics**.

1.1.2 Special Cases in Application

The requirements for hull construction, equipment, arrangement and scantlings of ships such as non-displacement type ships, not-single hull type ships, etc., which do not comply with the requirements in this Part, are to be at the Society's discretion.

1.2 General Requirements on Hull Structures

1.2.1 Application of Steels

1 Where the hull structural members are constructed of steels, application of steels is to be as given in **Table 5.1.1** and **Table 5.1.2**.

Table 5.1.1 Category of Structural members *1

Structural members		Category of structural members
Special members	(1) Sheer strake at strength deck (single strake)*2 (2) Stringer plate in strength deck (single strake)*2 (3) Bilge strake (single strake)*2,*3 (4) Strength deck strake adjoining to longitudinal bulkhead (single strake)*2 (5) Strength deck at cargo hatch corner (6) Cargo hatch coaming longitudinally extended on the strength deck with longitudinal members over 0.15*L*	Midship part of ship: Category III Fore and aft part of ship : Category II
Primary members	(1) Bottom plating (2) Strength deck plating (3) Shell plating within 0.1*D* downward from the lower surface of strength deck below (4) Longitudinal plating members above strength deck (except (6) of Special members) (5) Upper strake in longitudinal bulkhead adjoining to strength deck (single strake)*2	Midship part of ship: Category II Fore and aft part of ship : Category I
Secondary members	(1) Deck plating exposed to weather (2) Side plating (except Special members and primary members) (3) Longitudinal bulkhead (except primary members) (4) Stem plates (5) Stern frame (stern frame, rudder horn, rudder trunk and shaft bracket) (6) Rudder plate	Midship part of ships: Category I Fore and aft part of ship: *A*/*AH* steels specified in the **Part K of the Rules for the Survey and Construction of Steel Ships**.

Note:

*1: Structural members other than those specified in the table may be used *A*/*AH* grade steels regardless of the thickness.

*2: Single strake means the stake that the width of single steel plate is 800＋5*L* (*mm*) (Maximum width : 1,800 *mm*).

*3: Pad plate for fitting to the bilge keels and bilge keel with continuous length more than 0.15 *L* are to be used the same grade of steels required to the bilge plate.

Table 5.1.2 Application of Steels [*1]

Plate thickness t (mm)	Category III		Category II		Category I	
	Mild Steel	High tensile steel	Mild Steel	High tensile steel	Mild Steel	High tensile steel
$T \leq 15$	*A*	*AH*	*A*	*AH*	*A*	*AH*
$15 < t \leq 20$	*B*	*AH*	*A*	*AH*	*A*	*AH*
$20 < t \leq 25$	*D*	*DH*	*B*	*AH*	*A*	*AH*
$25 < t \leq 30$	*D*	*DH*	*D*	*DH*	*A*	*AH*
$30 < t \leq 35$	*E*	*EH*	*D*	*DH*	*B*	*AH*
$35 < t \leq 40$	*E*	*EH*	*D*	*DH*	*B*	*AH*
$40 < t \leq 50$	*E*	*EH*	*E*	*EH*	*D*	*DH*

Note:

*1: Grade of steels shown in the table for application of steels are to be in accordance with the requirements of **Part K of the Rules for the Survey and Construction of Steel Ships**.

2 Special members specified in **Table 5.1.1** for ships whose L is more than 250 m are to comply with the following requirements, regardless of the thickness.

(1) Special members specified in **(1)** and **(2)** in **Table5.1.1** are to be *E*/*EH*.

(2) Special member specified in **(3)** in **Table 5.1.1** is to be *D*/*DH* or *E*/*EH*.

3 For ships that have been designed to a specific design temperature (T_D) in order to operate in areas with low air temperatures (e.g. Arctic or Antarctic waters), the application of steels used for hull structures is to be suitable for the design temperature, regardless of the requirements specified in **-1**. In this case, the class notation on the design temperature (T_D) is affixed to the Class Characters in accordance with the requirement specified in **1.2.5-2, Part 1**.

1.2.2 Scantling

1 Unless specified otherwise, between the midship part and the parts $0.1L$ from each end of the ship, scantlings of structural members of the midship part can be reduced gradually over the length of $0.1L$ afore and abaft.

2 Section moduli of stiffeners and girders specified by the Rule include the steel plates with an effective breadth of $0.1l$ on either side of the members, where l is the length of the member specified in the relevant requirements. However, the $0.1l$ steel plates are not to exceed one-half of the distance to the next member.

3 When calculating the section moduli of stiffeners or girders and where these members are effectively supported inside the span such as vertical stiffeners and struts, these values may be properly reduced as defined in the formula.

4 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 the Rule.

5 For members such as girders and floors, where the inner edge of the web plate is flanged in lieu of a face plate, to which sectional area A (mm^2) of face plate and thickness of web plate t (mm) are specified, the breadth of the flange is not to be less than $A/t + 1.5t$ (mm).

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)**. However, this requirement is not applicable to fatigue requirements.

(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

1.2.3 Connection of Ends of Stiffeners, Girders and Frames

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

2 The length of the frame-side arm of brackets connected to the frames or stiffeners of locations such as bulkheads or deep tanks is not to be less than 1/8 specified in the relevant Chapter, unless otherwise specified.

3 Where stiffeners support the longitudinals penetrating floors or transverse girders in tanks, the connection of the stiffeners to the longitudinals is to have enough fatigue strength for the dynamic pressure that occurs in such tanks. These stiffeners are to be of a thickness not less than the minimum thickness required for floors or transverse girders and the depth of which is not to be less than 0.08 times the depth of girders or transverse floors ($\boldsymbol{d}_0$ (mm)) minus the height of the longitudinals. However, stiffeners of an equivalent or greater strength are deemed acceptable.

1.2.4 Brackets

1 The thickness of brackets is to be suitably increased where the depth of the brackets at the throat is less than 2/3 of the longer arm of the bracket.

2 Where lightening holes are cut into the brackets, the distance from the circumference of the hole to the free flange of the bracket is not to be less than the diameter of the lightening hole.

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.

1.2.5 Modification of Span (l) for Thicker Brackets

Where brackets are not thinner than the girder plates, the value of span (l) between girders or floors may be modified in accordance with the requirements specified in the following **(1)** to **(5)**.

(1) Where the sectional area of the face plate of the bracket is not less than 1/2 areas 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 1/2 areas 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 girder, or to a point 0.15 m inside the toe of the bracket, whichever is 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 allowance in l at either end to exceed 1/4 of the overall length of the girder including the part of end connection.

1.2.6 Structural Details

1 Special attentions are to be paid to the arrangements of hull structural members so that welding may be carried out without much difficulty.

2 Structural discontinuities and the abrupt changes of cross sections are to be avoided as far as practicable.

3 Welding joints are to be properly shifted from places where the stresses may highly concentrate.

4 Corners of all openings are to be well rounded.

5 Where rigid structural members with small sectional areas, such as brackets, are welded on to relatively thin plate, at least the toes of such members are to be welded on to other rigid members.

6 Upper ends of sheer strakes in midship part of the ship are to be finished smooth, and equipment, etc. are not to be directly welded to the sheer strakes. Where ships have rounded gunwales, equipment, etc. are not to be directly welded to rounded parts.

7 For openings arranged in structural members contributing the hull girder strength such as deck plate, bottom plate, inner bottom plate in double bottom structure, longitudinal bulkheads, longitudinal girders, etc., the major axis of opening is to be oriented to the longitudinal direction of the ship.
8 Air and drainage holes are to be provided in all non-watertight members in tanks in order to avoid puddling air or liquids in tanks.
9 Stiffeners are to be of a stable shape having the scantling complying with the following requirements. Where, K is the material factor specified in **Part 3**.

(1) Flat bar: The ratio of the height to the thickness is not more than $20\sqrt{K}$.

(2) T-section: The ratio of the height to the thickness of the web plate is not more than $65\sqrt{K}$.
The ratio of the breadth to the thickness of the face plate is not more than $33\sqrt{K}$.
The ratio of the area of face plate to the area of web plate is not less than 1/6.

(3) Angle: The ratio of the height to the thickness of the web plate is not more than $55\sqrt{K}$.
The ratio of the breadth to the thickness of the face plate is not more than $16.5\sqrt{K}$.
The ratio of the area of face plate to the area of web plate is not less than 1/6.

10 When deemed necessary by the Society, a fatigue strength assessment is to be carried out on the structural details of areas where stress is concentrated, such as joints of longitudinals (between the forward end of the engine room and the collision bulkhead) and transverse members (including ordinary transverses, transverse bulkheads or floors); girder members connecting side shell plating or bulkheads; and discontinuous structures. In this case, the documents related to the fatigue strength assessment are to be submitted to the Society.

1.2.7 Special Requirements

In applying the requirements in **3.3.1, Part 1**, special attentions are to be paid to the structural arrangements and their strength. In this case, the documents including the items considered and related to those are to be submit to the Society for reference.

1.3 Welding

1.3.1 General

1 The welded parts are to be executed under the conditions without an adverse effect being free from water, oil, rust, etc.
2 In principle, edge preparation is to be made by machining. In case where the edge preparation is not made by machining, the edge preparation is to be finished smooth.

1.3.2 Butt Welds

1 In case of welding of plates having a difference in thickness over 4 *mm* or in case of welding of plates that thickness of thinner one is less than 4 *mm* and the difference in thickness over 2 *mm*, butt welded joints are generally to be tapered by not more than one-third at the end of the thicker plate and welded to the thinner plate.
2 Welding of plates of hull below freeboard deck and exposed ones on superstructures, etc., are to be joined by the butt welds.
3 Welding of transverse edge parts of longitudinal members which consist of plates, girders and stiffeners arranged in the longitudinal direction is to be joined by the butt welds.
4 Welding of plates consisting of boundaries of watertight compartments is to be welded by butt welds.
5 Welding of divisions, girders and stiffeners arranged in watertight compartments is to be jointed by the butt welds.

1.3.3 Full Penetration Welds and Partial Penetration Welds

1 Welding specified in the following **(1)** to **(5)** is to be full penetration welds.

(1) Abutting plate panels with as-built thickness less than or equal to 12 *mm*, forming outer shell boundaries below the designed maximum draught, including but not limited to: sea chests, rudder trunks, and portions of transom.

(2) Crane pedestals and associated bracketing and support structure.

(3) Welded cruciform joints of plates of primary supporting members with thickness not more than 12 *mm*, which consist of the load-carrying members caused by the hull girder bending.

(4) Edge reinforcement or pipe penetration both to strength deck, sheer strake and bottom plating at midship parts of the ship, when the dimensions of the opening exceeds 300 *mm*.

(5) Rudder horns and shaft brackets to shell structure.

2 Welding specified in the following **(1)** and **(2)** is to be partial penetration welds. In this case, the depth of partial welds is to be not less than 2/3 thickness of thinner plate.

(1) Where the thickness of the thickness of stringer plates is not less than 13 *mm*, the joints of stringer plates and deck stringers.

(2) In case of **-1(1)**, the joints of plates where the thickness of the thinner plate is more than 12 *mm*.

1.3.4 Fillet Welds

1 The welding for the following **(1)** to **(12)** for the welded locations specified in **1.3.2** and **1.3.3** is to be continuous fillet welding.

(1) Connection of webs to face plates (all members)

(2) Lap joints

(3) Boundaries of tanks and watertight compartments

(4) Structural members in tanks and stiffeners and primary supporting members at tank boundaries

(5) Primary members such as girders in machinery rooms

(6) Attachments of fittings subject to loads not less than 10 *kN*

(7) Attachment of seating for equipment whose mass is not less than 1 *kN*

(8) Upper end and lower end of pillars

(9) Structural members fitted to parts requiring local reinforcement subject to bottom slamming and flare slamming.

(10) Welding pad plates of bilge keels to bilge strakes and welding pad plates to bilge keels

(11) Welding in way of all end connections of stiffeners and primary supporting members, including end brackets, lugs, scallops, and at orthogonal connections with other members.

(12) Others locations indicated by the Society

2 Overlap breadth for lap joints is not to be less than a value of twice the thickness of the thinner plate plus 25 *mm*, but need not exceed 50 *mm*.

3 Fillet welding other than that specified in **-1** may be intermittent fillet welding.

4 Leg lengths and throat thicknesses of fillet welds are to comply with the requirements given in **Table C1.4** and **C1.5, Part C of the Rules for the Survey and Construction of Steel Ships** or other standards set by manufacturers and deemed appropriate by the Society. However, where the ends of frames, beams and stiffeners are directly fillet welded to decks, shells, inner bottoms or bulkhead plates (without brackets) as well as for lap welds, the leg lengths of fillet welds are not to be less than 0.7 times the web thicknesses of such members.

1.3.5 Welding of Aluminium Alloys

1 Butt welds, and full penetration welds and partial penetration welds are to comply with the requirements specified in **1.3.2** and **1.3.3**.

2 The kinds and size of fillet welds and their application are to be in accordance with the requirements given in **Table C1.4** and **Table C1.5, Chapter 1, Part C of the Rules for the Survey and Construction of Steel Ships** respectively. However, the size of fillet f_{Al} is not to be less than that obtained from the following formula.

$$f_{Al} = (f_{steel} - 1.5)\frac{\sigma_r}{\sigma_d} \ (mm)$$

Where:

f_{steel}: Size of fillet of continuous fillet weld or intermittent fillet weld according to the thickness of the plate as specified in **Table C1.4, Chapter 1, Part C of the Rules for the Survey and Construction of Steel Ships** (*mm*)

σ_r : Proof stress given in **Table 3.2.2**, **Part 3** (*N/mm*^{2})

σ_d : The lower limit of the specified proof stress of the base material with suffix -*O* in the division or the temper condition concerned (*N/mm*^{2}) and specified in the requirements in **Chapter8, Part K of the Rules for the Survey and Construction of Steel Ships** (*N/mm*^{2})

1.4 Structural Arrangements

1.4.1 Bottom Structures

1 Ships are to be provided with watertight double bottoms extending from the collision bulkhead to the after peak bulkhead as far as practicable and so far to fit to the purpose of the ships.

2 In principle, the breadth of the plate keel over the whole length of the ship is not to be less than that obtained by 1,000 + 2 *x* L_{WL} (*mm*).

3 Where ships are provided with the double bottom, the height of double bottom is recommended to be not less than B_{WL}/20. Where the height of the double bottom is less than B_{WL}/20, the clear height in the double bottom structure is to be not less than 600 *mm* for longitudinal frame system and 800 *mm* for transverse frame system.

4 Where the longitudinal system of framing is transformed into the transverse system, or the 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.

5 In principle, the top plate of double bottom structure is to be continued out to the ships sides.

6 Bilge wells provided at the top of watertight double bottom are not to extend for more than 1/2 the depth of the double bottom as far as practicable, except those provided at the after end of the shaft tunnel. In addition, the vertical distance from the bottom of such a well to a plane coinciding with the keel line is not to be less than 0.5 *m*.

7 In principle, girders in double bottom structure are to be so arranged that the distance from the girder to the next girder and from the girder to longitudinal bulkhead does doses not exceed 4.5 *m*, and floors in double bottom structure are to be so arranged that the distance from the floor to the next floor and from the floor to the transverse bulkhead does not exceed 3.6 *m*. However, adequate strengthening of double bottom structure is to be made under main engines, thrust seating and other important equipment or heavy equipment, and the parts affected by the impact loads deemed necessary, by means of additional full or half-height girders or floors.

8 In principle, girders in single bottom structure are to be so arranged that the distance from the girder to the next girder and from the girder to the longitudinal bulkhead does not exceed 2.25 *m*, and transverses in single bottom are to be so arranged that the distance from the transverse to the next transverse and from the transverse to the transverse bulkhead does not exceed 3.6 *m*.

9 In principle, the bottom structure of *GNS-A* ships and *GNS-B* ships are to be longitudinal system of framing. The bottom structure of *GNS-C* ships and *GNS-D* ships are recommended to be longitudinal system of framing.

10 The minimum thickness of plate in double bottom structure is to be given by the followings.

(1) Steel ships: $0.75\sqrt{KL_{WL}}$ (*mm*)
K is the material factor given in **Table 3.2.1, Part 3**

(2) Aluminium ships: $0.75\sqrt{L_{WL} \times {}^{128}/_{\sigma_y}}$ or 4 *mm*, whichever is greater

11 The minimum thickness of plate of girders, stiffeners, etc. constituting bottom structures is to be given by the followings.

(1) Steel ships: $6\sqrt{K}$ (*mm*) or $0.6\sqrt{KL_{WL}}$ (*mm*), whichever is greater.
K is the material factor given in **Table 3.2.1, Part 3**

(2) Aluminium ships: 4 *mm*

12 The minimum thickness of bottom shell plating of ships which are needed to consider beaching operations is to be 1.2 times the value required in **-10**.

13 Regarding the structural arrangement of bottom structure, ships whose L_{WL} is not less than 90 *m* are to be paid attentions to the requirements in **Chapter 5** and **Chapter 6, Part C of the Rules for the Survey and Construction of Steel Ships** and ships whose L_{WL} is less than 90 *m* are to be paid attentions to the requirements in **Chapter 5** and **Chapter 6, Part CS of the Rules for the Survey and Construction of Steel Ships**.

1.4.2 Side Structures

1 Where the side structures are made by the transverse system of framing, transverse frames are to be so arranged that frames have the cross section characteristics or bottom structure and deck structure are efficiently supported by transverses and girders, or transverses or girders arranged in the appropriate intervals, except for structures near the collision bulkhead. Side structures near the collision bulkhead are to be strengthened appropriately considering the difference between structures forwards the collision bulkhead and those aft the collision bulkhead.

2 Where the side structures are made by single one with longitudinal system of framing, transverses in side structure are to be so arranged that the transverses are in line with those in bottom structures.

3 Where the side structures are made by double side structures, the width of double side structures is to not less than 600 *mm* for longitudinal system of framing and the clear width is to be not less than 800 *mm* for transverse system of framing. Transverses in the double side structure are to be arranged are in line with those on bottom structure, and horizontal girders in the double side structure are to be so arranged that the distance between horizontal girders or from the horizontal girder to deck or bottom are deemed appropriate by the Society, considering the access and measures for internal examination in double side structures.

4 The minimum thickness of side shells below the strength deck is to be given by the followings.

(1) Steel ships: $0.75\sqrt{KL_{WL}}$ (*mm*)
K is the material factor given in **Table 3.2.1, Part 3**.

(2) Aluminium ships: $0.75\sqrt{L_{WL} \times {}^{128}/_{\sigma_y}}$ (*mm*) or 4 *mm*, whichever is greater.

5 The minimum thickness of plate of girders and stiffeners, etc. constituting side structure is to be given by the followings.

(1) Ships other than high speed ships
(a) Steel ships: $4.5\sqrt{K}$ or $0.45\sqrt{KL_{WL}}$ (*mm*), whichever is greater
(b) Aluminium ships: $0.45\sqrt{L_{WL} \times {}^{128}/_{\sigma_y}}$ (*mm*)

1.4.3 Deck Structures

1 Deck structure on the strength deck is recommended to be longitudinal system of framing.

2 The transverses on strength deck are recommended to be arranged in line with those on side structure.
3 Appropriate girders and transverse or pillars are to be arranged in order to support the superstructure and deck houses.
4 The minimum thickness of plate of strength deck and structural members constituting the strength deck structure is to be $0.36\sqrt{KL_{WL}}$ (*mm*) for steel ships and 4 *mm* for aluminium ships.
5 The minimum thickness of plate of deck and structural members constituting the deck structure below strength deck is to be 3.2 *mm*.

1.4.4 Superstructures and Deck Houses

1 Structural arrangements of the superstructure and deck house for ships whose L_{WL} is not less than 90 *m* are to be paid attentions to the requirements in **Chapter 18** and **Chapter 19, Part C of the Rules for the Survey and Construction of Steel Ships** and those of ships whose L_{WL} is less than 90 *m* are to be paid attentions to the requirements in **Chapter 18** and **Chapter 19, Part CS of the Rules for the Survey and Construction of Steel Ships**.
2 The minimum thickness of plate of exposed walls and structural members attached thereto of walls of the superstructure and the deck house is to be 3.2 *mm* for steel ships and 2.4 *mm* for aluminium ships.

1.4.5 Stems and Stern Frames

1 The minimum thickness of steel plate stems at designed maximum load lines is to be given by the following.
(1) For ships whose L_{WL} is not less than 90 *m*: $1.5\sqrt{K(L_{WL}-50)}$
(2) For ships whose L_{WL} is less than 90 *m*: $0.1L_{WL}x\sqrt{K}$
2 Where the stems are constructed by steel casting or steel forging, the minimum thickness of stems is to be the discretion of the Society.
3 The minimum thickness of plate of rudder horn is to be given by the followings.

$$2.4\sqrt{L_{WL}K_{rh}}$$

Where:

$$K_{rh} = \left(235/\sigma_y\right)^e$$

$\sigma_y > 235$ (*N/mm*^{2}): *e*=0.75
$\sigma_y \leq 235$ (*N/mm*^{2}): *e*=1.0
σ_y : Yield stress or proof stress of the used material (*N/mm*^{2})

4 Structures of stems and stern of ships whose L_{WL} is not less than 90 *m* are to be paid attentions to the requirements in **Chapter 2, Part C of the Rules for the Survey and Construction of Steel Ships** and those of ships whose L_{WL} is less than 90 *m* are to be paid attentions to the requirements in **Chapter 2, Part CS of the Rules for the Survey and Construction of Steel Ships**.

Chapter 2 DESIGN LOADS

2.1 Longitudinal Bending Moments and Shearing Forces

2.1.1 General

1 Longitudinal bending moments and shearing forces acting upon hulls are to be calculated in accordance with the requirements in **2.2**, when hulls are assumed to be beams.

2 Longitudinal bending moments and shearing forces are to be obtained by adding those for still water to those for waves, respectively.

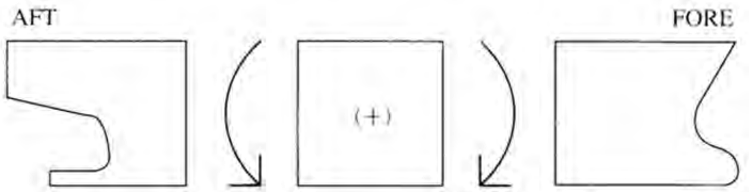
2.1.2 Longitudinal Bending Moments and Shearing Forces in Still Water

1 Bending moments (*kN-m*) and shearing forces (*kN*) in still water for transverse sections under consideration along the lengths of hulls are to be calculated from the buoyancy distributions and weight distributions for said transverse sections under all conceivable loading conditions.

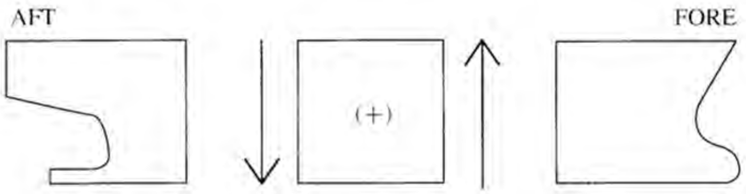
2 Positive values of longitudinal moments and shearing forces are to be as shown in **Fig. 5.2.1**.

Fig. 5.2.1 Positive Value of Longitudinal Bending Moments and Shearing Forces

Bending moments



Shearing forces



2.1.3 Direct Load Analysis

1 Longitudinal bending moments and shearing forces in waves are to be calculated using the following conditions, by appropriate calculation programs (methods based upon strip theory or slender body theory, the three-dimensional Green function method or the three-dimensional Rankine source method, etc.) approved by the Society.

(1) Ship speed is to be taken for three states: 0, design speed and 1/2 design speed

(2) Weight distribution is to be taken as one equivalent to the actual ship condition and the centre of gravity is to be considered to coincide with the design value.

(3) Encounter wave angles with ships taken at all headings for seven angels up to 180° at every 30°, when the wave angle encountered from the bow is taken as 0°, are to be considered.

(4) Response amplitude operators are to be calculated considering the various periods of waves with unit wave heights.

(5) Wave spectrums (*i.e.* energy density distribution functions of waves which are used order to approximately describe real waves by being superposed by the infinity linear functions of waves) $S(\omega)$ are to use the following formulae specified by the *ISSC* (International Ship Structure Committee)

$$S(\omega) = \frac{H_s^2}{4\pi}\left(\frac{2\pi}{T_z}\right)\omega^{-5} exp\left\{-\frac{1}{\pi}\left(\frac{2\pi}{T_Z}\right)^4 \omega^{-4}\right\}$$

Where:

H_s: Significant wave height (*m*) (The average height of the third of waves observed during a given period of time)

ω: Angular frequency of wave (*rad/s*)

T_z: Average wave period (*s*) is given by the following formula.

$$T_z = 2\pi\sqrt{\frac{m_0}{m_2}}$$

m_0, m_2: 0 order and 2nd order moment of response spectrum for each wave direction

$$m_n = \int_\omega^\theta \sum_{0-90°}^{0+90°} f_s(\theta)\omega^n \cdot S(\omega/H_s, T_Z, \theta)d\omega$$

n: taken as 0 or 2 .

$f_s(\theta)$: Distribution function for the direction, normally, is taken as $f_s(\theta) = \cos^2(\theta)$.

(6) Wave scatter diagrams corresponding to the North Atlantic (all seasons) given by Walden are to be used, and the occurrence probability is taken as the 10^{-8} probability level.

(7) Since the results specified in **(6)** are not included in the non-linear effects on high wave heights, 3-dimensional effects, operational effects for operation such as avoidance of navigation in stormy seas based upon weather forecasts, and speed reductions, etc., the factors of these effects is taken as 0.85.

2 For ships whose L_{WL} exceeds 50 *m* and which meet the conditions $L_{WL}/B_{WL} \geq 5.0$, $B_{WL}/D < 2.5$ and $C_b \geq 0.60$, design loads may be applied as follows instead of loads obtained in accordance with the requirement in **-1** above.

(1) For ships whose L_{WL} is not less than 90 *m*, the longitudinal bending moments and shearing forces specified in **Chapter 15, Part C of the Rules for the Survey and Construction of Steel Ships** may be used.

(2) For ships whose L_{WL} is less than 90 *m*, the longitudinal bending moments and shearing forces specified in **Chapter 15, Part CS of the Rules for the Survey and Construction of Steel Ships** may be used.

3 For high speed ships whose L_{WL} is less than 50 *m* which are classed as *GNS-C* ships and *GNS-D* ships, the longitudinal bending moments in waves specified in **2.8.1-1** of **Chapter 5 of the Rules for High Speed Craft** may be used.

4 For *GNS-C* ships and *GNS-D* ships whose L_{WL} is less than 50 *m* which are not classed as high speed ships, the longitudinal bending moments and shearing forces in waves need not be considered.

2.1.4 Longitudinal Bending Moments and Shearing Forces in Waves under Flooding Conditions

1 For all *GNS-A* ships and *GNS-B* ships, and for those *GNS-C* ships and *GNS-D* ships whose L_{WL} is more than 150 *m*, the following design loads are to be used in consideration of strengths for longitudinal bending moments and shearing forces under flooding and assuming the extent of damage and permeability specified in **3.2** of **Part 4**. Where more severe conditions (such as empty spaces located fore and aft) are considered, loads are to be calculated under the conditions where such spaces are assumed to be flooded rather than under the conditions where flooding in spaces within the extent of damage specified in **3.2** of **Part 4** are assumed.

(1) Longitudinal bending moments and shearing forces in still water

Longitudinal bending moments (*kN-m*) and shearing forces (*kN*) in still water at considered sections under flooded conditions are to be calculated in accordance with the requirements in **2.1.2**.

(2) Longitudinal bending moments and shearing forces in waves

Longitudinal bending moments (*kN-m*) and shearing forces (*kN*) in waves at considered sections under flooded conditions are to be calculated in accordance with the requirements in **2.1.3-1**. The ship speed specified in **2.1.3-1(1)**, however, is to be taken as 1/2 design speed and the factor 0.68 may be used instead of the factor 0.85 specified in **2.1.3-1(7)**.

2 For *GNS-C* ships and *GNS-D* ships whose L_{WL} exceeds 150 m and which meet the conditions $L_{WL}/B_{WL} \geq 5.0$, $B_{WL}/D < 2.5$ and $C_b \geq 0.60$, the longitudinal bending moments and shearing forces in waves may be taken as 0.8 times those specified respectively in **15.2.1-1** and **15.3.1-1 of Part C of the Rules for the Survey and Construction of Steel Ships** in consideration of the extent of damage and permeability specified in **3.2, Part 4**.

2.2 Design Wave Loads for Strength Assessments of Main Hull Structures

2.2.1 General

1 Design wave loads acting upon main hull structures are be considered and calculated in accordance with the requirements in **2.1.3-1**.

2 In calculating design wave loads, attention is to be paid to the following.

(1) Wave loads are to be distributed uniformly in lengthwise directions within the extents of the considered structures.

(2) At points on the considered load waterlines (where hydrostatic pressure becomes 0) and where the pressures due to waves become positive, wave loads above load waterline are to be obtained by the linear interpolation of water head values at load waterlines and up to positions corresponding to water heads converted from pressures due to waves at load water lines.

(3) At points on the considered load waterlines (where hydrostatic pressure becomes 0) and where the pressures due to waves become negative, wave loads below load waterlines are to take values so that total pressures obtained by hydrostatic pressures plus pressures due to waves are not negative.

3 For *GNS-C* ships and *GNS-D* ships meeting the conditions $L_{WL}/B_{WL} \geq 5.0$, $B_{WL}/D < 2.5$ and $C_b \geq 0.60$, design loads are to be obtained as follows.

(1) For ships whose L_{WL} is more than 150 m, design loads are to be in accordance with the requirements **-1** and **-2**.

(2) For ships whose L_{WL} is 90 m or more but does not exceed 150 m, design loads to either be given in accordance with the requirement in **(1)** above or relevant requirements in **Part C of the Rules for the Survey and Construction of Steel Ships**.

(3) For ships whose L_{WL} is less than 90 m, design loads are to be in accordance with relevant requirements in **Part CS of the Rules for the Survey and Construction of Steel Ships**.

(4) For high speed ships whose L_{WL} is more than 50 m, design loads are to be in accordance with relevant requirements in the **Rules for High Speed Craft**.

(5) In cases where relevant requirements in **Part C** and **Part CS of the Rules for the Survey and Construction of Steel Ships** and relevant requirements in the **Rules for High Speed Craft** are referred to in **(2)** to **(4)** above, and where the loads for each structural member consist of parts of the formulae for scantlings, design loads need not be calculated.

4 For the structural members of main hull structures subject to stresses generated by longitudinal bending moments, the stress due to longitudinal bending moments calculated by regarding the hull as a beam based upon the requirements in **Chapter 3** is to be considered.

2.2.2 Design Loads for Strength Assessments of Main Hull Structures under Flooding Conditions

1 For all *GNS-A* ships and *GNS-B* ships, and for those *GNS-C* ships and *GNS-D* ships whose L_{WL} is more than 150 m, loads for strength assessments of main hull structures under flooding conditions in consideration of the extents of damage and the permeability specified in **3.2, Part 4** are to be calculated in accordance with the followings.

(1) Static loads in flooding conditions

(2) Wave loads are to be based upon the requirements in **2.1.3-1**. The ship speed specified in **2.1.3-1(1)**, however, is to be taken as 1/2 design speed and the factor 0.68 may be used instead of the factor 0.85 specified in **2.1.3-1(7)**.

(3) The stress is to be obtained by multiplying the stress due to longitudinal bending moment calculated by regarding the hull as a beam in the intact condition by 0.75.

2 For *GNS-C* ships and *GNS-D* ships whose L_{WL} exceeds 150 m which meet the conditions $L_{WL}/B_{WL} \geq 5.0$, $B_{WL}/D < 2.5$ and $C_b \geq 0.60$, loads are to be at the discretion of the Society.

2.3 Design Wave Loads for Strength Assessments of Local Structures

2.3.1 Plating

1 Design wave loads for local structural members are to be taken as the maximum values at the considered locations calculated in accordance with the requirements in **2.2.1**.

2 For *GNS-C* ships and *GNS-D* ships meeting the conditions $L_{WL}/B_{WL} \geq 5.0$, $B_{WL}/D < 2.5$ and $C_b \geq 0.60$, design wave loads are to be calculated in accordance with the following requirements.

(1) For ships whose L_{WL} is not less than 90 m, design loads are to be in accordance with relevant requirements in **Part C of the Rules for the Survey and Construction of Steel Ships**.

(2) For ships whose L_{WL} is less than 90 m, design loads are to be in accordance with relevant requirements in **Part CS of the Rules for the Survey and Construction of Steel Ships**.

(3) For high speed ships whose L_{WL} is not more than 50 m, design loads are to be in accordance with relevant requirements in the **Rules for High Speed Craft**.

(4) In cases where relevant requirements in **Part C** and **Part CS of the Rules for the Survey and Construction of Steel Ships** and relevant requirements in the **Rules for High Speed Craft** are referred to in **(1)** to **(3)** above, and where the loads for each structural member consist of parts of the formulae for scantlings, design loads need not be calculated.

2.3.2 Loads Acting on Rudders

1 The rudder force and rudder torque of rudders moving to the maximum rudder angle of 35° are to be in accordance with the requirements in **3.2** and **3.3, Part C of the Rules for the Survey and Construction of the Steel Ships**.

2 Notwithstanding the requirement **-1** above, rudder force and rudder torque may be estimated by the model tests or detailed numerical simulations. In such cases, data related to said model tests and numerical simulations is to be submitted to the Society for approval.

3 For rudders having special forms or rudders moving to maximum rudder angles of more than 35°, rudder force and rudder torque are to be estimated in accordance with the requirement in **-2** above.

2.3.3 Loads for Internal Structures in Hulls below Freeboard Decks and Structures for Equipment Supports

1 Loads for internal structures in hulls below freeboard decks and structures for equipment supports are to be taken as the maximum loads at the considered locations in consideration of acceleration calculated in accordance with the requirement in **2.1.3-1**, static pressures due to liquids being carried and the self-weights of the structural members in question. Where static loads are calculated, the angles of inclination specified in **3.1.2, Part 1** are to be considered.

2 For *GNS-C* ships and *GNS-D* ships meeting the conditions $L_{WL}/B_{WL} \geq 5.0$, $B_{WL}/D < 2.5$ and $C_b \geq 0.60$, design wave loads are to be calculated in accordance with the following requirements.

(1) For ships whose L_{WL} is not less than 90 *m*, design loads are to be in accordance with relevant requirements in **Part C of the Rules for the Survey and Construction of Steel Ships**.

(2) For ships whose L_{WL} is less than 90 *m*, design loads are to be in accordance with relevant requirements in **Part CS of the Rules for the Survey and Construction of Steel Ships**.

(3) For high speed ships whose L_{WL} is not more than 50 *m*, design loads are to be in accordance with relevant requirements in the **Rules for High Speed Craft**.

(4) In cases where relevant requirements in **Part C** and **Part CS of the Rules for the Survey and Construction of Steel Ships** and relevant requirements in the **Rules for High Speed Craft** are referred to in **(1)** to **(3)** above, and where the loads for each structural member consist of parts of the formulae for scantling, design loads need not be calculated.

2.3.4 Loads for Equipment on Freeboard Decks and Support Structures

1 Loads for equipment on freeboard decks and support structures are to be taken as the loads at the considered locations in consideration of the acceleration calculated in accordance with the requirement in **2.1.3-1** and the impact loads due to green water, etc. In addition, loads due to wind which are to be calculated using the instantaneous maximum wind speed specified in **3.1.3, Part 1**. Where the static loads and self-weights of the considered structural members are calculated, the angles of inclination specified in **3.1.2, Part 1** are to be considered.

2 For *GNS-C* ships and *GNS-D* ships meeting the conditions $L_{WL}/B_{WL} \geq 5.0$, $B_{WL}/D < 2.5$ and $C_b \geq 0.60$, design wave loads are to be calculated in accordance with the following requirements.

(1) For ships whose L_{WL} is not less than 90 *m*, design loads are to be in accordance with relevant requirements in **Part C of the Rules for the Survey and Construction of Steel Ships**.

(2) For ships whose L_{WL} is less than 90 *m*, design loads are to be in accordance with relevant requirements in **Part CS of the Rules for the Survey and Construction of Steel Ships**.

(3) For high speed ships whose L_{WL} is not more than 50 *m*, design loads are to be in accordance with relevant requirements in the **Rules for High Speed Craft**.

(4) In cases where relevant requirements in **Part C** and **Part CS of the Rules for the Survey and Construction of Steel Ships** and relevant requirements in the **Rules for High Speed Craft** are referred to in **(1)** to **(3)** above, and where the loads for each structural member consist of parts of the formulae for scantlings, design loads need not be calculated.

2.3.5 Impact Loads due to Bottom Slamming

1 For ships having bow draughts which are 0.037 L_{WL} or 8.51 *m*, whichever is smaller, impact loads due to bottom slamming are to be considered.

2 Slamming loads are to be calculated in consideration of ship's motions, relative water heights against waves at the considered locations, etc. in accordance with the requirement in **2.1.3-1**.

3 For *GNS-C* ships and *GNS-D* ships meeting the conditions $L_{WL}/B_{WL} \geq 5.0$, $B_{WL}/D < 2.5$ and $C_b \geq 0.60$, design wave loads are to be calculated in accordance with the following requirements.

(1) For ships whose L_{WL} is not less than 90 *m*, design loads are to be in accordance with relevant requirements in **Part C of the Rules for the Survey and Construction of Steel Ships**.

(2) For ships whose L_{WL} is less than 90 *m*, design loads are to be in accordance with relevant requirements in **Part CS of the Rules for the Survey and Construction of Steel Ships**.

(3) For high speed ships whose L_{WL} is not more than 50 *m*, design loads are to be in accordance

with relevant requirements in the **Rules for High Speed Craft**.

(4) In cases where relevant requirements in **Part C** and **Part CS of the Rules for the Survey and Construction of Steel Ships** and relevant requirements in the **Rules for High Speed Craft** are referred to in **(1)** to **(3)** above, and where the loads for each structural member consist of parts of the formulae for scantlings, design loads need not be calculated.

2.3.6 Impact Loads at Flare Parts

1 For ships having flare angle greater than 50°, as measured from vertical lines to tangential lines of side shells at the considered points to the cross points between load waterlines and side shells at load waterlines, impact loads at flare parts are to be considered.

2 The impact loads at flare parts are calculated in consideration of ship's motions, relative water heights against the waves at the considered locations, etc. in accordance with the requirement in **2.1.3-1**.

3 For *GNS-C* ships and *GNS-D* ships meeting the conditions $L_{WL}/B_{WL} \geq 5.0$, $B_{WL}/D < 2.5$ and $C_b \geq 0.60$, design loads are to be in accordance with relevant requirements in **Part C of the Rules for the Survey and Construction of Steel Ships**.

2.3.7 Helicopter Loads, etc.

1 Minimum deck loads for helicopter landing areas and storage areas are to be taken as 2.1 kN/m^2.

2 Helicopter landing impact loads

(1) As for the deck loads in the ranges where helicopters take off or land, loads of 75 % of helicopter maximum take-off weights are to be taken on each of two 0.3 m × 0.3 m square areas. Areas for landing of helicopters may be taken as the actual sizes of the wheels of helicopters.

(2) For girders, stanchions, etc., the structural weights of helidecks are to be considered in addition to the helicopter impact loads specified in **(1)** above.

(3) Where the upper decks of superstructures or deckhouses are used as helidecks and the spaces below are normally manned, the impact loads specified in **(1)** above are to be multiplied by a factor of 1.15.

3 Stowed helicopter loads

(1) Deck loads in the spaces where helicopters are stowed are to be taken as the wheel loads at maximum take-off weights. In such cases, the total weights of helicopters and the dynamical effects due to ship's motions as well as the acceleration of ships calculated in accordance with the requirement in **2.1.3-1** are also to be taken into account.

(2) Uniformly distributed loads of 0.49 kN/m^2 are to be considered in cases where the closing appliances of storage spaces are treated as weathertight.

(3) Uniformly distributed loads of 0.49 kN/m^2, representing wet snow or ice are to be considered in cases where storage spaces are not enclosed.

(4) For girders, stanchions, etc., the structural weights of helidecks are to be considered in addition to the loads specified in **(1)** to **(3)** above.

4 Wheel loads

(1) Wheel loads are to be taken as the maximum designed wheel loads (kN) of vehicles multiplied by a factor due to the effects of the acceleration of ships calculated in accordance with the requirement in **2.1.3-1** (the minimum value is 1.5). Where ground lengths of wheels (*i.e.* the size of a wheel measured in orthogonal direction of the stiffener direction) is greater than the intervals of stiffeners, maximum designed wheel loads are to be taken as the maximum wheel loads multiplied by values obtained by the intervals of stiffeners divided by the ground lengths of wheels.

(2) In the case of tracked vehicles, track loads are to be taken as the maximum designed track

loads (*kN*) of tracked vehicles multiplied by a factor due to the effect of the acceleration of the ships calculated in accordance with the requirement in **2.1.3-1** (the minimum value is 1.5). Where the breadths and lengths of tracks are greater than the intervals of stiffeners or girders at landing areas, track loads are to take into account the intervals of stiffeners.

Chapter 3 STRENGTH OF HULL STRUCTURES

3.1 Longitudinal Strength

3.1.1 General

Longitudinal members are to be so arranged as to maintain the continuity of strength. Especially, where the longitudinal system of framing is transformed into the transverse system or the transverse system of framing is transformed into the longitudinal system, or hull form is suddenly changed to narrow or wide, special care is to be taken for the continuity of strength by means of additional intercostal girders, floors or stiffeners, etc.

3.1.2 Bending Strength at the Midship Part

1 The section moduli of the transverse sections of the hull at the midship part under consideration are not to be less than the values of Z_σ obtained from the following two formulae for all conceivable loading conditions.

$$Z_\sigma = 1000 \frac{1}{\sigma_{Allowable}} |M_s + M_w(+)| \ (cm^3)$$

$$Z_\sigma = 1000 \frac{1}{\sigma_{Allowable}} |M_s + M_w(-)| \ (cm^3)$$

Where,

M_s: Longitudinal bending moment in still water (*kN-m*) calculated in accordance with the requirement in **2.1.2**.

$M_w(+)$ and $M_w(-)$: Longitudinal bending moment in waves (*kN-m*) calculated in accordance with the requirement in **2.1.3**.

$\sigma_{Allowable}$: Allowable stress for longitudinal bending moment is given by the following.

(1) Ships other than high speed ships: $175/K$ (N/mm^2). Where, K is the material factor given in **Table 3.2.1**, **Part 3**.

(2) High speed ships: $0.6\sigma_y$. Where, σ_y (N/mm^2) is the proof stress given in **Table 3.2.1** or **Table 3.2.2, Part 3**.

2 Notwithstanding the requirements of **-1** above, the section modulus (W_{min}) and the moments of inertia (I_{min}) of the transverse section of the hull amidships is not to be less than the value of (W_{min}) obtained from the following formula.

$$W_{min} = C_1 {L_{WL}}^2 B_{WL}(C_b' + 0.7) \ (cm^3)$$

$$I_{min} = 3 W_{min} L_{WL} \ (cm^4)$$

Where: the coefficient C_1 is given by the following.

$50\ m \le L_{WL} < 90\ m$: $0.03L_{WL}+5$

$90\ m \le L_{WL} \le 300\ m$: $10.75 - \left(\frac{300-L_{WL}}{100}\right)^{1.5}$

$300\ m < L_{WL} \le 350\ m$: 10.75

$350\ m < L_{WL}$: $10.75 - \left(\frac{L_{WL}-350}{150}\right)^{1.5}$

C'_b: Block coefficient (C_b). However, C_b is taken as 0.6 where C_b is less than 0.6.

3 The scantlings of longitudinal members in way of the midship part are not to be less than the scantlings of longitudinal members at the midship which are determined by the requirement in **-1** and **-2** above, excluding changes in the scantlings due to variations in the sectional form of the transverse section of the hull.

4 Cross sectional area of deck at midship part of the ship, and decks on each side of the ship, of steel plating, longitudinal beams, longitudinal girders, etc., which extends midship part of the ship or judged to extend midship part of the ships are to be not less than that complying with the requirements on section modulus of cross section area specified in **-1** and **-2** above.

3.1.3 Longitudinal Strength at Sections Other Than Midship Part

1 Where the longitudinal bending moment in still water at sections other than midship part is equal to or greater than that at midship part of the ship or where the longitudinal bending moment in waves at sections other than midship part based on the results of analysis specified in **2.1.3-1** is equal to or greater than that at midship part, the requirement in **3.1.2** is to apply to the ship.

2 Where impact wave loads at the bottom of bow or stern or impact wave loads at flare part of bow are judged to have effect to the longitudinal bending strength of the ship, or where the hull girder vibration caused by such impact wave loads are not able to ignored longitudinal bending strength, ships are to have sufficient longitudinal strength considering such effect caused by the impact wave loads.

3 Longitudinal strength at sections other than midship part is to be given in the followings.

(1) 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 0.15 L_{WL} from the after and fore end of L_{WL}, respectively, are not to be less than 40 % the value at the middle point of L_{WL} for ships with machinery amidships, or 50 % for ships with machinery aft.

(2) 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 **(1)** may not be necessarily applied.

4 Parts where the rigidity of cross section is changed suddenly such as fore and aft end of machinery room, near collision bulkhead or after peak bulkhead, where the longitudinal system of framing is transformed into the transverse system or the transverse system of framing is transformed into the longitudinal system, or fore or after part where the large openings are provided on deck, or parts where the cross section shape are suddenly changed, the section modulus of cross section of the ship is to be paid attentions to the structural continuity.

5 Beyond 0.15 L_{WL} from each end, the effective sectional area and the thickness of the strength deck may be gradually reduced avoiding abrupt changes.

3.1.4 Calculation of Section Modulus of Transverse Section of Hull

1 The calculation of the section modulus of the transverse section of the hull is to be based on the following requirements, as given in **(1)** through **(7)**.

(1) All longitudinal members which are considered effective to the 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 *m* in length and 1.2 *m* in breadth need not be deducted, provided that the sum of their breadths in any single transverse section is not more than $0.06(B\text{-}\Sigma b)$. Σb is the sum of the openings exceeding 1.2 *m* in breadth or 2.5 *m* 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:

$$Y\left(0.9+0.2\frac{X}{B_{WL}}\right)$$

Y: Horizontal distance (*m*) from the top of continuous strength member to the centre line of the ship

X: 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 or the vertical distance from the neutral axis to the bottom of keel in case where the keel is hat-type construction.

(7) Vertical distance (*m*) from the horizontal neutral axis to the bottom of keel in case where the keel is of hat-type construction.

3.2 Shearing Strength

3.2.1 Thickness of Shell Plating below Strength Deck

1 The thickness of the side shell plating below strength deck and side shell of the superstructure is not to be less than the values of t_s obtained from the following two formulae at any transverse section under consideration along the length of the hull for all conceivable loading conditions.

$$t_s=\frac{1}{2}\frac{1}{\tau_{Allowable}}|F_s+F_w(+)|\frac{m}{I}\ (mm)$$

$$t_s=\frac{1}{2}\frac{1}{\tau_{Allowable}}|F_s+F_w(-)|\frac{m}{I}\ (mm)$$

Where:

I: Moment of inertia (cm^4) of the transverse section under consideration about its horizontal neutral axis, where the requirements in **3.1.4** are to be applied to the calculation method

m: Moment of area about the horizontal neutral axis (cm^3) on the transverse section for longitudinal members above the considered position of side shell plating when the considered position is above the horizontal neutral axis, and below the considered position when the considered position is under the horizontal neutral axis. The requirements in **3.1.4** are to be applied to the calculation method.

F_s: Shearing force in still water (*kN*) at the transverse section under consideration along the length of the hull, which is calculated by a method deemed appropriate by the Society. The positive value of F_s, however, is to be defined as a positive value which is obtained assuming that downward loads are taken as positive values and are integrated in the forward direction from the aft end of the ship.

$F_w(+)$ and $F_w(-)$: The values are given in **2.1.3-1** and **-2**.

$\tau_{Allowable}$: Allowable shearing stress, is given by the following.

Ships other than high speed ships: $100/K$ (N/mm^2)

High speed ships: $0.35\sigma_y$

Where: K is the material factor given in **Table 3.2.1, Part 3**, and σ_y (N/mm^2) is the proof stress given in **Table 3.2.1** or **3.2.2, Part 3**.

2 The cross section considered is to be taken account of the section where the shearing force is changed largely and near at 0.25 L_{WL} from the end of fore and aft, respectively. For ships having openings in side shell, the shearing strength at the section in question is to be taken account.

3 For *GNS-C* ships and *GNS-D* ships meeting the condition of $L_{WL}/B_{WL}\geq 5.0$, $B_{WL}/D<2.5$ and $C_b\geq 0.60$, shearing strength may be evaluated in accordance with **15.3.1, Part C of the Rules**

for the Survey and Construction of Steel Ships.

4 Where either the impact wave loads at the bottoms of bows or sterns, or the impact wave loads at the flare parts of bows are judged to affect to the shearing strengths of ships, the sharing strengths for such sections are to be considered.

5 For ships having longitudinal bulkheads, the thickness of side shell plating and longitudinal bulkhead plating is to be obtained by using the shearing forces acting upon side shells and longitudinal bulkheads according to the results of shear flow analyses deemed appropriate by the Society and the formula specified in **-1**. For *GNS-C* ships and *GNS-D* ships meeting the condition of $L_{WL}/B_{WL} \geq 5.0$, $B_{WL}/D < 2.5$ and $C_b \geq 0.60$, the thicknesses of side shells and longitudinal bulkheads may be obtained in accordance with the requirements specified in **15.3.2, Part C of the Rules for the Survey and Construction of Steel Ships**.

3.3 Buckling Strength

3.3.1 General

1 The buckling strength of the plating and the longitudinals subject to hull girder bending and shear stresses and contributing to longitudinal strength is to be evaluated in addition to the strength evaluations specified in **3.1** and **3.2**.

2 In addition to the requirement in **-1**, throughout the length of the ship, the buckling strength of plating, girders and stiffeners arranged in regions where the cross section is significantly changed, the framing system is changed or where the effect caused by the forward bottom slamming impact loads specified in **2.3.6**, by flare slamming impact loads specified in **2.3.7**, are to be evaluated.

3.3.2 Working Stress

1 For examination of buckling strength according to the requirements in this section, the working compressive stress σ_a of the member considered is to be obtained from the following formula.

$$\sigma_a = \frac{M_s + M_w}{I} y \times 10^5 \quad (N/mm^2)$$

However, σ_a is not to be less than $30/K$.

K : Material factor given in **Table 3.2.1, Part 3**.

M_s : Longitudinal bending moment (*kN-m*) in still water as specified in **2.1.2**

M_w : longitudinal bending moment (*kN-m*) in waves as specified in **2.1.3**.

For members located above the neutral axis in the transverse section, the maximum values of M_s and M_w are to be taken in sagging condition, and for members located below the neutral axis, the maximum values of M_s and M_w are to be taken in hogging condition.

I : Moment of inertia (cm^4) at the transverse section considered as given by **3.2.1-1.**

y : Vertical distance (*m*) from the neutral axis to the location of the member considered in the transverse section

2 For examination of buckling strength according to the requirements in this section, the working shearing stress τ_a of the member considered is to be obtained from the following **(1)** or **(2)**.

(1) Ships without longitudinal bulkhead

$$\tau_a = \frac{0.5mF}{It} \times 10^2 \quad (N/mm^2)$$

F: Shearing force (*kN*) $|F_s + F_w(+)|$ or $|F_s + F_w(-)|$ as specified in **2.1.3**, whichever is greater.

I, m: As specified in **3.2.1-1**.

t: Thickness (*mm*) of the member considered

(2) Ships with longitudinal bulkhead

$$\tau_a = \frac{mF}{It} \times 10^2 \quad (N/mm^2)$$

F: Shearing force (kN) as specified in **2.1.3**
m, I, t : As given in preceding **(1)**

3.3.3 Elastic Buckling Stresses of Plates

1 Compressive buckling stress σ_E of plates is given by the following formula.

$$\sigma_E = 0.9 K_m E \left[\frac{t_b}{1000s}\right]^2 \quad (N/mm^2)$$

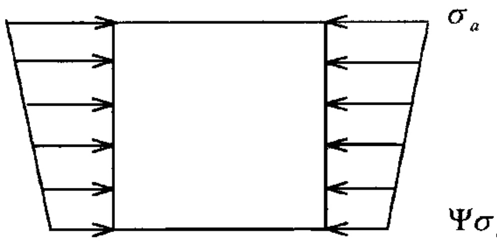
E: Modulus of tensile elasticity (N/mm^2) given in **Table 3.2.1, Part 3**.
t_b: Thickness of plate (mm)
s : Span (m) of shorter side of plate panel
K_m: For plating with longitudinal system of framing

$$K_m = \frac{8.4}{\Psi + 1.1} \quad (\text{for } 0 \le \Psi \le 1)$$

For plating with transverse system of framing

$$K_m = c\left[1 + \left[\frac{s}{l}\right]^2\right]^2 \frac{2.1}{\Psi + 1.1} \quad (\text{for } 0 \le \Psi \le 1)$$

l : Span (m) of longer side of plate panel
Ψ: Ratio between min. and max. compressive stress σ_a when linear variation across panel



c: Coefficients obtained according to the kind of stiffeners at compressive side, which are given by the following:
1.30: when plating stiffened by floors or deep girders
1.21: when stiffeners are angles or T-sections
1.10: when stiffeners are bulb flats
1.05: when stiffeners are flat bars

2 Shear buckling stress τ_E of plate is given by the following formula:

$$\tau_E = 0.9 k_t E \left[\frac{t_b}{1000s}\right]^2 \quad (N/mm^2)$$

k_t: As given by the following.

$$k_t = 5.34 + 4\left[\frac{s}{l}\right]^2$$

E, t_b, s and l: As specified in **-1** above

3.3.4 Elastic Buckling of Longitudinal Frame, Longitudinal Beam and Longitudinal Stiffener

1 Compressive buckling stress σ_E of longitudinal frame, beam and stiffener is given by the following formula.

$$\sigma_E = 0.001 E \frac{I_a}{A l^2} \quad (N/mm^2)$$

E: Modulus of tensile elasticity (N/mm^2) given in **Table 3.2.1, Part 3**.
I_a: Moment of inertia (cm^4) of longitudinal including plate flange and calculated with thickness
A: Cross-sectional area (cm^2) of longitudinal including plate flange and calculated with thickness
l: Span (m) of longitudinal

2 Torsional buckling stress σ_E of longitudinal frame, beam and stiffener is given by the following formula.

$$\sigma_E = \frac{\pi^2 E I_W}{10^4 I_p l^2}\left[m^2 + \frac{K}{m^2}\right] + 0.385E\frac{I_t}{I_P} \quad (N/mm^2)$$

I_t : St. Venant's moment of inertia (cm^4) obtained without plate flange according to the kind of longitudinals, which is given by the following:

$$I_t = \frac{h_w t_w^3}{3} \times 10^{-4} \quad (cm^4) \text{ for flat bar}$$

$$I_t = \frac{1}{3}\left[h_w t_w^3 + b_f t_f^3\left[1 - 0.63\frac{t_f}{b_f}\right]\right] \times 10^{-4} \quad (cm^4) \text{ for flanged section}$$

I_p : Polar moment of inertia (cm^4) about connection of stiffener to plate obtained according to the kind of longitudinals, which is given by the following

$$I_P = \frac{h_w^3 t_w}{3} \times 10^{-4} \quad (cm^4) \text{ for flat bar}$$

$$I_P = \left[\frac{h_w^3 t_w}{3} + h_w^2 b_f t_f\right] \times 10^{-4} \quad (cm^4) \text{ for flanged section}$$

I_w : Sectorial moment of inertia (cm^6) about connection of stiffener to plate obtained according to the kind of longitudinals, which is given by the following

$$I_W = \frac{h_w^3 t_w^3}{36} \times 10^{-6} \quad (cm^6) \text{ for flat bar}$$

$$I_W = \frac{t_f b_f^3 h_w^2}{12} \times 10^{-6} \quad (cm^6) \text{ for } T\text{-sections}$$

$$I_W = \frac{b_f^3 h_w^2}{12(b_f + h_w)^2}\left[t_f(b_f^2 + 2b_f h_w + 4h_w^2) + 3t_w b_f h_w\right] \times 10^{-6} \quad (cm^6) \text{ for angles and bulb sections}$$

h_w: Web height (mm)

t_w: Web thickness (mm)

b_f: Flange width (mm)

t_f: Flange thickness (mm). For bulb sections, the mean thickness of the bulb is to be used.

l : Span (m) of longitudinal

K_1: As given by the following

$$K_1 = \frac{Cl^4}{\pi^4 E I_w} \times 10^6$$

C: As given by the following

$$C = \frac{k_p E t_p^3}{3s\left[1 + \frac{1.33 k_p h_w t_P^3}{1000 s t_w^3}\right]} \times 10^{-3}$$

s : Spacing (m) of longitudinal

t_P: Thickness (mm) of plate connected to longitudinals

k_P: As given by the following, but not less than zero. For longitudinals with flanges, the value need not be taken as less than 0.1

$$k_P = 1 - \eta_P$$

η_P: As given by follows:

$$\eta_P = \frac{\sigma_a}{\sigma_{EP}}$$

σ_a: Calculated compressive stress for longitudinals as specified in **3.3.2**.

σ_{EP}: Elastic buckling stress of supporting plate as calculated in **3.3.3**.

E: Modulus of tensile elasticity (N/mm^2) given in **Table 3.2.1, Part 3**.

m: The value corresponding to K_1 and are given by **Table 5.3.1**.

Table 5.3.1 The value of m

	$0 < K_1 < 4$	$4 \leq K_1 < 36$	$36 \leq K_1 < 144$	$(m-1)^2 m^2 \leq K_1 < m^2(m+1)^2$
m	1	2	3	m

3 Compressive buckling stress σ_E for web plate of longitudinals is given by the following formula.

$$\sigma_E = 3.8E\left[\frac{t_w}{h_w}\right]^2 \quad (N/mm^2)$$

E, t_w, h_w: as given in proceeding **-2**.

3.3.5 Critical Buckling Stress

1 The critical buckling stress in compression σ_C is determined as follows

$\sigma_C = \sigma_E$ when $\sigma_E \leq \frac{\sigma_Y}{2}$

$\sigma_C = \sigma_Y\left[1 - \frac{\sigma_Y}{4\sigma_E}\right]$ when $\sigma_E > \frac{\sigma_Y}{2}$

σ_E : The compressive buckling stress calculated according to **3.3.3** and **3.3.4**

σ_Y : Minimum yield stress or proof stress (N/mm^2) of material given in **Table 3.2.1**, **Part 3**

2 The critical buckling stress in shear τ_C is determined as follows

$\tau_C = \tau_E$ when $\tau_E \leq \frac{\tau_Y}{2}$

$\tau_C = \tau_Y\left[1 - \frac{\tau_Y}{4\tau_E}\right]$ when $\tau_E > \frac{\tau_Y}{2}$

τ_E : The shearing buckling stress calculated according to **3.3.3**.

τ_y : As given by the following

$$\tau_Y = \frac{\sigma_Y}{\sqrt{3}}$$

3 When examining the buckling strength of plates with openings, the elastic buckling stress σ_E and τ_E obtained from the following formulae are to be used in place of σ'_E and τ'_E for determination of critical buckling stress in **-1** and **-2**.

$\sigma'_E = \gamma\sigma_E$ (N/mm^2)

$\tau'_E = \gamma\tau_E$ (N/mm^2)

σ_E and τ_E : As given in preceding **-1** and **-2**.

γ : Reduction factor due to the opening, given by the following. When the opening is reinforced properly, it may be taken as 1.0

$$\gamma = \frac{1}{\{1 + \phi/(2S)\}^2}$$

ϕ : Span (m) of the major axis of the opening

S : Span (m) of the side of the panel along the major axis of the opening.

However, when the opening is reinforced properly, it may be taken as 1.0

3.3.6 Scantling Criteria

The buckling strength for platings (including web platings of longitudinal girders and stringers) and longitudinals is to comply with the following

(1) For compressive, bending and torsional buckling

$\sigma_C \geq \beta\sigma_a$

β : Coefficient given by the following

1.0: for plating and for web plating of stiffeners 0

1.1: for stiffeners

(2) For shearing buckling of plate panels $\tau_C \geq \tau_a$

3.4 Strength of Main Structures

3.4.1 General

1 For all *GNS-A* ships and *GNS-B* ships and for *GNS-C* ships and *GNS-D* ships whose L_{WL} is more than 150 m, strength of the main structures are to be evaluated by the structural analysis specified in **3.4.2**.

2 For *GNS-C* ships and *GNS-D* ships whose L_{WL} is not more than 150 m and not meeting the condition of $L_{WL}/B_{WL} \geq 5.0$, $B_{WL}/D < 2.5$ or $C_b \geq 0.60$ and for high speed ships whose L_{WL} is more than 50 m, strength of the main structures are to be evaluated by the structural analysis specified in **3.4.2**.

3 For *GNS-C* ships and *GNS-D* ships whose L_{WL} is not more than 150 m and meeting the condition of $L_{WL}/B_{WL} \geq 5.0$, $B_{WL}/D < 2.5$ and $C_b \geq 0.60$, strength of the main structures is to be evaluated in accordance with the following requirements.

(1) For ships whose L_{WL} is 90 m and more but does not exceed 150 m, strength of the main structures is given by relevant requirements in **Part C of the Rules of the Survey and Construction of Steel Ships**.

(2) For ships whose L_{WL} is less than 90 m, strength of the main structures is given by relevant requirements in **Part CS of the Rules of the Survey and Construction of Steel Ships**.

(3) For high speed ships whose L_{WL} is not more than 50 m, strength of the main structures is given by relevant requirements of the **Rules for High Speed Craft**.

4 In applying the requirements in **-1** to **-3**, the requirements on the longitudinal bending and shear strength specified in **3.3**, the requirements on the structural details and the minimum thickness of plates specified in **Chapter 1** and the requirements on local strength specified in **3.7** are to be complied with.

5 Where relevant requirements of the **Rules for the Survey and Construction of Steel Ships** are referenced in the requirement of **-3**, the following attentions are to be paid.

(1) Where scantling formula specified in the **Rules for the Survey and Construction of Steel Ships**, the following requirements are to be applied.

(a) In the scantling formula, corrosion additions specified in **3.2.1, Part 1** are to be considered instead of the constant values described in the end of the scantling formula.

(b) In the formula for areas, section modulus and moments of inertia of girders and stiffeners, corrosion additions specified in **3.2.1, Part 1** are to be considered after the values obtained by the formula are to be divided by 1.2.

(2) Where scantling formula specified in the **Rules for High Speed Craft**, the following requirements are to be applied.

(a) Corrosion addition specified in **3.2.1, Part 1** ire to be considered, instead of the corrosion addition *C*

(b) The coefficient of the corrosion addition *C* is to be taken as 1.0, and corrosion additions specified in **3.2.1, Part 1** are to be considered.

3.4.2 Analysis Methods

1 Analysis methods and programs are to be such that the influences of bending, shearing, axial, and torsional deflections can be effectively taken into consideration.

2 Analysis methods and programs are to be such that the behaviours of plane or space structures can be effectively expressed and or displayed under reasonable boundary conditions.

3 Analysis programs are to have sufficient analysing accuracy. When considered necessary, the Society may require submission of data on the details of the analysis methods, verification of accuracy, etc.

4 When direct calculations were used for determining scantlings, the materials and data specifying the conditions of the calculations and data summarizing their results are to be submitted to the Society.

3.4.3 Loads

1 Loads due to longitudinal bending moment of hull girders at the forward and aft end boundaries of the structure model may, as a rule, not be taken into consideration. When these loads are taken into consideration, however, the allowable stress to be applied to the results of calculations is to be determined as deemed appropriate by the Society.

2 Loads to be considered is the loads specified in **2.3** in addition to the static loads.

3 Loads due to the inertial force of cargoes are to be considered in addition to those specified in **-2** above, when the Society considers it is necessary.

4 Special consideration is to be made for cargo holds where dynamic impact loads such as sloshing loads are predicted, and proper data in this regard such as analytical theory, structural analysis methods, etc., are to be submitted.

5 Loads of liquids or ballast water are to be taken as follows.

(1) The upper end of the water head for a tank is to be the mid-point of the distance between the top of the tank and the top of the overflow pipe.

(2) For the water head of large deep tanks, proper additional water head corresponding to dynamical influences is to be considered in addition to the water head specified in **(1)** above.

3.4.4 Structural Models

1 Modelling of structure is to be carried out in accordance with the followings.

(1) The structural model to be analyzed is to include surrounding members that are considered to have material influences on the behaviour of the members of which the scantlings are to be determined by direct calculations.

(2) The structure may be modelled as a two or three dimensional structure by using beam elements, shell elements or hybrid elements. The modelling is to be such that any proper elements chosen from among plate bending elements, membrane elements, beam elements, bar elements, etc. can reproduce the behaviour of the structure with the highest possible fidelity.

(3) When the model is not sufficiently divided into model elements for the determination of scantlings by direct calculations, the member concerned is to be remeshed with fine meshes to enable further study on the basis of the results of the analysis.

2 Modelling Using Shell Elements

(1) Side shells, longitudinal bulkheads and other similar members subjected to large shearing forces are preferably to be modelled into two or three dimensional structures using shell elements.

(2) When meshing, a proper mesh size is to be selected in accordance with the stress distribution in the model which can be predicted, and abnormally large aspect ratios of meshes are to be avoided.

(3) Girders and similar members having stress gradients along their depth are to be meshed to three elements so as to enable their discrimination. However, girders with flange and depth of web less than 1,000 *mm* but not less than 500 *mm* may be meshed to two elements and the girders with the depth of web less than 500 *mm* may be meshed to one element.

3 Modelling Using Beam Elements

(1) Where the stiffeners are modeled by the beam elements, in principle, the attached being effectively reinforced by other members or deemed by the Society to have sufficient thickness may be considered. In this case, the plates to be considered are to be in accordance with the requirements in **1.2.2**.

(2) Where the model is to use rigid members for connections and bracketed parts and anywhere where constructions of high rigidity that the moment of inertia of the connection part is more

than 3 times that of other parts of the stiffener are employed.

(3) Attention is to be paid to the position of the neutral axis. In particular, offset beam elements are to be used when modelling on a hybrid structure of beam and shell elements.

3.4.5 Allowable Stress

The stress generated in each structural member does not exceed the allowable stress given in **Table 5.3.2**. However, where the stresses generated exceeds the allowable stress, that are caused by the element size in structural modelling or near boundary of the model, additional structural analysis may be required by the Society.

Table 5.3.2 Allowable Stress (Unit: *N/mm*^{2})

	Structural members considered		σ_l	σ_t	σ_a	σ_e
Longitudinal strength members	Bottom shell plating; inner bottom plating; Longitudinal bulkhead		125/*K*	145/*K*	-	145/*K*
	Girders in double bottom Girders in double side structure		-	-	-	175/*K*
Transverse strength members	Bottom floors, deck beams, side transverses, transverses on longitudinal bulkhead, struts	Face plates (parallel part)	-	-	175/*K*	-
		Face plates (corner part)	-	-	195/*K*	-
		Web plates (parallel part)	-	-	-	175/*K*
		Web plates (corner part)	-	-	-	195/*K*
	Floors in double bottom, cross deck, transverses in double side structure		-	-	-	175/*K*

(Note)

1. σ_e : Longitudinal strength members: $\sqrt{(\sigma_l^2 - \sigma_l \cdot \sigma_t + \sigma_t^2 + 3\tau^2)}$,

Transverse strength members: $\sqrt{(\sigma_\chi^2 - \sigma_\chi \cdot \sigma_y + \sigma_y^2 + 3\tau^2)}$

2. σ_l and σ_t: Normal stress in lengthwise direction and in breadthwise direction, respectively
3. τ: Shearing stress on the lengthwise face in the breadthwise direction for longitudinal strength members and shearing stress in the *X*-*Y* plane of the element coordinate system for transverse strength members
4. σ_χ and σ_y: Normal stress in *X*-direction and *Y*-direction of element coordinate system, respectively.
5. σ_a: Normal stress of face plate
6. Openings in floors and girders, if any, are to be taken into consideration in evaluating the stress.
7. The point of detecting stress is to be the centre of the element.
8. *K* is the material factor given in **Table 3.2.1, Part 3**.

3.5 Buckling Strength of Main Hull Structures

3.5.1 General

1 Buckling strength of each structural member of the hull is to be examined on the basis of the results of direct calculations carried out in accordance with the requirements in **3.4**.

2 Buckling strength can be examined by other analytical procedures when deemed appropriate by the Society.

3.5.2 Working Stress in a Panel

1 The working in-plane stresses determined by the element coordinate systems listed below are necessary prior to analysing the panel by direct calculations in accordance with the requirements in **3.4**. (*See* **Fig. 5.3.1**)

σ_x: Compressive stress in *x*-direction (*N/mm*^{2})

σ_{xb}: In-plane bending stress in *x*-direction (*N/mm*^{2})

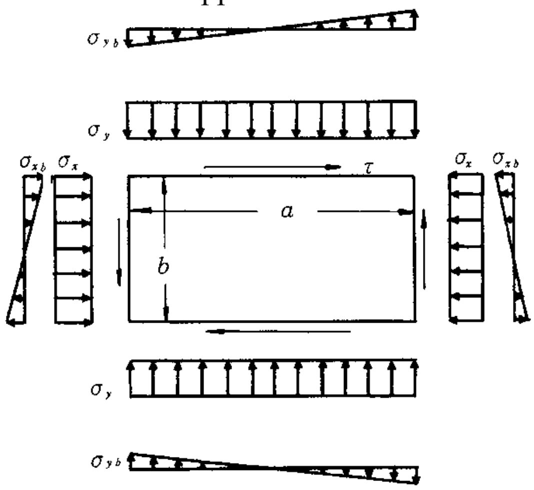
σ_y: Compressive stress in *y*-direction (*N/mm*^{2})

σ_{yb}: In-plane bending stress in y-direction (N/mm^2)

τ: Shearing stress (N/mm^2)

Here, the stresses σ_x and σ_y are to be taken as positive when they are compressive stresses, and zero when they are tensile stresses.

Fig. 5.3.1 Applied Stresses on Plate Panel



2 As loads due to the longitudinal bending moment in still water at the end boundaries of the structural model are not taken into account in determining the working stresses specified in **-1**, the stress due to the longitudinal bending moment of hull girders is to be added for specific members according to their location.

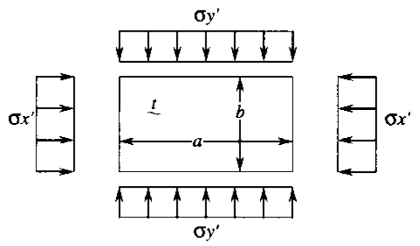
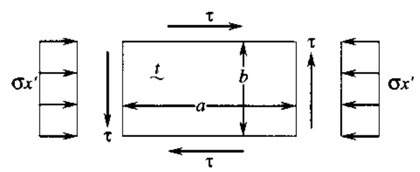
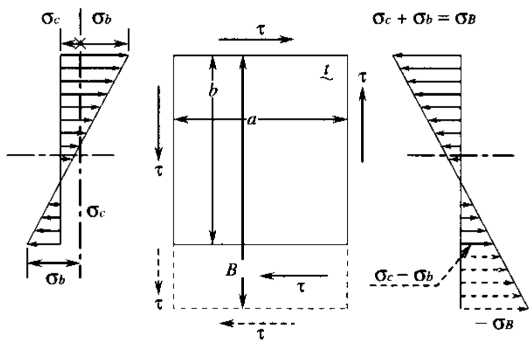
3 Members and panels are to be grouped according to **Table 5.3.3** depending upon the features of the distribution of their working stresses. Where members and panels fit more than one group, examination is to be done based on each group.

4 Working stresses of the panel obtained by the requirement in **-1** are to be modified on each group specified in **Table 5.3.4** or modified by the transformation of the coordinate system as deemed necessary, the modified stresses are to be stresses of the panel for the evaluation of the buckling strength.

Table 5.3.3 Grouping

Group	Features	Examples of members to be considered	Buckling criterion λ	Remarks
A	Relatively small shearing stress and in-plane bending stress in comparison with compressive stresses or Bi-axial compressive stress with same order	Decks, bottom and inner bottom shell related to longitudinal strength; longitudinal bulkhead plating etc., forming bi-axial stress field	1.2	
		Transverse bulkhead plating and deep girder, etc., forming bi-axial stress field	1.2	
B	Relatively small in-plane bending stress and large uni-axial compressive stress with shearing stress	Side shell and sloped bulkhead of side tank, etc., forming uni-axial and shearing stress field; bulkhead plating under high shearing stress; girder and floor, etc., forming mono-axial and shearing stress field	1.2	In case of longitudinal girders related to longitudinal strength of hull girder, stress due to longitudinal still water bending moment is to be added
C	Relatively small compressive stress and large in-plane bending stress with shearing stress	Girder and floor, etc., forming bending and shearing stress field	1.2	

Table 5.3.4 Modification of In-Plane Stresses for Each Group

Group	Stress conditions	Modified in-plane stresses
A	where $\sigma_x \geqq \sigma_{xb}$ and $\sigma_y \geqq \sigma_{yb}$, to be assumed as: $\sigma_x' = \sigma_x + 1/2 \cdot \sigma_{xb}$ $\sigma_y' = \sigma_y + 1/2 \cdot \sigma_{yb}$	
B	where $\sigma_x \geqq \sigma_{xb}$, to be assumed as: $\sigma_x' = \sigma_x + 1/2 \cdot \sigma_{xb}$	
C	where $\sigma_x < \sigma_{xb}$, to be assumed as: $\sigma_c = \sigma_x$ $\sigma_b = \sigma_{xb}$ $\sigma_B = \sigma_c + \sigma_b$	 Assumed panel width B: $B = \left(1 + \frac{\sigma_c}{\sigma_b}\right) b = \frac{\sigma_B}{\sigma_b} \cdot b$

3.5.3 Buckling Strength Calculation

1 The representative equivalent stress σ_{eq} is to be calculated as given in **Table 5.3.5** from the working stresses of the panel specified in **3.5.2**.

2 Elastic buckling stresses σ_{xcr}, σ_{ycr} and τ_{cr} are to be calculated by the interaction formula given in **Table 5.3.6**, and the equivalent elastic buckling stress σ_{cr} is to be calculated from the buckling stresses σ_{xcr}, σ_{ycr} and τ_{cr}. It is to be noted that the aspect ratio β of Group *A* should not be less than 1.0.

3 When the equivalent elastic buckling stress σ_{cr} is greater than half of the yield stress σ_Y (=235/*K*), the equivalent plastic buckling stress σ'_{cr} is to be calculated as given in **Table 5.3.5**.

3.5.4 Judgement of Buckling Strength

1 The results derived from **3.5.3** are to satisfy the following conditions **(a)** or **(b)**, where λ is the buckling criterion given in **Table 5.3.3**.

(1) Where the equivalent elastic buckling stress σ_{cr} is greater than half of the yield stress σ_Y, $\sigma'_{cr} \geq \lambda\sigma_{eq}$

(2) Where the equivalent elastic buckling stress σ_{cr} is smaller than half of the yield stress σ_Y: $\sigma_{cr} \geq \lambda\sigma_{eq}$

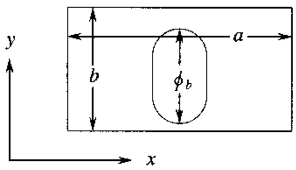
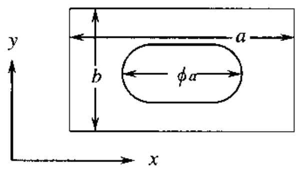
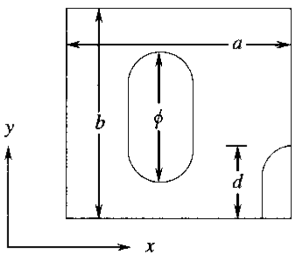
Table 5.3.5 Buckling Strength Calculation

	Group *A*	Group *B*	Group *C*
Working stress	σ'_x, σ'_y	σ'_x, τ	σ_B, τ
σ_{eq}	$\sqrt{\sigma'^2_x - \sigma'_x \cdot \sigma'_y + \sigma'^2_y}$	$\sqrt{(\sigma'^2_x + 3\tau^2)}$	$\sqrt{\left(\frac{3}{4}\sigma_B\right)^2 + 3\tau^2}$
Aspect ratio β	$a/b(\geq 1)$	a/b	a/B
Bucking stress	$\sigma_{xcr} = K_x \cdot \sigma_e$ $\sigma_{ycr} = K_y \cdot \sigma_e$	$\sigma_{xcr} = K_x \cdot \sigma_e$ $\tau_{cr} = K_s \cdot \sigma_e$	$\sigma_{Bcr} = K_B \cdot \sigma_e$ $\tau_{cr} = K_s \cdot \sigma_e$
Euler's stress of plate σ_e	$\frac{E\pi^2}{12(1-v^2)}\left(\frac{t}{b}\right)^2$		$\frac{E\pi^2}{12(1-v^2)}\left(\frac{t}{B}\right)^2$
interaction formula	See **Table 5.3.6**	See **Table 5.3.6**	See **Table 5.3.6**
σ_{cr}	$\sqrt{\sigma^2_{xcr} - \sigma_{xcr} \cdot \sigma_{ycr} + \sigma^2_{ycr}}$	$\sqrt{\sigma^2_{xcr} + 3\tau^2_{cr}}$	$\sqrt{\left(\frac{3}{4}\sigma_{Bcr}\right)^2 + 3\tau^2_{cr}}$
σ'_{cr}	where $\sigma_{cr} > 1/2 \cdot \sigma_r$ $\sigma'_{cr} = \sigma_Y\left(1 - \frac{\sigma_Y}{4\sigma_{cr}}\right)$ σ_Y: The yield stress of material specified in **Table 3.2.1, Part 3**		

Table 5.3.6 Interaction Formula for Elastic Buckling

Group *A*	Group *B*	Group *C*
$\frac{K_x}{K_{x0}} + \frac{K_y}{K_{y0}} = 1$ $\frac{K_y}{K_x} = \frac{\sigma'_y}{\sigma'_x}$ $K_{x0} = \gamma_x \frac{\beta^2}{m^2}\left(\frac{m^2}{\beta^2} + 1\right)^2$ $K_{y0} = \gamma_y \left(\frac{m^2}{\beta^2} + 1\right)^2$ *m*: positive integer equal to the number of half waves of buckling mode which gives the minimum value of buckling stress γ_x and γ_y: reduction factor due to opening, See **Table 5.3.7**.	$\frac{K_x}{K_{x0}} + \left(\frac{K_s}{K_{s0}}\right)^\alpha = 1$ $\frac{K_s}{K_x} = \frac{\tau}{\sigma'_x}$ $K_{x0} = \gamma_x \frac{\beta^2}{m^2}\left(\frac{m^2}{\beta^2} + 1\right)^2$ K_{s0}: where $\beta < 1$ $\gamma_s\left(4 + \frac{5.34}{\beta^2}\right)$ where $\beta \geq 1$ $\gamma_s\left(5.34 + \frac{4}{\beta^2}\right)$ *m*: where $\beta \leq \sqrt{2} \cdots 1$ where $\sqrt{2} < \beta \leq \sqrt{6} \cdots 2$ where $\sqrt{6} < \beta \leq \sqrt{12} \cdots 3$ where $\sqrt{12} < \beta \leq \sqrt{20} \cdots 4$ where $\sqrt{20} < \beta \cdots \beta$ α: where $\beta \geq 1/2 \cdots 2$ where $\beta < 1/2$ $0.7(1/\beta + 1)$ or 4.9 whichever is the smaller γ_x and γ_s: reduction factor due to opening, See **Table 5.3.7**.	$\left(\frac{K_B}{K_{B0}}\right)^2 + \left(\frac{K_s}{K_{s0}}\right)^2 = 1$ $\frac{K_s}{K_B} = \frac{\tau}{\sigma_B}$ K_{B0}: where $\beta \leq 2/3$ $15.87 + \frac{1.87}{\beta^2} + 8.6\beta^2$ where $\beta > 2/3 \cdots 23.9$ K_{s0}: where $\beta < 1$ $\gamma_s\left(4 + \frac{5.34}{\beta^2}\right)$ where $\beta \geq 1$ $\gamma_s\left(5.34 + \frac{4}{\beta^2}\right)$ γ_s: reduction factor due to opening, See **Table 5.3.7**.

Table 5.3.7 Reduction Factor due to Opening

γ_x	$\gamma_x = \dfrac{1}{\{1+\phi_b/(2b)\}^2}$ where ϕ_b is the overall dimension of opening in x-direction of element coordinate system. In the case where the surroundings of the opening are properly reinforced, γ_x may be taken as 1.0.	
γ_y	$\gamma_y = \dfrac{1}{\{1+\phi_a/(2a)\}^2}$ where ϕ_a is the overall dimension of opening in y-direction of element coordinate system. In the case where the surroundings of the opening are properly reinforced, γ_y may be taken as 1.0.	
γ_s	$\gamma_s = \delta \cdot \gamma_{xy}$ where γ_{xy} is obtained from the following formula: $\gamma_{xy} = \dfrac{1}{\{1+\phi/(2S)\}^2}$ ϕ is the greater dimension of opening. S is the plate breadth in the direction of the major axis of opening. In the case where the surroundings of the opening are properly reinforced, γ_{xy} may be taken as 1.0. δ is obtained from the following formula: $\delta = \dfrac{1}{4\cdot(d/a)-1}$ d is the depth of slot without reinforcement; δ is to be taken as 1.0, where $d/a \leq 0.5$	

3.6 Strength of Main Structures under Flooding Condition

3.6.1 General

1 For all *GNS-A* ships and *GNS-B* ships, and for those *GNS-C* ships and *GNS-D* ships whose L_{WL} is more than 150 *m*, strengths of main structures under flooding conditions are to be evaluated subject to the design loads specified in **2.1.4** and **2.2.2** and the structural analysis specified in **3.4.2**.

2 For ships other than those specified in **-1**, the strength of the main structures under flooding condition need not be evaluated, unless otherwise required by the Society.

3.6.2 Structural Strength and Buckling Strength of Main Structures under Flooding Condition

1 The stresses calculated by the structural analysis do not exceed the yield stressor proof stress of the used materials. In the evaluation of the buckling strength of plates and stiffeners, the buckling criterion is to be taken as 1.0.

2 Where the stresses calculated by the structural analysis exceed the allowable stress, the detailed calculation may be required by the Society considering the degree and extent of the exceedance.

3.7 Strength of Local Structural Members

3.7.1 Plates

1 For all *GNS-A* ships and *GNS-B* ships, and for that of *GNS-C* ships and *GNS-D* ships not meeting the conditions $L_{WL}/B_{WL} \geq 5.0$, $B_{WL}/D < 2.5$ or $C_b \geq 0.60$, plate thicknesses are not to be less than the values obtained by the following formulae in consideration of the loads specified in **2.3.1**, the static loads for the considered plates, and stresses due to longitudinal bending moments.

(1) Plates subject to uniform loads such as wave pressures：

Plate surrounded by girders and stiffeners are assumed to be panels with fixed boundaries on all four sides, and plate thicknesses are to be equal to or more than the values obtained by the following formulae based upon the plastic collapse model.

(a) Longitudinal system of framing

$$t = 31.6s\sqrt{\frac{SF \times P}{4\frac{\sigma_Y}{K}2\left(1-\sigma/\frac{\sigma_Y}{K}\right)}}\ (mm)$$

(b) Transverse system of framing

$$t = 31.6s\sqrt{\frac{SF \times P}{4\frac{\sigma_Y}{K}\left(1-\left(\sigma/\frac{\sigma_Y}{K}\right)^2\right)}}\ (mm)$$

s: Spacing (m) between longitudinal stiffeners

P: Loads (kN/m^2) acting upon the considered plate, calculated by the requirement in **2.3.1**.

σ: Stress (kN/mm^2) at the considered location of the plate caused by the longitudinal bending moment.

K: Material factor

σ_Y: Proof stress (N/mm^2) of the material used

SF: Safety factor is taken as 1.35.

Where side shell structures are transverse systems of framing, the thicknesses of side shell plates are to be taken as the maximum required thickness in the depth direction.

(2) Structural members subject to the impact loads

In applying the formula specified in **(1)**, stresses caused by longitudinal bending moments need not be considered and safety factors (*SF*) may be taken as 1.0.

(3) Tanks made up of plates

The formulae specified in **(1)** above are to be applied. In such cases, safety factors (*SF*) are to be taken as 1.5.

(4) Watertight bulkheads made up of plates

Water pressures corresponding to water heads measured from the lowest points of the compartments in question to the points of bulkhead decks or damage control decks are to be used instead of wave pressures in the formulae specified in **(1)**. Safety factors of the formulae specified in **(1)** are to be taken as 1.15.

(5) For plates subject to concentrated loads, plate thicknesses are to be as follows.

(a) Where concentrated loads act upon single points on plates, plate thicknesses are to be calculated assuming that such loads are acting upon single points located in the middles and centres of panels with fixed boundaries on all four sides, and taking the safety factors in the plastic collapse modes of such panels as 1.35 where the stresses caused by longitudinal bending moments are considered, and as 1.7 where the stresses caused by longitudinal bending moments are not considered.

(b) Where concentrated loads act upon two or more points on plates, plate thicknesses are to be calculated in accordance with **(a)** above with consideration given to the locations of the load acting points, the distances between the load acting points and the number of the load acting points.

(c) Where line loads such as the tracks of vehicles act upon plates, plate thicknesses are to be calculated in accordance with **(a)** above assuming that such line loads act upon lines which are on the centreline parallel to stiffeners and upon lines at the middles of plates orthogonal to stiffeners.

2 For *GNS-C* ships and *GNS-D* ships meeting the conditions $L_{WL}/B_{WL} \geq 5.0$, $B_{WL}/D < 2.5$ and $C_b \geq 0.60$ and for high speed ships whose L_{WL} is not more than 50 m, thicknesses of plates are to be calculated by the followings.

(1) For ships whose L_{WL} is 90 *m* or more but does not exceed 150 *m*, strengths of main structures are to be in accordance with relevant requirements in **Part C of the Rules of the Survey and Construction of Steel Ships**.

(2) For ships whose L_{WL} is less than 90 *m*, strengths of main structures are to be in accordance with the requirements in **Part CS of the Rules of the Survey and Construction of Steel Ships**.

(3) For high speed ships whose L_{WL} is not more than 50 *m*, strengths of main structures are to be in accordance with relevant requirements of the **Rules for High Speed Craft**.

3 In applying the requirements in **-1** and **-2** above, the requirements for the longitudinal bending and shear strength specified in **3.3**, and the requirements for the structural details and the minimum thickness of plates specified in **Chapter 1** are also to be complied with.

4 Where relevant requirements of the **Rules for the Survey and Construction of Steel Ships**, etc., are referenced in the requirement of **-2**, attention is to be paid to the following.

(1) Where scantling formulae specified in the **Rules for the Survey and Construction of Steel Ships** are used, the corrosion additions specified in **3.2.1, Part 1** are to be considered instead of the constant values indicated at the ends of the scantling formulae specified in the **Rules for the Survey and Construction of Steel Ships.**

(2) Where scantling formulae specified in the **Rules for High Speed Craft** are used, the corrosion additions specified in **3.2.1, Part 1** are to be considered, instead of the corrosion addition *C*.

3.7.2 Stiffeners

1 For all *GNS-A* ships and *GNS-B* ships and for those *GNS-C* ships and *GNS-D* ships not meeting the conditions $L_{WL}/B_{WL} \geq 5.0$, $B_{WL}/D < 2.5$ or $C_b \geq 0.60$, the section properties of stiffeners which are assumed to be beam fixed at both ends are to be not less than the values obtained by the following formulae in consideration of the loads specified in **2.3.1** and static loads for the considered stiffener, and considering the stress due to longitudinal bending moments.

(1) Stiffeners subject to uniform loads such as wave pressure：

(a) Longitudinal system of framing

$$Z = \frac{SF \times 1000Psl^2}{MF(\sigma_Y/K - \sigma)} \ (cm^3)$$

(b) Transverse system of framing

$$Z = \frac{SF \times 1000Psl^2}{MF \times \sigma_Y/K} \ (cm^3)$$

Where stiffeners fitted to side structures use transverse systems of framing, loads at the lower ends of the stiffeners are to be assumed to act uniformly upon the whole stiffener in the depth direction.

Where: *s*, *K*, *P*, σ_Y and σ: as given in **3.7.1-1**.

l: span (*m*) of the stiffener

SF: Safety factor as given by 1.0

MF: Coefficient related to modeling to the beam with fixed end, as given by 12.

(2) Stiffeners subject to impact loads

In applying the formulae specified in **(1)** above, stresses caused by longitudinal bending moments need not be considered. Safety factors (*SF*) are to be taken as 1.0 and (*MF*) is to be taken as 16.

(3) Stiffeners attached to the plates which make up tanks

The formulae specified in **(1)** above are to be applied. However, safety factors (*SF*) are to be taken as the values specified in the following **(a)** and **(b)**.

(a) For static loads: 1.67

(b) For static loads plus dynamic loads due to the ship's motion: 1.17

(4) Stiffeners attached to the plates making up watertight bulkheads

In applying the formulae specified in **(1)** above, safety factors (*SF*) are to be taken as 1.25 and (*MF*) is to be taken as 16.

(5) For stiffeners subject to concentrated loads, the section properties of the stiffeners are to be as follows.

(a) Where the concentrated loads acts upon single points on the stiffeners, the section moduli of stiffeners are to be calculated in accordance with the following assuming that the concentrated loads are acting upon single points located at the middles of stiffener with fixed ends

(i) Longitudinal system of framing

$Z = \frac{SF \times 1000Fl}{MF(\sigma_Y/K - \sigma)}$ (cm^3)

(ii) Transverse system of framing

$Z = \frac{SF \times 1000Fl}{MF \times \sigma_Y/K}$ (cm^3)

Where, F: the concentrated loads (*kN*)

SF, σ, σ_Y and K: as given in **(1)**.

MF: The coefficient related to the modeling of the beam with the fixed end, is taken as 8.

(b) Where concentrated loads act upon two or more points on stiffeners, consideration is to be given to the locations of the load acting points, the distances between the load acting points and the number of the load acting points as well as the elastic bending moments at the ends of beams with fixed ends and the stresses caused by longitudinal bending moments. Safety factors (*SF*) are to be taken as 1.0.

(c) Where line loads such as the tracks of vehicles act upon stiffeners, section moduli of stiffeners are to be calculated using the formulae specified in **(a)** above using the values obtained by the line loads (F_L) (*kN/m*) divided by the breadth (b_L) (*m*) of the line loads also as given in the formulae specified in **(a)**,

2 Where brackets are provided at the ends of stiffeners and the distances from the ends of stiffeners to the points where the moments of inertia of the brackets are the same as that of the stiffeners, or where web stiffeners are provided, the breadths of web stiffeners may be subtracted from the spans of stiffeners.

3 For members (*e.g.* web plates and face plates) complying with the requirements in **-1** and **-2**, above making up stiffeners, the respective corrosion additions specified in **3.2.1 of Part 1** for such members are to be considered.

4 For *GNS-C* ships and *GNS-D* ships meeting the conditions $L_{WL}/B_{WL} \geq 5.0$, $B_{WL}/D < 2.5$ and $C_b \geq 0.60$ and for high speed ships whose L_{WL} is not more than 50 *m*, the section properties of stiffeners are to be calculated as follows.

(1) For ships whose L_{WL} is 90 *m* or more but does not exceed 150 *m*, the scantlings of stiffeners to be in accordance with relevant requirements in **Part C of the Rules for the Survey and Construction of Steel Ships**.

(2) For ships whose L_{WL} is less than 90 *m*, the scantlings of stiffeners are to be in accordance with relevant requirements in **Part CS of the Rules for the Survey and Construction of Steel Ships**.

(3) For high speed ships whose L_{WL} is not more than 50 *m*, the scantlings of stiffeners are to be in accordance with relevant requirements in the **Rules for High Speed Craft**.

5 Where relevant requirements of the **Rules for the Survey and Construction of Steel Ships**, etc., are referenced in the requirement of **-4** above, attention is to be paid to the following.

(1) Where the scantling formulae specified in the **Rules for the Survey and Construction of**

Steel Ships are used, the corrosion additions specified in **3.2.1, Part 1** after the values obtained for the members of stiffeners required by the **Rules for the Survey and Constriction of Steel Ships** are divided by 1.2, respectively.

(2) Where the scantling formulae specified in the **Rules for High Speed Craft** are used, the coefficient (*C*) related to the corrosion additions specified in the **Rules for High Speed Craft** are to be taken as 1.0. In such cases, the corrosion additions specified in **3.2.1, Part 1** are to be considered for those members (*e.g.* face plates and web plates) making up stiffeners having the required section properties, respectively.

6 The section areas of pillars are to be calculated using buckling formulae (*e.g.* Euler's equation) with both ends supported and allowable stresses of 1/2 proof stress for the materials used.

7 Bulkhead decks, tank walls, and closing covers for openings provided on bulkhead decks are to be stiffened so that the moments of inertia of the structures have amounts of deflection for the structures in question not exceeding 1/2,400 of intervals between stiffeners of girders. For watertight bulkheads, the amounts of deflection may be taken as 1/800.

3.7.3 Other Structural Members

1 made up of two plate members such as double bottom structures and double side structures, web stiffeners provided at locations where the stiffeners penetrate the webs of girders are subject to the requirements in **1.1.14-3, Part C of the Rules for the Survey and Construction of Steel Ships** and other related requirements, except in cases where the structural members at the considered locations are to be modelled for detailed structural analysis and the fatigue assessments specified in **Chapter 4** are to be carried out.

2 Where stiffeners are provided in order to avoid the buckling of plate members and such stiffeners have heights which are 5 times the thicknesses of the attached plates and where the scantlings of such stiffeners comply with the requirements specified in **1.2.6-9**, the strengths of such stiffeners need not be evaluated.

3.8 Strength of Rudder

3.8.1 General

1 The strengths of rudders are to be in accordance with the requirements in **Chapter 3, Part C of the Rules for the Survey and Construction of Steel Ships**. In applying these requirements, attention is to be paid to the following.

(1) The corrosion additions specified in **3.2.1, Part 1** are to be considered instead of the constant values specified in the ends of the formulae for rudder plates given in **3.6.1, Part C of the Rules for the Survey and Construction of Steel Ships**.

(2) The formulae to be used for rudder plate thickness are the ones for the thicknesses of horizontal webs specified in **3.7.4** and the ones for the thicknesses of rudder plates and vertical webs specified in **3.7.5, Part C of the Rules for the Survey and Construction of Steel Ships**, is to be used that not considered the constant value specified at the end of the formula in in **3.6.1, Part C of the Rules for the Survey and Construction of Steel Ships**. Instead, the corrosion additions specified in **3.2.1, Part 1** are to be considered in rudder plate thickness calculations

2 The rudder provided to the high speed ships is to be in accordance with the requirements in the **Rules for the High Speed Craft**. In this case, the corrosion addition specified in **3.2.1, Part 1** is to be considered, instead of the corrosion addition *C*.

3 For the rudder force and rudder torque calculated by the requirement in **2.3.2**, in determining the scantling of each part of the rudder, the following moments and forces are to be evaluated by the direct calculation methods deemed appropriate by the Society and the scantling of each part of the rudder is to be evaluated by the direct strength assessment methods deemed appropriate by the Society. In this case, the allowable stress is to be taken as $165/K$ (N/mm^2) for the rudder plate and the value for rudder pintle specified in **3.6.3, Part C of the Rules for the Survey and Construction of Steel Ships**.

(1) Bending moment and shear force for whole rudder body

(2) Bending moment and torque for rudder neck

(3) Reacting force for pintle bearing and neck bearing of rudder

Chapter 4 FATIGUE STRENGTH

4.1 General

4.1.1 Application

1 For all *GNS-A* ships and *GNS-B* ships which are constructed of steel, and for those *GNS-C* ships and *GNS-D* ships whose L_{WL} is more than 150 *m*, which are constructed of steels, f fatigue strength assessments of stress concentration parts are to be carried out.
2 For ships, regardless of ship length, constructed of aluminium alloys, fatigue strength assessments of major welded joints, stress concentration parts and parts affected by vibrations are to be carried out.
3 Where the effects of vibrations caused by machinery and propellers is not able to be ignored, consideration is to be given to the impact of the natural frequency of such vibrations on structures located nearby and fatigue strength assessments of such structures are to be carried out.

4.1.2 Assumptions

1 Fatigue strength assessments are to be carried out using *S-N* curves such as the curves specified in the "*Fatigue Design of Welded Joints and Components: Recommendations of IIW Joint Working Group XIII–XV*" corresponding to the kinds of materials, presence of welded parts, etc. based upon the principle of the linear cumulative fatigue damage model.
2 Design fatigue life is 25 years or more.
3 In fatigue strength assessments, quasi-static wave loads (i.e. static loads which take into consideration the instantaneous minimum values or maximum values of variable loads) are to be calculated in accordance with the requirement in **2.1.3-1**. In applying the requirement in **2.1.3-1(6)**, however, equivalent waves corresponding to the excessive probability level 10^{-2} are to be calculated.
4 In fatigue strength assessments of parts of structural discontinuity and end parts of welds, hot spot stresses (*i.e.* stresses considered to be stress concentrations caused by the existence of structural discontinuity or attachments by welding, but which do not included non-linear peak stresses caused by notches at the ends of welds) are to be used. In addition, stress generated at the free edges of non-welded parts is to be used as local stress at the considered location, and hot spot stresses are then to be obtained by multiplying stress concentration factors by nominal stresses obtained using simplified methods based upon beam theory, etc., or by detailed finite element analysis using very fine meshes with sizes equal to the thicknesses of the plates for the considered structures.
5 Stress ranges for fatigue strength assessments are to be obtained by simplified stress analysis methods. For structural discontinuities and complex structures, however, finite element analysis is to be used for the stress calculations.
6 Long term distributions of the stress ranges of detailed structures are to use a two-parameter Weibull distribution. In such cases, the shape parameters of the Weibull distributions are to be taken as 1.0, and the stress ranges for fatigue strength assessments are to be obtained from reference stresses corresponding to an exceedance probability level of 10^{-2}.
7 Fatigue strength assessments are to be carried out in accordance with the principles of linear cumulative fatigue damage models, and the criterion for cumulative fatigue damage is to be less than 1.0.

4.2 Assessment of Fatigue Strength

4.2.1 Stress and Stress Range

1 The stresses and the stress range at welded joints are to be the maximum and minimum value and the difference between the maximum and the minimum calculated at the considered location under the same wave condition, respectively.

2 Where the plate thickness of the considered location is more than 22 *mm*, the stress distribution in the direction of plate thickness is to be taken account.

3 Where the static load varies largely like that the static load in tanks changes from the empty to fully loaded, the stress to be used for the evaluation is to be calculated considering the effect of the mean stress appropriately.

4 The evaluation methods and the results about the stresses and the stress range of the structural members to be assessed the fatigue strength due to local vibration are to be submitted to the Society.

4.2.2 Calculation and Evaluation of the Cumulative Fatigue Damage

1 The cumulative fatigue damage is to be calculated by the following formula.

$$D = \sum_{i=1}^{n_{total}} \frac{n_i}{N_i}$$

Where:

n_i : The number of stress cycle at the stress range $\Delta\sigma_i$

N_i : The number of stress cycle to fatigue damage at the stress range $\Delta\sigma_i$

i : The number of division (block) of the stress range. It is recommended that the frequency distribution of the stress range is divided into 20 and more blocks.

n_{total} : The total number of the blocks

2 The cumulative fatigue damage D calculated is to be less than 1.0.

Chapter 5 HULL GIRDER ULTIMATE STRENGTH

5.1 General

5.1.1 Application

1 The requirements of this Chapter apply to all *GNS-A* ships and *GNS-B* ships, and to those *GNS-C* ships and *GNS-D* ships whose L_{WL} is more than 150 *m*.
2 For *GNS-C* ships and *GNS-D* ships whose L_{WL} is 90 *m* and more but does not exceed 150 *m*, and for which intervals of transverses in midship parts of ships exceed 5 *m*, hull girder ultimate strength is to be assessed in accordance with the requirements of this Chapter.
3 Ships complying with the requirements of this Chapter are affixed the class notation "*PrimeShip-Hull Girder Ultimate Strength Assessment*" to their Classification Characters.

5.1.2 Condition to be Evaluated, etc.

1 The draught conditions to be evaluated are those conditions corresponding to designed maximum load waterlines and consumption conditions.
2 The hull girder ultimate longitudinal bending moment capacity, M_U, is defined as the maximum bending capacity of a hull girder beyond which the hull structure collapses. Hull girder failure is depends upon the buckling, ultimate strength and yielding of longitudinal structural elements.

5.1.3 Assumptions

1 Methods for calculating ultimate hull girder capacity are to identify the critical failure modes for all main longitudinal structural elements.
2 Structures compressed beyond their buckling limit have the reduced load carrying capacity. All relevant failure modes for individual structural elements (*e.g.* plate buckling, torsional stiffener buckling, stiffener web buckling, lateral or global stiffener buckling, and their interactions), are to be considered in order to identify the weakest inter-frame failure mode.
3 Only hull girder vertical bending is to be considered, and the effects of shear force, torsional loading, horizontal bending moment and lateral pressure may be ignored. For *GNS-A* ships and *GNS-B* ships whose L_{WL} is not less than 300 *m* or whose B_{Max} is not less than 32 *m*, however, hull girder ultimate strength which considers the effects of lateral pressures is also to be evaluated.

5.2 Evaluation Methods

5.2.1 Incremental-iterative Method

The hull girder ultimate strength is to be evaluated by the incremental-iterative method specified in **5.3**.

5.2.2 Alternative Methods

1 Where the hull girder ultimate strength is evaluated by the non-linear finite elements analysis, etc. as an alternative method, the general principle is given in the requirement in **5.5**.
2 Application of alternative methods is to be agreed by the Society prior to commencement. Documentation of the analysis methodology and detailed comparison of its results are to be submitted for review and approval.
3 Where the alternative method is applied, the use of such methods may require the partial safety factors to be recalibrated.
4 Ships complying with the requirements on the alternative method are affixed the class notation "*PrimeShip-Hull Girder Ultimate Strength Assessment - Advanced*" to their Classification Characters.

5.3 Incremental-iterative Method

5.3.1 Assumption

1 In applying the incremental-iterative method, the following assumptions are generally to be made:

(1) The ultimate strength is calculated at transverse sections between two adjacent transverse webs.

(2) The hull girder transverse section remains plane during each curvature increment

(3) The hull materials constituting the cross section of the hull have an elasto-plastic behaviour

(4) The hull girder transverse section is divided into a set of elements which are considered to act independently.

2 According to the iterative procedure, the bending moment M_i acting on the transverse section at each curvature value χ_i is obtained by summing the contribution given by the stress σ acting on each element.

3 The stress σ corresponding to the element strain ε is to be obtained for each curvature increment from the non-linear load-end shortening curves σ-ε of the element.

4 These curves are to be calculated, for the failure mechanisms of the element, from the formulae specified in **5.3.2**.

5 The stress σ is selected as the lowest among the values obtained from each of the considered load-end shortening curves σ-ε.

6 The procedure is to be repeated until the value of the imposed curvature reaches the value χ_F (m^{-1}) in hogging and sagging conditions, obtained from the following formula.

$$\chi_F = \pm 0.003 \frac{M_Y}{EI_y}$$

Where:

M_Y : Lesser of the values M_{Y1} and M_{Y2}, in *kN-m*.

$$M_{Y1} = 10^3 \sigma_Y Z_B$$

$$M_{Y2} = 10^3 \sigma_Y Z_D$$

E : Modulus of tensile elasticity (N/mm^2) specified in **Table 3.2.1, Part 3**.

I_y : The moment of inertia (m^4) of the cross section of the hull around the horizontal neutral axis, which are calculated by the requirements in **3.1.4**.

σ_Y: The proof stress (N/mm^2) specified in **Table 3.2.1, Part 3**. (N/mm^2)

Z_B and Z_D : Section modulus at bottom and deck in m^3, calculated by the requirements in **3.1.4**.

7 Where the value χ_F is not sufficient to evaluate the peaks of the curve M-χ_F, the procedure is to be repeated until the value of the imposed curvature permits the calculation of the maximum bending moments of the curve.

5.3.2 Procedure

1 General

(1) The curve M-χ_F is to be obtained by the simplified calculation means of an incremental-iterative approach. Summary of the evaluation flow is given in **Fig. 5.5.1**.

(2) In this procedure, the ultimate hull girder bending moment capacity M_U is defined as the peak value of the curve with vertical bending moment M versus the curvature χ of the ship cross section as shown in **Fig. 5.5.2**. The curve is to be obtained through an incremental-iterative approach.

(3) Each step of the incremental procedure is represented by the calculation of the bending moment M_i which acts on the hull transverse section as the effect of an imposed curvature χ_i.

(4) For each step, the value χ_i is to be obtained by summing an increment of curvature $\Delta\chi$ to the value relevant to the previous step χ_{i-1}. This increment of curvature corresponds to an

increment of the rotation angle of the transverse section around its horizontal neutral axis.

(5) This rotation increment induces axial strains ε in each hull structural element whose value depends on the position of the element. In hogging condition, the structural elements above the neutral axis are lengthened, while the elements below the neutral axis are shortened, and vice-versa in sagging condition.

(6) The stress σ induced in each structural element by the strain ε is to be obtained from the load-end shortening curve σ-ε of the element, which takes into account the behaviour of the element in the non-linear elasto-plastic domain.

(7) The distribution of the stresses induced in all the elements composing the hull transverse section determines, for each step, a variation of the neutral axis position since the relationship σ-ε is non-linear. The new position of the neutral axis relevant to the step considered is to be obtained by means of an iterative process, imposing the equilibrium among the stresses acting in all the hull elements on the transverse section.

(8) Once the position of the neutral axis is known and the relevant element stress distribution in the section is obtained, the bending moment of the section M_i around the new position of the neutral axis, which corresponds to the curvature χ_i imposed in the step considered, is to be obtained by summing the contribution given by each element stress.

(9) The main steps of the incremental-iterative approach described above are summarised as follows: (*See* **Fig. 5.5.1**)

(a) *Step* 1 : Divide the transverse section of hull into stiffened plate elements.

(b) *Step* 2 : Define stress-strain relationships for all elements as shown in **Table 5.5.1**.

(c) *Step* 3 : Initialise curvature χ_i and neutral axis for the first incremental step with the value of incremental curvature (*i.e.* curvature that induces a stress equal to 1 % of yield strength in strength deck) as follows:

$$\chi_1 = \Delta\chi = 0.01\frac{\sigma_Y}{E}\frac{1}{z_D - z_n}$$

z_D: Z-coordinate (m) of strength deck at side.

z_n: Z-coordinate (m) of horizontal neutral axis of the hull transverse section

(d) *Step* 4 : Calculate for each element the corresponding strain $\varepsilon_i = \chi(z_i - z_n)$ and the corresponding stress σ_i

(e) *Step* 5 : Determine the neutral axis z_{NA_cur} at each incremental step by establishing force equilibrium over the whole transverse section as:

$\sum A_i\sigma_i = \sum A_j\sigma_j$ (i-th element is under compression, j-th element under tension)

(f) *Step* 6 : Calculate the corresponding moment by summing the contributions of all elements as follows:

$$M_u = \sum \sigma_{Ui}A_i|(Z_i - Z_{NA\_cur})|$$

(g) *Step* 7 : Compare the moment in the current incremental step with the moment in the previous incremental step. If the slope in M-χ relationship is less than a negative fixed value, terminate the process and define the peak value of M_U. Otherwise, increase the curvature by the amount of $\Delta\chi$ and go to *Step* 4.

Fig. 5.5.1 Flow Chart of the Procedure for the Evaluation of the Curve M- χ

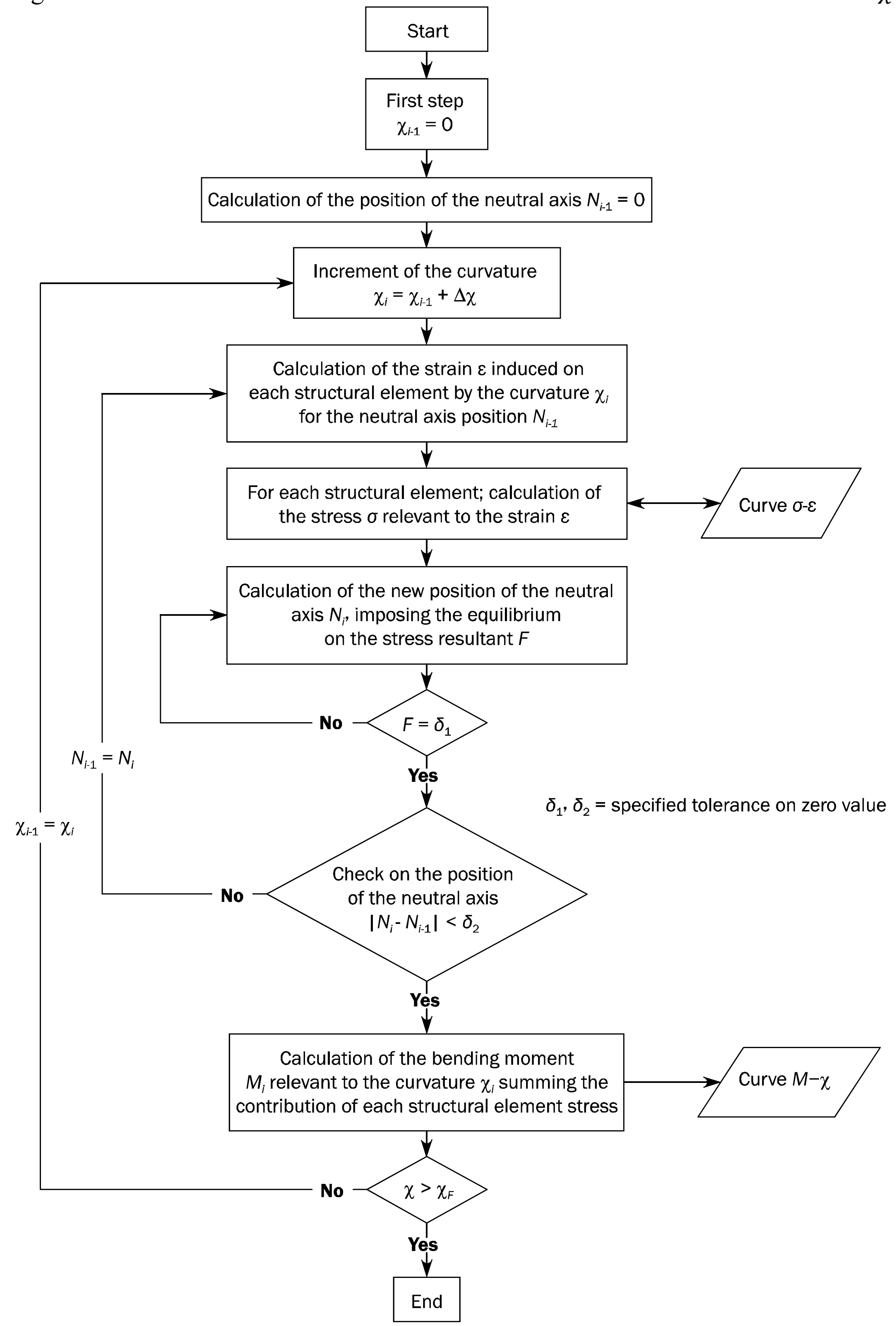


Fig. 5.5.2 Hull Girder bending Moment versus the curvature χ

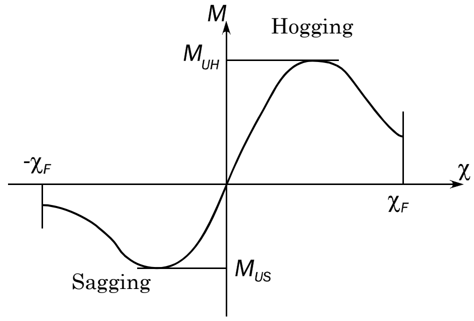


Table 5.5.1 Modes of Failure of Stiffened Plate Element and Stiffener Element

Element	Mode of failure	Curve $\sigma - \varepsilon$ defined in
Lengthened stiffened plate element or stiffener element	Elasto-plastic collapse	**5.3.3-2**
Shortened stiffener element	Beam column buckling Torsional buckling Web local buckling of flanged profiles Web local buckling of flat bars	**5.3.3-3** **5.3.3-4** **5.3.3-5** **5.3.3-6**
Shortened stiffened plate element	Plate buckling	**5.3.3-7**

2 Classification of the structural members

(1) Hull girder transverse sections are to be considered as being constituted by the members contributing to the hull girder ultimate strength.

(2) Sniped stiffeners are also to be modelled, taking account that they do not contribute to the hull girder strength.

(3) The structural members are categorised into a stiffener element, a stiffened plate element or a hard corner element. The plate panel including web plate of girder or side stringer is idealised into either a stiffened plate element, an attached plate of a stiffener element or a hard corner element.

(4) The plate panel is categorised into the following two kinds:
- (a) Longitudinally stiffened panel of which the longer side is in the longitudinal direction; or
- (b) Transversely stiffened panel of which the longer side is in the perpendicular direction to the longitudinal direction.

(5) Hard corner element is defined as follows:
- (a) Hard corner elements are sturdier elements composing the transverse section, which collapse mainly according to an elasto-plastic mode of failure (material yielding).
- (b) They are generally constituted by two plates not lying in the same plane.
- (c) The extent of a hard corner element from the point of intersection of the plates is taken equal to 20 times the thickness of the plate on a transversely stiffened panel and to 0.5 times the spacing of the adjacent longitudinal stiffener on a longitudinally stiffened panel. (*See* **Fig. 5.5.3**)
- (d) Bilge, sheer strake-deck stringer elements, girder-deck connections and face plate-web connections on large girders whose depth is greater than the spacing of the adjacent longitudinal stiffener are typical hard corners.
- (e) In case of the knuckle point as shown in **Fig. 5.5.4**, the plating area adjacent to knuckles in the plating with an angle greater than 30 degrees is defined as a hard corner. The extent of the hard corner is given in **(c)** as treated that the knuckle point is regarded the

point of intersection of the plates.

(6) Stiffener element is constituted by the stiffener together with the attached plate. The attached plate width is in principle:

(a) Equal to the mean spacing of the stiffener when the panels on both sides of the stiffener are longitudinally stiffened, or

(b) Equal to the width of the longitudinally stiffened panel when the panel on one side of the stiffener is longitudinally stiffened and the other panel is of the transversely stiffened. (*See* **Fig. 5.5.3**)

(7) The plate between stiffener elements, between a stiffener element and a hard corner element or between hard corner elements is to be treated as a horizontally stiffened plate element. (*See* **Fig. 5.5.3**)

Fig. 5.5.3 Extension of the Breadth of the Attached Plating and Hard Corner Element

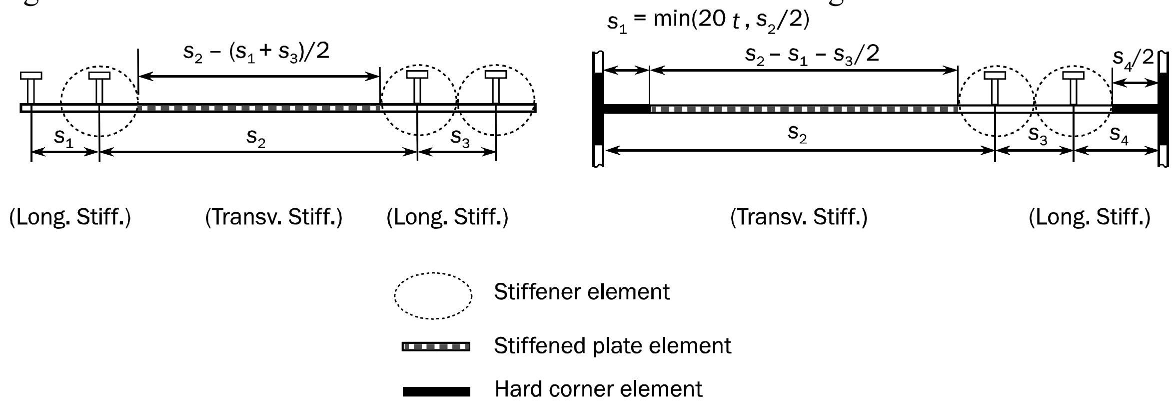
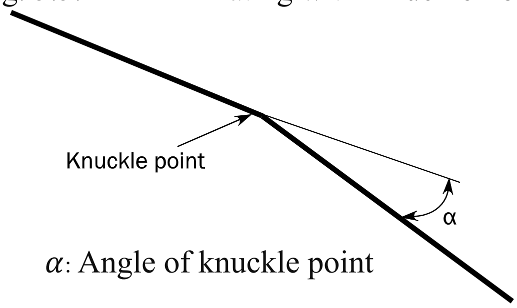


Fig. 5.5.4 Plating with Knuckle Point



α: Angle of knuckle point

3 Modelling of the hull girder cross section

(1) The hull girder cross section is to be modeled by the hard corner element, stiffener element and the horizontally stiffened panel element in accordance with the classification of the structural members specified in **-2**.

(2) Where the plate members are stiffened by non-continuous longitudinal stiffeners, the non-continuous stiffeners are considered only as dividing a plate into various elementary plate panels.

(3) Where the opening is provided in the stiffened plate element, the openings are to be considered in accordance with the requirements in **3.1.4**.

(4) Where attached plating is made of steels having different thicknesses and/or yield stresses, an average thickness or average yield stress obtained by the proportional division of the thickness and the minimum yield stress corresponding to their breadth and area with each thickness and minimum yield stress of each material.

(5) Where the minimum yield stress of the stiffener is different from that of the attached plate, or where the minimum yield stress of the face plate of the girder is different from that of web

plate, the minimum yield stress is to be taken as the lesser one.

5.3.3 Load-end Shortening Curves

1 Horizontally stiffened plate elements and stiffener elements

Horizontally stiffened plate elements and stiffener elements composing the hull girder transverse sections may collapse following one of the modes of failure specified in **Table 5.5.1**.

(1) Where the plate members are stiffened by non-continuous longitudinal stiffeners, the stress of the element is to be obtained in accordance with **-2** to **-7**, taking into account the non-continuous longitudinal stiffener. In calculating the total forces for checking the hull girder ultimate strength, the area of non-continuous longitudinal stiffener is to be assumed as 0.

(2) Where the opening is provided in the stiffened plate element, the considered area of the horizontally stiffened plate element is to be obtained by deducting the opening area from the plating in calculating the total forces for checking the hull girder ultimate strength. Consideration of the openings is to be given in **5.3.2-3(3)**.

(3) For horizontally stiffened plate element, the effective width of plate for the load shortening portion of the stress-strain curve is to be taken as full plate width, *i.e.* to the intersection of other plate or longitudinal stiffener – neither from the end of the hard corner element nor from the attached plating of stiffener element, if any. In calculating the total forces for checking the hull girder ultimate strength, the area of the horizontally stiffened plate element is to be taken between the hard corner element and the stiffener element or between the hard corner elements, as applicable.

2 Load-end shortening curves of hard corner element and elasto-plastic collapse of structural elements

The equation describing the load-end shortening curve $\sigma - \varepsilon$ for the elasto-plastic collapse of structural elements composing the transverse section is to be obtained from the following formula. In this case, both positive (compressive) and negative (tensile) value of the strain are to be considered.

$\sigma = \Phi\sigma_{YA}$

Where:

σ_{YA} : Equivalent minimum yield stress (N/mm^2) of the considered element obtained by the following formula:

$$\sigma_{YA} = \frac{\sigma_{YP}A_P + \sigma_{YS}A_S}{A_P + A_S}$$

A_P and A_S : Section area (cm^2) of the stiffener and the attached plate, respectively

σ_{YP} and σ_{YS} : Minimum yield stress (N/mm^2) of the stiffener and the attached plate, respectively

Φ : Edge function, equal to the following

$\Phi = -1$ for $\varepsilon < -1$

$\Phi = \varepsilon$ for $-1 \le \varepsilon \le 1$

$\Phi = 1$ for $\varepsilon > 1$

ε : Relative strain, equal to the following:

$\varepsilon = \varepsilon_E / \varepsilon_Y$

ε_E : Element strain.

ε_Y : Strain at yield stress in the element, equal to the following:

$\varepsilon = \sigma_{YA} / \mathrm{E}$

E : Modulus of tensile elasticity (N/mm^2) specified in **Table 3.2.1, Part 3**

3 Beam column buckling

The equation describing the load-end shortening curve σ_{CR1}-ε for the beam column buckling of stiffeners composing the hull girder transverse section is to be obtained from the following formula.

$$\sigma_{CR1} = \Phi\sigma_{C1}\frac{A_{PE} + A_S}{A_P + A_S}$$

Φ : Edge function, as given in **-2**.

σ_{C1} : Critical stress (N/mm^2), equal to the following

$\sigma_{C1} = \sigma_{E1}/\varepsilon$ for $\sigma_{E1} \le \frac{\sigma_{YB}}{2}\varepsilon$

$\sigma_{C1} = \sigma_{YB}\left(1 - \frac{\sigma_{YB}\varepsilon}{4\sigma_{E1}}\right)$ for $\sigma_{E1} > \frac{\sigma_{YB}}{2}\varepsilon$

σ_{YB}: Equivalent minimum yield stress (N/mm^2) of the considered element obtained by the following formula:

$$\sigma_{YB} = \frac{\sigma_{YP}A_{PE1}l_{PE} + \sigma_{YS}A_S l_{SE}}{A_{PE1}l_{PE} + A_S l_{SE}}$$

A_{PE1} : Effective area (cm^2), and given by $A_{PE1} = 10b_{E1}t$

b_{E1} : Effective width (m) of the attached plating, equal to the following:

$b_{E1} = s/\beta_E$ for $\beta_E > 1.0$

$b_{E1} = s$ for $\beta_E \le 1.0$

Where:

$$\beta_E = 10^3\frac{s}{t}\sqrt{\frac{\varepsilon\sigma_{YP}}{E}}$$

l_{PE}: Distance (mm) measured from the neutral axis of the stiffener with attached plate of width b_{E1} to the bottom of the attached plate

l_{SE}: Distance (mm) measured from the neutral axis of the stiffener with attached plate of width b_{E1} to the top of the stiffener

ε : Relative strain, as defined in **-2**.

σ_{E1} : Euler column buckling stress (N/mm^2), equal to the following:

$$\sigma_{E1} = \pi^2 E\frac{I_E}{A_E l^2}10^{-4}$$

I_E : Moment of inertia of stiffeners (cm^4) with attached plating of width b_{E1}.

A_E : Area (cm^2) of attached plating of width b_E, equal to the following

b_E : Effective width corrected for relative strain (m) of the attached plating, equal to the following

$b_E = \left(\frac{2.25}{\beta_E} - \frac{1.25}{\beta_E^2}\right)s$ for $\beta_E > 1.25$

$b_E = s$ for $\beta_E \le 1.25$

A_P and A_S : Section area (cm^2) of the stiffener and the attached plate, respectively

σ_{YP} and σ_{YS} : Minimum yield stress (N/mm^2) of the stiffener and the attached plate, respectively

t : Thickness (mm) of the attached plate

s : Spacing (m) of the adjacent longitudinal stiffener

E : Modulus of tensile elasticity (N/mm^2) specified in **Table 3.2.1, Part 3**

4 Torsional buckling

The load-end shortening curve σ_{CR2}-ε for the flexural-torsional buckling of stiffeners composing the hull girder transverse section is to be obtained according to the following formula.

$$\sigma_{CR2} = \Phi\frac{A_P\sigma_{CP} + A_S\sigma_{C2}}{A_P + A_S}$$

Φ : Edge function, as given in **-2**.

σ_{C2}: Critical stress (N/mm^2), equal to the following:

$\sigma_{C2} = \frac{\sigma_{E2}}{\varepsilon}$ for $\sigma_{E2} \le \frac{\sigma_{YS}}{2}\varepsilon$

$\sigma_{C2} = \sigma_{YS}\left(1 - \frac{\sigma_{YS}\varepsilon}{4\sigma_{E2}}\right)$ for $\sigma_{E2} > \frac{\sigma_{YS}}{2}\varepsilon$

σ_{E2}: Euler torsional buckling stress (N/mm^2), equal to the following:

$$\sigma_{ET} = \frac{E}{I_P}\left(\frac{\varepsilon\pi^2 I_\omega}{l^2}10^2 + 0.385 I_T\right)$$

I_P: Polar moment of inertia (cm^4) of the stiffener about point C as shown in **Fig. 5.5.5**, as defined in **Table 5.5.2**.

I_T: St. Venant's moment of inertia (cm^4) of the stiffener, as defined in **Table 5.5.2**.

I_ω: Sectional moment of inertia (cm^6) of the stiffener about point C as shown in **Fig. 5.5.5**, as defined in **Table 5.5.2**.

ε_1 : Degree of fixation, equal to the following.

$$\varepsilon_1 = 1 + \frac{(l/\pi)^2 10^{-3}}{\sqrt{I_w[(0.75s/t_p^3)+\{(e_f-0.5t_f)/t_w^3\}]}}$$

t_p, e_f, t_w, t_f : As given in **Fig. 5.5.5**.

s: Spacing (m) of the adjacent longitudinal stiffener

l: Span (m) of the stiffener

ε: Relative strain, as defined in **-2**.

σ_{CP} : Buckling stress of the attached plating (N/mm^2), equal to the following:

$\sigma_{CP} = \left(\frac{2.25}{\beta_E} - \frac{1.25}{{\beta_E}^2}\right)\sigma_{YP}$ for $\beta_E > 1.25$

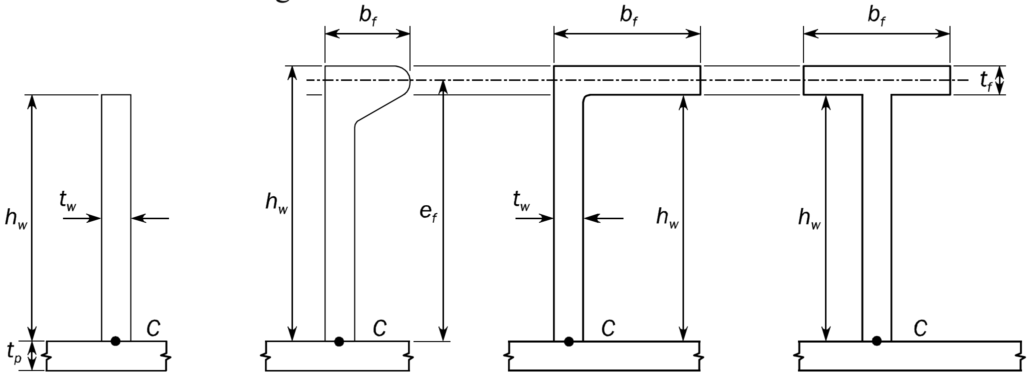
$\sigma_{CP} = \sigma_{YP}$ for $\beta_E \le 1.25$

β_E: Coefficient, as defined in **-3**.

Table 5.5.2 Moments of Inertia

	Flat bar	Bulb, Angle and T-Profiles
I_P	$\frac{h_w^3 t_w}{3\times10^4}$	$\left(\frac{A_w(e_f-0.5t_f)^2}{3} + A_f e_f^2\right)10^{-4}$
I_T	$\frac{h_w t_w^3}{3\times10^4}\left(1-0.63\frac{t_w}{h_w}\right)$	$\frac{(e_f-0.5t_f)t_w^3}{3\times10^4}\left(1-0.63\frac{t_w}{e_f-0.5t_f}\right) + \frac{b_f t_f^3}{3\times10^4}\left(1-0.63\frac{t_f}{b_f}\right)$
I_ω	$\frac{h_w^3 t_w^3}{36\times10^6}$	$\frac{A_f e_f^2 b_f^2}{12\times10^6}\left(\frac{A_f+2.6A_w}{A_f+A_w}\right)$ for bulb and angle profiles $\frac{b_f^3 t_f e_f^2}{12\times10^6}$ for T profiles.
A_w : Section area (mm^2) of web, A_f : Section area (mm^2) of flange		

Fig. 5.5.5 Stiffener Cross Sections



5 Web local buckling of stiffeners made of flanged profiles

The load-end shortening curve σ_{CR3}-ε for the web local buckling of flanged stiffeners composing the hull girder transverse section is to be obtained from the following formula:

$$\sigma_{CR3} = \Phi \frac{10^3 b_E t_p \sigma_{YP} + \left(h_{we} t_w + b_f t_f\right)\sigma_{YS}}{10^3 s t_p + h_w t_w + b_f t_f}$$

Φ : Edge function, as defined in **-2**.

b_E : Effective width (m) of the attached shell plating, as defined in **-3**.

h_{we} : Effective height (mm) of the web, equal to the following:

$$h_{we} = \left(\frac{2.25}{\beta_w} - \frac{1.25}{\beta_w^2}\right) h_w \quad \text{for} \quad \beta_w > 1.25$$

$$h_{we} = h_w \qquad \text{for} \quad \beta_w \leq 1.25$$

β_w : Coefficient, given as follow : $\beta_w = \frac{h_w}{t_w}\sqrt{\frac{\varepsilon \sigma_{YS}}{E}}$

ε : Relative strain, as defined in **-2**.

σ_{YP}, σ_{YS}, s, t_p, E : as given in **-4**.

h_w, t_w, b_f, t_f : as given in **Fig. 5.5.5**.

6 Web local buckling of stiffeners made of flat bars

The load-end shortening curve σ_{CR4}-ε for the web local buckling of flat bar stiffeners composing the transverse section is to be obtained from the following formula:

$$\sigma_{CR4} = \Phi \frac{A_P \sigma_{CP} + A_S \sigma_{C4}}{A_P + A_S}$$

Φ : Edge function, as defined in **-2**.

σ_{CP} : Buckling stress of the attached plating (N/mm^2), as defined in **-4**.

σ_{C4} : Critical stress (N/mm^2), equal to the following:

$$\sigma_{C4} = \frac{\sigma_{E4}}{\varepsilon} \qquad \text{for} \quad \sigma_{E4} \leq \frac{\sigma_{YS}}{2}\varepsilon$$

$$\sigma_{C4} = \sigma_{YS}\left(1 - \frac{\sigma_{YS}\varepsilon}{4\sigma_{E4}}\right) \quad \text{for} \quad \sigma_{E4} > \frac{\sigma_{YS}}{2}\varepsilon$$

σ_{E4} : Local Euler buckling stress (N/mm^2), equal to the following:

$$\sigma_{E4} = 160000\left(\frac{t_w}{h_w}\right)^2$$

ε : Relative strain, as defined in **-2**.

7 Plate buckling

The load-end shortening curve $\sigma_{CR5} - \varepsilon$ for the buckling of transversely stiffened panels composing transverse section is to be obtained from the following formula:

$$\sigma_{CR5} = \min\begin{cases} \sigma_{YP}\Phi \\ \Phi\sigma_{YP}\left[\frac{s}{l}\left(\frac{2.25}{\beta_E} - \frac{1.25}{\beta_E^2}\right) + 0.1\left(1 - \frac{s}{l}\right)\left(1 + \frac{1}{\beta_E^2}\right)^2\right] \end{cases}$$

Φ : Edge function, as defined in **-2**.

β_E : Coefficient, as defined in **-3**.

s : Plate breadth (m), taken as the spacing between the stiffeners.

l : Longer side of the plate (m).

5.3.4 Criteria of Hull Girder Ultimate Strength

The hull girder ultimate strength of any transverse section at the midship part of the ship is to be complied with the following criteria.

$M \leq M_U / \gamma_R$

Where,

M : Hull girder vertical bending moment, as given in the following.

$$M = \gamma_S M_S + \gamma_W f_\beta M_W$$

Where:

M_S : Longitudinal bending moment (*kN-m*) in still water, as given in **2.1.2**.

M_W : Longitudinal bending moment (*kN-m*) in waves, as given in **2.1.3**.

γ_S : Partial safety factor for longitudinal bending moment in still water, is taken equal to 1.0.

γ_W : Partial safety factor for longitudinal bending moment in waves, is taken as the following value.

(1) 1.3 for *GNS-A* ships and for *GNS-B* ships whose L_{WL} is more than 150 *m*

(2) 1.5 for ships required to consider the whipping effects by the Society

(3) 1.2 for ships other than those specified in **(1)** and **(2)**

f_β : Coefficient about the ship's heading angle, is taken equal to 1.05.

γ_R : Partial safety factor for the vertical hull girder ultimate bending capacity is to be taken equal to:

$\gamma_R = \gamma_M \gamma_{DB}$

γ_M : Partial safety factor for the vertical hull girder ultimate bending capacity, covering material, geometric and strength prediction uncertainties; in general, is to be taken equal to 1.1.

γ_{DB} : For ships having the double bottom structure at the midship part of the ships, partial safety factor for the vertical hull girder ultimate bending capacity, covering the effect of double bottom bending, is to be taken equal to1.1 for hogging condition and 1.0 for sagging condition. For ships not having the double bottom structure, partial safety factor is to be taken equal to 1.0 for hogging condition.

5.4 Hull Girder Ultimate Strength Assessment Considering the Effect of the Lateral Loads

5.4.1 Application

1 For *GNS-A* ships whose L_{WL} is not less than 300 *m* or whose B_{Max} is not less than 32 *m*, hull girder ultimate strength assessments considering the effects of lateral loads are to be carried out in accordance with the requirements in this **5.4**.

2 The draught conditions to be evaluated are those conditions corresponding to designed maximum load waterlines and consumption conditions. Where tanks are located in the considered section, the tanks are assumed to be empty.

3 The considered wave condition is the head sea condition.

4 The section to be evaluated is to be a single transverse section located between two adjacent transverse webs located at the midship part.

5 Where bottom structures employ longitudinal framing systems, the bottom shells and bottom longitudinals in said spans (this includes the hull girder transverse sections specified in **-4** being modelled are to be divided into stiffener elements consisting of a longitudinal and an attached plate. Where bottom structures employ transverse framing systems, the plates in the transverse sections specified in **-4** above being modelled to be are to be modelled as horizontally stiffened plate elements.

6 Where elements are made up of attached plates of different thicknesses, average thickness is to be obtained by the proportional division of the thicknesses through modelleing.

7 Where elements have stiffeners made of materials different from the materials used for attached plates, the yield strength value to be used for the element is, in principle, the one for the material with the lower yield strength.

8 Procedures used for evaluations of hull girder ultimate strength are to in accordance with the incremental-iterative method specified in **5.3.2**.

5.4.2 Derivation of Stress Acting on Stiffener Element and Calculation of Ultimate Strength of Stiffener Element

1 Derivation of stress acting on stiffener element

The longitudinal stress σ_{xi} (N/mm^2) and the transverse stress σ_{yi} (N/mm^2) which are generated at the bottom shell of the position of stiffener element *i* are to be calculated according to the requirements in **Chapters 2** and **3**.

2 Calculation of ultimate strength of stiffener element

The ultimate strength of stiffener element *i*, σ_{USi}, (N/mm^2) is to be as follow, but is not to be less than 0.

$\sigma_{USi} = min(\sigma_{US1i}, \sigma_{US2i}, \sigma_{US3i}) - \sigma_{x0i}$ for bulb, angle and T profiles

$\sigma_{USi} = min(\sigma_{US1i}, \sigma_{US2i}, \sigma_{US4i}) - \sigma_{x0i}$ for flat bars

σ_{x0i} : Longitudinal stress (N/mm^2) acting on stiffener element *i* due to lateral loads, to be taken as follows:

$$\sigma_{x0i} = \sigma_{xi} - \sigma_{HG}$$

σ_{xi} : Longitudinal stress (N/mm^2), as specified in **-1**.

σ_{HG} : Hull girder bending stress (N/mm^2), to be taken as follows:

$$\sigma_{HG} = \frac{M_{Smax} + M_{W-Hog-Mid}}{Z_B} 10^{-3}$$

M_{Smax} : Permissible maximum vertical still water bending moment (kN-m) at the transverse section under consideration

$M_{W-Hog-Mid}$: Maximum vertical bending moment in waves specified in **2.1.3-1, Chapter 2**.

$\sigma_{US1i}, \sigma_{US2i}, \sigma_{US3i}, \sigma_{US4i}$: Ultimate strength of stiffener element *i* (N/mm^2) for each critical failure mode, to be taken as follow. All the symbols given in the following **(1)** through **(4)** pertain to stiffener element *i*.

(1) Ultimate strength of beam column buckling σ_{US1i} (N/mm^2), to be taken as follows:

$$\sigma_{USi} = \sigma_{C1} \frac{A_{PE} + A_S}{A_P + A_S}$$

σ_{C1} : Critical stress (N/mm^2), equal to the following:

$\sigma_{C1} \leq \sigma_{E1}$ for $\sigma_{E1} \leq \frac{\sigma_{YB}}{2}$

$\sigma_{C1} = \sigma_{YB}\left(1 - \frac{\sigma_{YB}}{4\sigma_{E1}}\right)$ for $\sigma_{E1} > \frac{\sigma_{YB}}{2}$

σ_{YB}: Equivalent minimum yield stress (N/mm^2), to be taken as follows:

$$\sigma_{YB} = \frac{\sigma_{YP} A_{PE1} l_{PE} + \sigma_{YS} A_S l_{SE}}{A_{PE1} l_{PE} + A_S l_{SE}}$$

l_{PE} : Distance (mm) measured from the neutral axis of the stiffener with attached plate of width b_{E1} to the bottom of the attached plating.

l_{SE} : Distance (mm) measured from the neutral axis of the stiffener with attached plating of width b_{E1} to the top of the stiffener.

A_{PE1} : Area (cm^2) of attached plating, equal to the following:

$A_{PE1} = 10 b_{E1} t$

b_{E1} : Corrected effective width (m) of the attached plating, equal to the following:

$b_{E1} = \frac{s}{\beta_E}$ for $\beta_E > 1.0$

$b_{E1} = s$ for $\beta_E \leq 1.0$

β_E : Coefficient, given as follows:

$$\beta_E = \sqrt{\frac{k\pi^2}{12(1-\nu^2)}} \cdot \sqrt{\frac{\sigma_{YP}}{\sigma_E}}$$

k: Coefficient, given as follows:

$$k = \left(\frac{m_0 s}{l} + \frac{l}{m_0 s}\right)^2$$

m_0: Integer which satisfies the following formula, but is to be not less than 1.

$$\sqrt{m_0(m_0-1)} < \frac{l}{s} \leq \sqrt{m_0(m_0+1)}$$

σ_E: Elastic buckling stress of attached plating (*N/mm*^{2}), equal to the following:

$$\sigma_E = \frac{Ek'\pi^2}{12(1-\nu^2)}\left(\frac{t}{10^3 s}\right)^2 - \left(\frac{l}{ms}\right)^2 \sigma_{yi}$$

m: Coefficient, given as follows:

$m = m_0$ for $\sigma_{yi} \leq \sigma_{ycm}$ or $m_0 \leq 2$

$m = m_0 - 1$ for $\sigma_{yi} > \sigma_{ycm}$

$$\sigma_{ycm} = \frac{E\pi^2}{12(1-\nu^2)}\left(\frac{t}{10^3 s}\right)^2 \left(1 - {m_0}^2(m_0-1)^2\left(\frac{s}{l}\right)^4\right)$$

k' : Coefficient, given as follows:

$$k' = \left(\frac{ms}{l} + \frac{l}{ms}\right)^2$$

σ_{yi} : Transverse stress (*N/mm*^{2}) specified in **-1**.

σ_{E1} : Euler column buckling stress (*N/mm*^{2}), equal to the following:

$$\sigma_{E1} = \pi^2 E \frac{I_E}{A_E l^2} 10^{-4}$$

I_E : Moment of inertia of stiffener (*cm*^{4}) with attached plating of width b_{E1}.

A_E : Area (*cm*^{2}) of stiffeners with attached plating width b_E.

b_E : Effective width (*m*) of attached plating, equal to the following:

$b_E = \left(\frac{2.25}{\beta_E} - \frac{1.25}{\beta_E^2}\right) s$ for $\beta_E > 1.25$

$b_E = s$ for $\beta_E \leq 1.25$

A_{PE} : Area (*cm*^{2}) of attached plating width b_E, equal to the following:

$A_{PE} = 10 b_E t$

(2) Ultimate strength of torsional buckling σ_{US2i} (*N/mm*^{2}), to be taken as follows:

$$\sigma_{US2i} = \frac{A_P \sigma_{CP} + A_S \sigma_{C2}}{A_P + A_S}$$

σ_{C2} : Critical stress (*N/mm*^{2}), equal to the following:

$\sigma_{C2} = \sigma_{E2}$ for $\sigma_{E2} \leq \frac{\sigma_{YS}}{2}$

$\sigma_{C2} = \sigma_{YS}\left(1 - \frac{\sigma_{YS}}{4\sigma_{E2}}\right)$ for $\sigma_{E2} > \frac{\sigma_{YS}}{2}$

σ_{E2} : Euler torsional buckling stress (*N/mm*^{2}), taken as σ_{ET} specified in **5.3.3-4**.

σ_{CP} : Buckling stress of the attached plating (*N/mm*^{2}), equal to the following:

$\sigma_{CP} = \left(\frac{2.25}{\beta_E} - \frac{1.25}{\beta_E^2}\right)\sigma_{YP}$ for $\beta_E > 1.25$

$\sigma_{CP} = \sigma_{YP}$ for $\beta_E \leq 1.25$

β_E : As defined in **(1)** above.

(3) Ultimate strength of web local buckling of flanged stiffeners σ_{US3i} (*N/mm*^{2}), to be taken as follows:

$$\sigma_{US3i} = \frac{10^3 b_E t \sigma_{YP} + (h_{we} t_w + b_f t_f)\sigma_{YS}}{10^3 st + h_w t_w + b_f t_f}$$

b_E : As defined in **(2)** above.

h_{we} : Effective height of the web (*mm*), equal to the following:

$h_{we} = \left(\frac{2.25}{\beta_w} - \frac{1.25}{\beta_w^2}\right) h_w$ for $\beta_w > 1.25$

$h_{we} = h_w$ for $\beta_w \leq 1.25$

β_w : Coefficient, given as follows:

$$\beta_w = \frac{h_w}{t_w}\sqrt{\frac{\sigma_{YS}}{E}}$$

(4) Ultimate strength of web local buckling of flat bar stiffeners σ_{US4i} (*N/mm*^{2}), to be taken as follows:

$$\sigma_{US4i} = \frac{A_P \sigma_{CP} + A_S \sigma_{C4}}{A_P + A_S}$$

σ_{CP} : As defined in **(2)** above.

σ_{C4} : Critical stress (*N/mm*^{2}), equal to the following:

$\sigma_{C4} = \sigma_{E4}$ for $\sigma_{E4} > \frac{\sigma_{YS}}{2}$

$\sigma_{C4} = \sigma_{YS}\left(1 - \frac{\sigma_{YS}}{4\sigma_{E4}}\right)$ for $\sigma_{E4} > \frac{\sigma_{YS}}{2}$

σ_{E4} : Local Euler buckling stress (*N/mm*^{2}), equal to the following:

$$\sigma_{E4} = 160000\left(\frac{t_w}{h_w}\right)^2$$

3 Calculation of hull girder ultimate bending moment capacity

Hull girder ultimate bending moment capacity considering the effect of lateral loads M_{U_DB} (*kN-m*) is to be taken as follows:

$$M_{U\_DB} = \alpha_U \sigma_{US\_avg} Z_B 10^3$$

σ_{US_avg} : Average of ultimate strength (*N/mm*^{2}) of all stiffener elements, to be taken as follows:

$$\sigma_{US\_avg} = \frac{\sum_{i=1}(\sigma_{USi} A_i)}{\sum_{i=1} A_i}$$

σ_{USi} : As specified in **-2**.

A_i : Area (*cm*^{2}) of stiffener element *i*, to be taken as follows:

$A_i = A_P + A_S$

α_U : Correction factor, to be taken as follows:

$\alpha_U = 1.25$

4 Where the hull girder ultimate strength assessment considering the effect of the lateral loads and where the whipping effect is estimated by the direct analysis, data concerning the calculation methods and procedures are to be submitted to the Society for approval.

5.4.3 Criteria of Hull Girder Ultimate Strength Considering the Effect of the Lateral Loads

1 The hull girder ultimate strength considering the effect of the lateral loads of any transverse section at the midship part of the ship is to be complied with the following criteria.

$$\gamma_S M_{Smax} + \gamma_{Wh} M_{W-Hog-Mid} \leq M_{U\_DB}/\gamma_M$$

γ_S : Partial safety factor for longitudinal bending moment in still water, is given by the following equation.

γ_S = 1.0

γ_{Wh} : Partial safety factor for longitudinal bending moment considering the whipping effect, is given by the following equation.

γ_{Wh}= 1.5

γ_M: Partial safety factor for the vertical hull girder ultimate bending capacity, covering material, geometric and strength prediction uncertainties; in general, is to be taken equal to **1.1**.

M_{Smax} : The maximum longitudinal bending moment (*kN*-*m*) in still water at the considered transverse section.

$M_{W-Hog-Mid}$: as given by the requirements in **3.1.2-1**. (*kN*-*m*)

M_{U_DB} : The hull girder ultimate strength (*kN*-*m*) considering the effect of the lateral loads, is given in **-3**.

2 Where the partial safety factor for the whipping effect being different from that in **-1** is used in applying the requirements in **5.4.2-4**, the data concerning the partial safety factor is to be submitted to the Society.

5.5 Alternative Methods

5.5.1 General

1 Application of alternative methods is to be agreed by the Society prior to commencement. Documentation of the analysis methodology and detailed comparison of its results are to be submitted for review and approval. The use of such methods may require the partial safety factors to be recalibrated.

2 The bending moment-curvature relationship, M-χ, may be established by alternative methods. Such models are to consider all the relevant effects important to the non-linear response with due considerations of:

(1) Non-linear geometrical behaviour.
(2) Inelastic material behaviour.
(3) Geometrical imperfections and residual stresses (geometrical out-of-flatness of plate and stiffeners).
(4) Simultaneously acting loads:
    (a) Bi-axial compression.
    (b) Bi-axial tension.
    (c) Shear and lateral pressure.
(5) Boundary conditions.
(6) Interactions between buckling modes.
(7) Interactions between structural elements such as plates, stiffeners, girders, etc.
(8) Post-buckling capacity.
(9) Overstressed elements on the compression side of hull girder cross section possibly leading to local permanent sets/buckle damages in plating, stiffeners, etc. (double bottom effects or similar).

5.5.2 Non-linear Finite Element Analysis

1 Advanced non-linear finite element analyses models may be used for the assessment of the hull girder ultimate bending moment capacity.

2 Particular attention is to be given to modelling the shape and size of geometrical imperfections. It is to be ensured that the shape and size of geometrical imperfections trigger the most critical failure modes.

Chapter 6 RESIDUAL STRENGTH

6.1 Application

6.1.1 General

1 The requirements in this Chapter apply to all *GNS-A* ships and *GNS-B* ships, and to those *GNS-C* ships and *GNS-D* ships whose L_{WL} exceeds 150 *m*.

2 It is to be confirmed that the hull girder ultimate strength under damage conditions of ships in service complies with the criteria on the residual strength specified in **6.2**.

6.1.2 Damaged Condition to be Estimated

1 For *GNS-A* ships and *GNS-B* ships as well as *GNS-C* ships whose L_{WL} is more than 150 *m*, the following types of damages are to be assumed.

(1) Flooding caused by collision and hull damage due to collision

(2) Flooding caused by grounding and hull damage due to grounding (including hull damage due to impacts of in-water explosions)

(3) Damage to decks, watertight bulkheads and side shells caused by fire or explosions in a single hull compartment and flooding expected to be caused by such damage

2 For *GNS-D* ships whose L_{WL} is more than 150 *m*, the following types of damages are to be assumed.

(1) Flooding caused by collision and hull damage due to collision

(2) Flooding caused by grounding and hull damage due to grounding

6.2 Assumption of Damage

6.2.1 General

1 The extent of damage caused by the collision specified in **6.1.2-1(1)** and **6.1.2-2(1)** is to be as given in the requirements of **3.2.1-1** to **-3, Part 4**.

2 The extent of damage caused by the grounding specified in **6.1.2-1(2)** and **6.1.2-2(2)** is to be as given in the requirements of **3.2.2, Part 4**.

3 The extent of damage specified in **6.1.2-1(3)** is to be as given in the requirements of **3.2.1-4, Part 4**.

4 In applying the requirements in **-1** to **-3**, the permeability is to be as given in **Table 4.3.1, Part 4**.

5 Stiffener elements (i.e. stiffeners and their attached plates) are to be assumed to be sound unless the connection parts of the stiffeners and attached plates are located within the extent of damage specified in **-1** to **-3**.

6 For strength assessments of considered transverse damage cross sections, only the damage for a single side is to be considered and the ship is to be considered to be without trim and heel.

6.3 Hull Girder Ultimate Bending Moments in the Damaged Condition

6.3.1 Longitudinal Bending Moment in Still Water

Longitudinal bending moments in still water in the damaged conditions M_{SW-D} (*kN-m*) is to be calculated in accordance with the requirement in **2.1.2**, considering the following items.

(1) Damaged structural members assumed by the requirement in **6.2** are not to be included in calculations of the hull girder strength.

(2) Assumed flooding is to be considered as additional weight in flooded compartments.

6.3.2 Longitudinal Bending Moments in Waves

Longitudinal bending moments in waves $M_{WV\text{-}D}$ (kN-m) is to be assumed to be those in the intact condition based upon the requirements in **2.1.3**, regardless of the assumption of damage.

6.4 Checking Criteria

6.4.1 Checking Criteria

Vertical hull girder ultimate bending capacity in the damage condition for all hull transverse sections is to satisfy the following criteria.

$$M_D \leq \frac{M_{UD}}{\gamma_{RD} C_{NA}}$$

M_D : Vertical bending moment (kN-m) in the damaged condition, to be obtained by the following formula.

$$M_D = \gamma_{SD} M_{SW-D} + \gamma_{WD} M_{WV-D}$$

$M_{SW\text{-}D}$: Permissible still water bending moment (kN-m), in the hogging and sagging conditions for the hull transverse section considered, as given by **6.3.1**.

$M_{WV\text{-}D}$: Vertical wave bending moment (kN-m), in the hogging and sagging conditions for the hull transverse section considered, as given by **6.3.2**.

γ_{SD}: Partial safety factor for the still water bending moment in the damaged condition, to be taken equal to:

γ_{SD}= 1.1

γ_{WD}: Partial safety factor for the vertical wave bending moment in the damage condition, to be taken as:

γ_{WD} = 0.68

M_{UD}: Vertical hull girder ultimate bending capacity (kN-m) in the damage condition to be obtained as specified in **5.3**.

γ_{RD}: Partial safety factor for the vertical hull girder ultimate bending capacity in the damage condition, to be taken as:

γ_{RD} = 1.1

C_{NA}: Neutral axis coefficient taken as follows

(1) C_{AN} = 1.1 for the damages specified in **6.1.2-1(1)** and **6.1.2-2(1)**:

(2) C_{AN} = 1.0 for other damages

6.5 Alternative Methods

6.5.1 General

In cases where alternative methods are applied, the requirements in **5.5** are to be followed.

Part 6 HULL EQUIPMENT

Chapter 1 GENERAL

1.1 General and Application

1 The requirements in this Part apply to hull equipment of ships which class notation is affixed to in accordance with the purpose of a ship, including anchorage, towing and mooring equipment, steering gear, hand rails and means of access, doors, windows, cargo handling appliances, mast equipment, replenishment at sea (*RAS*) system, helicopter facility, air conditioners and ventilation system, pipe equipment, refrigerating machinery and refrigerator.
2 The equipment of fire-extinguishing applications for fire safety are to be applied in the requirements of **Part 9** and the equipment of life-saving appliance and accommodation facilities are to be applied in the requirements of **Part 10**.
3 Ships which are intended to navigate in the threat sea area specified in **2.2.2, Part 1** are to comply with the requirements of **3.3, Part 1**.

Chapter 2 ANCHORAGE, TOWING AND MOORING EQUIPMENT

2.1 Anchors, Chain Cables and Mooring Ropes

2.1.1 General

1 All ships, according to the number of their equipment, are to be provided with anchors, chain cables and mooring ropes which are not less than that given in **Table 6.2.1**, and **Table 6.2.2** or **2.1.5**. In the case of anchoring equipment for ships in deep and unsheltered waters, the Society may require special consideration be given to such equipment. All ships are to be provided with suitable appliances, for handling anchors and lines.

2 Anchors, chain cables and mooring ropes for ships having equipment numbers not more than 50 or more than 16,000 are to be as determined by the Society.

3 Two of the anchors given in **Table 6.2.1** are to be connected to their cables and be positioned on board ready for use.

4 Anchors, chain cables, wire ropes and fibre ropes used for mooring lines are to be in compliance with the requirements in **Chapter 2, 3.1, Chapter 3, Chapters 4** and **5, Part L of the Rules for the Survey and Construction of Steel Ships**, respectively.

5 When an owner designates the method for calculation of anchor, anchor chain and mooring line specifications different from those based on the equipment numbers as mentioned in this chapter, provide the Society with both results, calculation based on the number of equipment and the method designated by the owner.

2.1.2 Equipment Numbers

1 Equipment number is the value obtained from the following formula:

$$W^{\frac{2}{3}} + 2.0hB + 0.1A$$

Where:

W : Full load displacement (t)

h and A : Values specified in the following **(1)**, **(2)** and **(3)**:

(1) h is the value obtained from the following formula:

$$f + h'$$

f : Vertical distance (m), at the mid ship, from the designed maximum load line to the top of the uppermost continuous deck beam at side

h' : Height (m) from the uppermost continuous deck to the top of uppermost superstructure or deckhouse having a breadth greater than B/4. 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:

$$fL_1 + \sum h''l$$

f : Value specified in **(1)**

L_1 : Whichever is shorter of the length of ship (m) specified in **2.3.1, Part 1** or 97 % of length overall (L_{OA}) (m). Where, the fore end of L_1 is to be the waterplane that passes through the front plane of the stem at designed maximum load line and the rearward position of is to be the vertical plane which passes a point of length L_1 from the fore end to the stern.

$\sum h''l$: 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) In the application of **(1)** and **(2)** above, screens and bulwarks more than 1.5 m in height are to be regarded as parts of superstructures or deckhouses.

2 Notwithstanding **-1** above, for tugs, the equipment number is to be obtained from the following formula:

$$W^{\frac{2}{3}} + 2.0\left(fB + \sum h''b\right) + 0.1A$$

W, *f* and *A* :As specified in **-1** above

$\sum h''b$: Sum of the products of the height *h"* (*m*) and the breadth *b* (*m*) of each superstructure and deckhouse which have a breadth greater than *B*/4 and are located above the uppermost continuous deck

2.1.3 Anchors

1 The mass of individual anchors may vary by ±7% of the mass based on the equipment number as given in **Table 6.2.1** (hereinafter simply called "specified value"), regardless of the descriptions in **2.1.1-1**. The total mass of anchors is not less than that obtained from multiplying the mass per anchor given in the table by the number installed on board. However, where approval by the Society is obtained, anchors which are increased in mass by more than 7 % may be used.

2 Where stocked anchors are used, the mass, excluding the stock, is not to be less than 0.80 times the mass shown in the table for ordinary stockless anchors.

3 Where high holding power anchors are used, the mass of each anchor may be 0.75 times the mass shown in **Table 6.2.1** for ordinary stockless anchors.

4 Where super high holding power anchors are used, the mass of each anchor may be 0.5 times the mass required for ordinary stockless anchors. However, super high holding power anchor mass is not to exceed 1,500 *kg*.

5 When using an ordinary anchor for the fore anchor, its mass may be 1.33 times the mass shown in the table for ordinary stockless anchors, instead of the mass described in **Table 6.2.1**.

2.1.4 Chain Cables

Chain cables for anchors are to be stud link chains of Grade 1, 2 or 3, specified in **3.1 Part L of the Rules for the Survey and Construction of Steel Ships**. However, Grade 1 chains made of Class 1 chain bars (*KSBC*31) are not to be used in association with high holding power anchors.

2.1.5 Tow and Mooring Lines

1 As for tow lines, wire ropes and fibre ropes used as mooring lines, the breaking test load specified in **Chapter 4** or **5, Part L of the Rules for the Survey and Construction of Steel Ships** is not to be less than the breaking load given in **Table 6.2.2** or **-3** respectively. However, when the owners require the method of calculation to determine the particulars of tow lines for other towing specified in **2.4.1-1(2)**, the requirements for the breaking load above may not be applied.

2 The number of mooring lines for ships whose equipment numbers do not exceed 2,000 is to be in accordance with **Table 6.2.2**. For ships having the ratio *A*/*EN* above 0.9, the following number of ropes should be added to the number required by **Table 6.2.2** 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

EN : Equipment number.

A : Value specified in **2.1.2-1(2)**.

3 The number and strength of mooring lines for ships whose equipment numbers exceed 2,000 are to be in accordance with the followings **(1)** to **(4)**.

(1) Minimum breaking strength (*MBL*) is not to be less than that obtained from the following formula:

$MBL = 0.1A_1 + 350$ (*kN*)

A_1: Ship lateral projected area specified in **-5**

(2) Head lines, stern lines, breast lines or spring lines in the same service are to be of the same

characteristics in terms of strength and elasticity. The strength of spring lines is to be the same as that of the head, stern and breast lines.

(3) The total number of head, stern and breast lines is to be obtained from the following formula and rounded to the nearest whole number:

(a) For ships whose the ratio of the freeboard in the lightest draft and the full load condition is equal to or above two

$n = 8.3 \times 10^{-4} A_1 + 4$

(b) For the ships other than those in **(a)** above

$n = 8.3 \times 10^{-4} A_1 + 6$

(4) The total number of spring lines is to be taken as not less than:

Two lines when the equipment number < 5,000

Four lines when the equipment number ≧ 5,000

4 Notwithstanding the requirement in **-3** above, the number of head, stern and breast lines may be increased or decreased in conjunction with an adjustment to the strength of the lines. The adjusted strength, MBL^*, is to be taken as:

$MBL^* = 1.2 MBL \cdot n/n^* \leq MBL$ (kN) for an increased number of lines

$MBL^* = MBL \cdot n/n^*$ (kN) for a reduced number of lines

n^*: The increased or decreased total number of head, stern and breast lines

n: The number of lines for the considered ship type as calculated by the formulae specified in **-3(3)** without rounding.

In the same manner, the strength of head, stern and breast lines may be increased or decreased in conjunction with an adjustment to the number of lines. If the number of head, stern and breast lines is increased in conjunction with an adjustment to the strength of the lines, the number of spring lines is to be likewise increased, but rounded up to the nearest even number.

5 The ship side-projected area A_1 is to be obtained from the same formula specified in **2.1.2-1(2)**. However, following **(1)** to **(4)** are to be considered.

(1) The lightest draft of usual loading conditions is to be considered for the calculation of the side-projected area A_1. For other ships, the lightest draft of usual loading conditions is to be considered if the ratio of the freeboard in the lightest draft and the full load condition is equal to or above two.

(2) Wind shielding of the pier can be considered for the calculation of the side-projected area A_1 unless the ship is intended to be regularly moored to jetty-type piers. A height of the pier surface of 3 m over waterline may be assumed; in other words, the lower part of the side-projected area with a height of 3 m above the waterline for the considered loading condition may be disregarded for the calculation of the side-projected area A_1.

(3) Deck cargo is to be included for the determination of side-projected area A_1. Deck cargo may not need to be considered if a usual light draft condition without cargo on deck generates a larger side-projected area A_1 than the full load condition with cargo on deck. The larger of both side-projected areas is to be chosen as side-projected area A_1.

(4) Usual loading conditions mean loading conditions as given by the trim and stability booklet that are to be expected to regularly occur during operation and, in particular, excluding light weight conditions, propeller inspection conditions, etc.

6 The mooring lines specified in **-3** and **-4** above are based on the following environmental conditions:

(1) Maximum current speed: 1.0 m/s

(2) Maximum wind speed v_w in m/s as follows.

$v_w = 25.0 - 0.002(A_1 - 2000)$ (m/s)

However, v_w is not to be less than 21.0 (m/s) or greater than 25.0 (m/s).

7 Among the environmental conditions specified in **-6** above, the maximum wind speed v_w may be increased and decreased in conjunction with an adjustment to the *MBL* of the lines as the acceptable wind speed v_w^*. In this case, the acceptable wind speed v_w^* is to be obtained from the following formula:

$$v_w^* = v_w \sqrt{\frac{MBL^*}{MBL}}$$

MBL^*: The adjusted strength of mooring lines (kN)

However, the maximum wind speed v_w can be decreased where maximum breaking strength, *MBL*, specified in **-3(1)** is more than 1,275 kN. The acceptable wind speed v_w^* is to be not less than 21 m/s.

8 The length of mooring lines for ships is to be in accordance with the following requirements:

(1) For ships whose equipment number is less than or equal to 2,000: See **Table 6.2.2**.

(2) For ships whose equipment number exceeds 2,000: 200 m.

9 Application of tow lines and synthetic fibre ropes for mooring lines is to be as deemed appropriate by the Society.

10 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.

11 The length of individual mooring lines may be reduced by up to 7 % of the lengths given in **-8** above, 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 **-2** or **-4** above.

12 Tow Lines

Where ships are provided with tow lines, it is advised that tow lines are in accordance with the following, except if owner specifies the calculated formula of the tow lines in other towing specified in **2.4.1-1(2)**:

(1) The length of tow lines is not less than that given in **Table 6.2.1** according to ships' equipment numbers.

(2) As for wire ropes and fibre ropes used as tow lines, the breaking test load specified in **Chapter 4** or **5, Part L of the Rules for the Survey and Construction of Steel Ships** is not to be less than the breaking load given in **Table 6.2.1** according to the ships' equipment numbers. The application of synthetic fibre ropes for tow lines is as deemed appropriate by the Society.

(3) Wire ropes, fibre ropes used as tow lines are to be in compliance with the requirements in **Chapter 4** or **5, Part L of the Rules for the Survey and Construction of Steel Ships**, respectively.

2.1.6 Chain Lockers

1 Chain lockers are to be of capacities and depths adequate to provide an easy direct lead of the cables through the chain pipes and a self-stowing of the cables. For ships, which are designed to do handling work in the chain locker during stowing, the chain lockers are to have sufficient capacity for such work at the upper area even if 70 % of the total chain in length is stowed.

2 Chain lockers including spurling pipes are to be watertight up to the weather deck and to be provided with a means for drainage.

3 Chain lockers are to be subdivided by centre line screen walls.

4 Where a means of access is provided, it is to be closed by a substantial cover and secured by closely spaced bolts.

5 Where a means of access to spurling pipes or cable lockers is located below the weather deck, the access cover and its securing arrangements are to be to the satisfaction of the Society. Butterfly nuts and/or hinged bolts are prohibited as the securing mechanism for the access cover.

6 Spurling pipes through which anchor cables are led are to be provided with permanently attached closing appliances to minimize water ingress.

7 The inboard ends of the chain cables are to be secured to the structures by fasteners able to withstand a force not less than 15 % and not more than 30 % breaking load of the chain cable.

8 Fasteners are to be provided with a means suitable to permit, in case of emergency, an easy slipping of chain cables to the sea, operable from an accessible position outside the chain locker.

2.1.7 Supporting Hull Structures of Anchor Windlasses and Chain Stoppers

1 The supporting hull structures of anchor windlasses and chain stoppers are to be sufficient to accommodate operating loads and sea loads

(1) Operating loads are to be taken as not less than the following:

(a) For chain stoppers, 80 % of the chain cable breaking load

(b) For windlasses, where no chain stopper is fitted or a chain stopper is attached to the windlass, 80 % of the chain cable breaking load

(c) For windlasses, where chain stoppers are fitted but not attached to the windlass, 45 % of the chain cable breaking load

For the chain stopping equipment of ships, which are not equipped with chain stoppers or chain stoppers with windlass 80 % of the anchor chain cable breaking load applies.

(2) Sea loads are to be taken according to the following forces.(See **Fig. 6.2.1**)

$P_x = 200A_x$, in kN, acting normal to the shaft axis.

$P_y = 150A_y f$, in kN, acting parallel to the shaft axis (inboard and outboard directions to be examined separately).

where:

A_x: Projected frontal area, in m^2.

A_y: Projected side area, in m^2.

f: Coefficient taken as:

$f = 1 + B_w/H$, but not to be taken greater than 2.5.

B_w: Breadth of windlass measured parallel to the shaft axis, in m, see **Fig. 6.2.1**.

H: Overall height of windlass, in m, see **Fig. 6.2.1**.

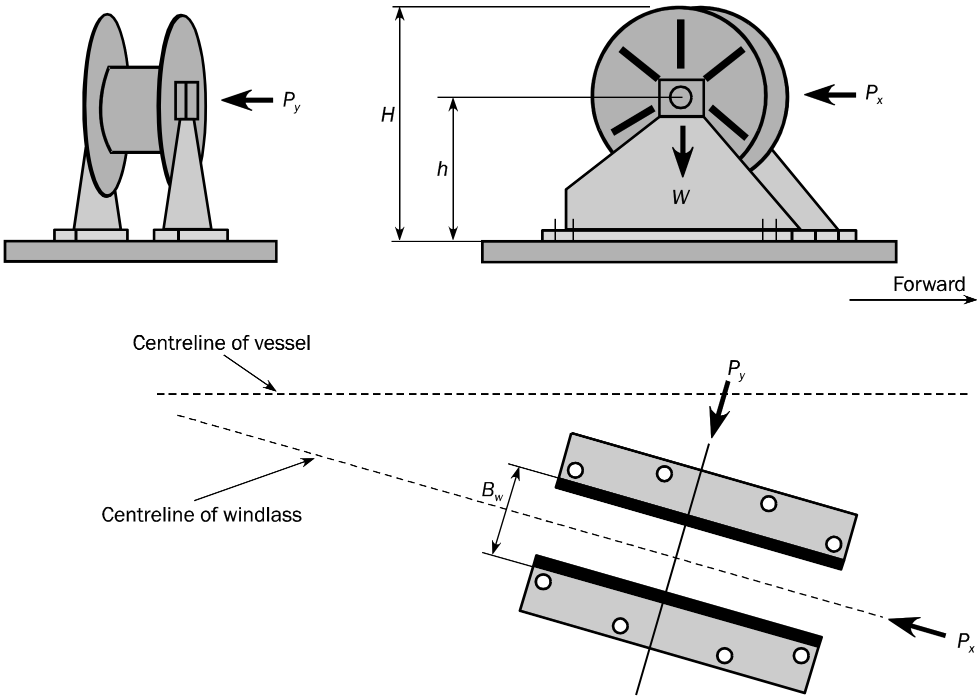
2 The permissible stresses for supporting hull structures of windlasses and chain stoppers, based on gross thicknesses, are not to be greater than the following permissible values:

(1) Normal stress: 1.00 R_{eH}

(2) Shear stress: 0.60 R_{eH}

R_{eH}: The specified minimum yield stress of the material

Fig. 6.2.1 Directions of Forces and Weight



2.2 Windlasses

2.2.1 General

1 Windlasses fitted to the ship in order to handle anchors are to be suitable for the size of chain cable being used. Moreover, it is to be suitable for the use and layout of the ships to which the windlass is mounted, including horizontal or vertical type and electric-powered or electro-hydraulic powered, etc.

2 The design, construction and testing of windlasses are to conform to a standard or code of practice recognized by the Society in addition to requirements in this chapter. The standard or code of practice is to specify criteria for stress, performance and testing.

2.2.2 Terminology

Terms used in this chapter are defined as follows:

(1) "Prime mover" means electric motors, hydraulic motors, steam turbines and so on, which drive cable lifters.

(2) "Torque-transmitting components" means components which transmit power from the prime movers to cable lifters when anchors and chain cables are paid out or hoisted; for example, shafts, gears, clutches, couplings and coupling bolts, etc. (includes components which constitute prime movers)

(3) "Load-bearing components" means components which are loaded; this, however, excludes torque-transmitting components such as shaft bearings, cable lifters, sheaves, drums, bed-frames, brakes, chain cable stoppers and foundations, etc.

2.2.3 Drawings and Data

The following drawings and data showing design specifications, standards of compliance, engineering analyses and details of construction, are, in principle, to be submitted.

(1) Drawings and data for approval:

(a) Windlass design specifications
(b) Windlass arrangement plan
(c) Dimensions, materials and welding details of torque-transmitting components and load-bearing components
(d) Drawings and data concerning hydraulic systems
(e) Control, monitoring and instrumentation arrangements
(f) Procedures for shop tests
(g) Other drawings and data considered necessary by the Society

(2) Drawing and data for reference:
(a) Calculated strength for torque-transmitting components and load-bearing components
(b) General arrangements and sectional assembly drawings of chain cable stoppers and documents which demonstrate the chain cable stoppers are in accordance with requirements specified in **2.2.5-2(6)** (in cases where chain cable stoppers are fitted)
(c) Load calculations of prime movers (in cases where the load test specified in **2.2.6-1(3)** is not carried out)
(d) Calculation sheets for cable lifter brake capacities (in cases where the cable lifter brake capacity test specified in **2.2.6-1(4)** is not carried out)
(e) Operation and maintenance procedures
(f) Other drawings and data considered necessary by the Society

2.2.4 Fabrication

1 Welded fabrication
Welded fabrication is to comply with the following requirements:
(1) Weld joint designs, the degree of non-destructive examination of welds and post-weld heat treatment, if any, are to be indicated in the drawings and data specified in **2.2.3(1)**.
(2) Welding procedures and related specifications are to be qualified in accordance with requirements of standards recognized by the Society or the requirements of **Chapter 11, Part D of the Rules for the Survey and Construction of Steel Ships**.
(3) Each welder to be engaged in the welding work is to pass the qualification tests specified in **Part M of the Rules for the Survey and Construction of Steel Ships** (including initial and renewal tests) with respect to each required welder qualification depending on the applicable welding process and materials to be welded. In addition, each welder is to obtain a qualification certificate issued by the Society.
(4) Welding consumables are to be type-approved by the Society in accordance with the requirements in **Part M of the Rules for the Survey and Construction of Steel Ships**.

2.2.5 Design

1 Windlasses and their beds as well as any other accessories and facilities are to be installed effectively and securely onto the deck.
2 Mechanical designs of windlasses are to be according to the following requirements:
(1) Design loads are to comply with the following requirements:
(a) Holding loads
Calculations are to be made to show that, in the conditions specified in **i)** and **ii)** below, the maximum stress for each load bearing component do not exceed yield strength (or 0.2 % proof stress) of the material.
i) The holding condition (single anchor, cable lifter brake fully applied and cable lifter declutched)
ii) Under a load equal to 80 % of the specified breaking test load of the chain cable (For installations fitted with a chain cable stopper, 45 % of the specified breaking test load of the chain cable may instead be used for the calculation.)

(b) Inertia loads

Designs for drive trains (including prime movers, reduction gears, bearings, clutches, shafts, cable lifters and bolting) are to consider the dynamic effects of the sudden stopping and starting of the prime movers or chain cables so as to limit inertial loads.

(2) The continuous duty pull is to be decided in accordance with the following requirements:

(a) Prime movers are to be able to exert, for at least 30 *minutes*, a continuous duty pull corresponding to the grade and diameter of chain cable as follows:

i) Maximum anchorage depth is to be not deeper than 82.5 *m* for the following windlasses:

1) those using Grade 1 chain cables: $Z_{cont1} = 37.5d^2$ (N) (3.82 d^2 (kgf))

2) those using Grade 2 chain cables: $Z_{cont1} = 42.5d^2$ (N) (4.33 d^2 (kgf))

3) those using Grade 3 chain cables: $Z_{cont1} = 47.5d^2$ (N) (4.84 d^2 (kgf))

where

Z_{cont1}: the continuous duty pull

d: the nominal diameter of chain cable (mm)

ii) Maximum anchorage depth is to be deeper than 82.5 *m* for the following windlasses:

Z_{cont2} (N) = Z_{cont1} (N) + (D − 82.5) × 0.27d^2

(Z_{cont2} (kgf) = Z_{cont1} (kgf) + (D − 82.5) × 0.0275d^2)

where

Z_{cont2}: the continuous duty pull

d: the nominal diameter of chain cable (mm)

D: the maximum anchorage depth (m)

(b) In general, the stresses in each torque-transmitting component are not to exceed 40 % of the yield strength (or 0.2 % proof stress) of the material when the continuous duty pull is loaded.

(3) Prime movers are to be able to provide the necessary temporary overload capacity for breaking out the anchor. This temporary overload capacity or "short term pull" is to be at least 1.5 times the continuous duty pull applied for at least 2 *minutes*. The speed in this period may be lower than that specified in **(4)** below.

(4) The mean speed of the chain cable during hoisting of the anchor and chain cable is to be at least 0.15 *m/s* when the windlass hoists over two shots of chain cable and initially with at least three shots of chain cable (82.5 *m*) with the anchor submerged and hanging free.

(5) Windlasses are to be fitted with cable lifter brakes of capacities sufficient to stop the anchor and the chain cable when paying out the chain cable. Such brakes are to produce torques capable of withstanding the following loads without any permanent deformation of strength members and without brake slip.

(a) with a chain cable stopper: 0.45 × the breaking test load of chain cable

(b) without a chain cable stopper: 0.80 × the breaking test load of chain cable

(6) Chain cable stoppers, if fitted, along with their attachments are to be designed to withstand, without any permanent deformation, 80 % of the specified minimum breaking strength of the chain cable.

(7) Hull supporting structures of windlasses and chain cable stoppers are to be according to the following requirements:

(a) Hull supporting structures of windlasses and chain cable stoppers are to comply with the requirements specified in **2.1.7**.

(b) For those ships of 80 *m* or more in length L_1 that are specified in **2.1.2-1(2)**, all windlass mounts on an exposed deck over the forward 0.25 L_1 line are to be of sufficient strength in cases where the height of the exposed deck in way of the item is mounted is less than 0.1 L_1 or 22 *m* above the designed maximum load line, whichever is lesser.

(c) The strength of any above deck framing and hull structure supporting a windlass and its securing bolt is to be according to the requirements in **10.7.1, Part C** or **10.6.1, Part CS of the Rules for the Survey and Construction of Steel Ships**.

3 Hydraulic systems where employed for driving windlasses are to comply with the requirements specified in other chapters of this Part in addition to those in this chapter.

4 Electrical systems (*e.g.*, electric motors and electrical circuits) are to comply with the requirements specified in **Part 8** in addition to those in this chapter.

5 The following protections are to be provided:

(1) Suitable protection systems which limit the speed and torque of the prime mover to protect mechanical parts, including component housings such as over pressure protection devices, slipping clutches between electric motors and gearing, torque limiting devices (for electrically driven windlasses only)

(2) Means to contain debris consequent to any severe damage to the prime mover due to over-speed in the event of uncontrolled rendering of the cable; for example, covers, particularly when an axial-piston-type hydraulic motor is used as the prime mover

(3) Devices or parts necessary for the safety of users; for example, covers for any exposed gearing, covers for any hot surfaces of steam cylinders, etc.

6 Windlasses are to be fitted with couplings, which are capable of disengaging between cable lifters and drive shafts. Hydraulically or electrically operated couplings are to be capable of being disengaged manually.

7 Windlasses are to be permanently marked with the following information:

(1) Nominal size of chain cable; for example, 100/3/45 means the nominal diameter of 100 *mm* and grade 3, with a holding load of 45 % of the breaking test load.

(2) Maximum anchorage depth (*m*)

2.2.6 Tests

1 Shop Tests

For conformance with approved plans, windlasses are to be inspected during fabrication at the manufacturer facilities and acceptance tests, as specified in the specified standard of compliance and including at least **(1)** to **(4)** below, are to be carried out in the presence of the Surveyor.

(1) Pressure tests

Before assembly, hydrostatic pressure tests are to be carried out for the following components in accordance with the requirements in **13.15.1**. The test pressure is to be 1.5 times design pressure. However, the test pressure for steam cylinders may be 1.5 times working pressure.

(a) Housings with covers for hydraulic motors and pumps

(b) Hydraulic pipes

(c) Valves and fittings

(d) Pressure vessels

(2) No-load tests

Windlasses are to be run without loads at nominal speed for 15 *minutes* in each direction (for a total of 30 *minutes*). In cases where the windlass is provided with a gear change, additional runs in each direction for 5 *minutes* at each gear change are required.

(3) Load tests

Windlasses are to be tested to verify that the continuous duty pull, overload capacity and hoisting speed as specified in **2.2.5-2** can be attained. In case where the manufacturing works does not have adequate facilities, the following **(a)** or **(b)** may be complied instead of the load tests:

(a) Submission of the documents specified in **2.2.3(2)(c)**.

(b) To carry out the load tests, including adjustments of overload protection, on board ship. In such cases, functional testing at manufacturer works is to be performed under no-load conditions.

(4) Cable lifter brake capacity tests
It is to be verified that either the holding power of the cable lifter brake complies with **2.2.5-2 (5)** through testing or submission of the calculation sheet specified in **2.2.3(2)(d)**.

2.3 Mooring Winches

2.3.1 Structure, etc.

1 Mooring winches are to comply with *ISO* Standards, *JIS* or any other recognized standards.

2 Mooring winches and their beds as well as any other accessories and facilities are to be installed effectively and securely onto the deck.

3 Mounts of mooring winches which are integrated with windlasses are to be in accordance with the requirements in **2.2.5-2(7)(b)** and **(c)**.

2.3.2 Tests

All mooring winches are to be subjected to the following tests after their installation on board.

(1) Confirmation tests for abnormalities with all mooring winches being operated for 15 *minutes* in each direction at maximum speed under no loads.

(2) Functioning tests of drum brakes under the operating conditions specified in **(1)** above.

(3) Notwithstanding the requirements of **(1)** and **(2)** above, in cases where there are multiple units of the same type, the period of testing and number of units to be tested may be reduced.

2.4 Towing and Mooring Fittings

2.4.1 General

1 The requirements in **2.4** apply to shipboard fittings used for towing and mooring operations associated with the normal operation of the ship, and their supporting hull structures.(hereinafter “shipboard fittings above” are referred to as “shipboard fittings” and “supporting hull structures”.) With respect to this requirement, towing is limited to the following **(1)** and **(2)**:

(1) Normal towing: towing operations necessary for manoeuvring in ports and sheltered waters associated with the normal operation of the ship

(2) Other towing: emergency towing by another ship or a tug.

2 Ships are to be adequately provided with shipboard fittings.

3 Shipboard fittings are to comply with the requirements of **2.4.2** and **2.4.3** respectively.

4 When the shipboard fittings are not selected from industry standards deemed appropriate by the Society, the corrosion additions specified in **2.4.4** are to be applied to shipboard fittings and their supporting structures such as foundations.

5 When the shipboard fittings are not selected from industry standards deemed appropriate by the Society, the wear down allowances specified in **2.4.5** are to be applied to shipboard fittings.

6 The scantlings of supporting hull structures are to be built at least with the gross scantlings obtained by adding the corrosion addition specified in **2.4.4** to the net scantlings obtained by applying the criteria specified in this section.

7 The scantlings of supporting hull structures are to be in accordance with the relevant chapters or sections in addition to this section.

2.4.2 Towing Fittings

1 Arrangement

(1) Towing fittings are to be located at the stern, in addition to the fore part if ships tow other ships, and also to be located on stiffeners, girders, or both which are parts of the deck construction so as to facilitate efficient distribution of the towing load.

(2) When towing fittings cannot be located as specified in **(1)** above, appropriate reinforced members are to be provided directly underneath the towing fittings.

2 Selection

(1) Towing fittings are to be selected from industry standards deemed appropriate by the Society, and are to be at least based on the following loads.

(a) For normal towing operations, the intended maximum towing load (*e.g.* static bollard pull) as indicated on the towing and mooring arrangements plan specified in **2.1.2, Part 2**.

(b) For other towing services, the minimum breaking strength of the tow line specified in **Table 6.2.1** according to the equipment number determined in **2.1.2**

(c) For the towing fittings used for other towing, the load under the conditions specified by the owner, such as towing speed and calm weather and sea states.

(d) For fittings intended to be used for both normal and other towing operations, the greater of the loads specified in **(a)** to **(c)** above

(2) When towing fittings are not selected from industry standards deemed appropriate by the Society, the strength of the fitting and of its attachment to the ship are to be in accordance with **-3** and **-4** below. For strength assessments, beam theory or finite element analysis using net scantlings is to be applied as appropriate. At the discretion of the Society, load tests may be accepted as alternatives to strength assessments by calculations.

(3) Towing bitts using double bollards are to be of sufficient strength to withstand the loads caused by the tow line attached with eye splice.

3 Design Load

Design load for the supporting hull structures of towing fittings are to be as specified in **(1)** to **(7)** below:

(1) For the normal towing operations specified in **2.4.1-1(1)**, the minimum design load is to be 1.25 times the intended maximum towing load.

(2) For the other towing services specified in **2.4.1-1(2)**, the minimum design load is to be the greater which either the breaking strength of the tow line specified in **Table 6.2.1** according to the equipment number determined in **2.4.1-1(2)** or the load specified in **-2(1)(c)** above**.**

(3) For fittings intended to be used for both normal and other towing operations, the minimum design load is to be the greater of the design loads specifies in **(1)** and **(2)** above.

(4) The design load is to be applied to fittings in all directions that may occur by taking into account the arrangements shown in the towing and mooring arrangements plan specified in **2.1.2, Part 2**.

(5) The point where the towing force acts on towing fittings is to be taken as the attachment point of the tow line. For bollards and bitts, the attachment points of tow line is to be taken as not less than 4/5 of the tube height above the base (see **Fig.6.2.2**).

(6) Where the tow line takes a turn at a fitting, the design load is to be equal to the resultant force of the design loads acting on the line, but needs not exceed twice the design load on the line. The design load acting on the line is to be the minimum design load specified in **(1)** and **(2)** (see **Fig.6.2.3**).

(7) Notwithstanding the requirements in **(1)** to **(6)** above, when a safe towing load (*TOW*) greater than that determined according to **-5** is requested by the applicant, the design load is to be increased in accordance with the appropriate *TOW*/design load relationship given by **-3** above and **-5** below.

4 Allowable Stresses

Allowable stresses of supporting hull structures are not to be more than the following:

(1) For strength assessments using beam theory or grillage analysis:

(a) Normal stress: 100 % of the specified minimum yield point of the material

(b) Shearing stress: 60 % of the specified minimum yield point of the material

(2) For strength assessments using finite element analysis:

(a) Equivalent stress: 100 % of the specified minimum yield point of the material

5 Safe Towing Load (*TOW*)

(1) For towing fittings used for the normal towing operations specified in **2.4.1-1(1)**, *TOW* is not to exceed 80 % of the minimum design load specified in **-3(1)** above.

(2) For towing fittings used for the other towing operations specified in **2.4.1-1(2)**, *TOW* is not to exceed 80 % of the minimum design load specified in **-3(2)** above.

(3) For towing fittings used for both normal and other towing operations, *TOW* is to be the greater of the minimum design loads.

(4) For fittings intended to be used for both towing and mooring, *SWL* according to **2.4.3** is to be marked in addition to *TOW*.

(5) The *TOW* (in tonnes) of each fitting is to be marked by weld beads and paint, or the equivalent, on the fitting.

Fig.6.2.2 Acting point of the towing force

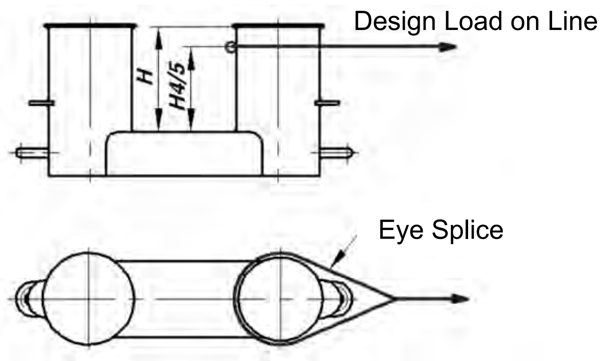
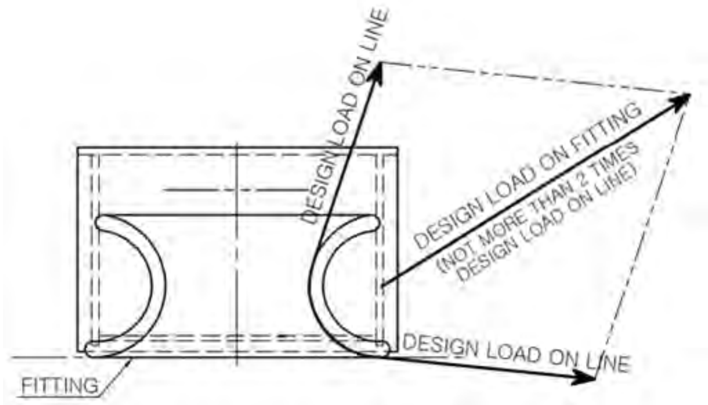


Fig.6.2.3 Design Load



2.4.3 Mooring Fittings

1 Arrangement

(1) Mooring fittings, winches and capstans are to be located on stiffeners, girders, or both which are part of the deck construction so as to facilitate efficient distribution of the mooring load.

(2) When mooring fittings, winches and capstans cannot be located as specified in **(1)** above, appropriate reinforced members are to be provided directly underneath them.

(3) When reels are used to accommodate the mooring ropes, the reels will be basically installed inboard and its position is to be appropriate for reeling out and reeling in.

2 Selection

(1) Mooring fittings are to be selected from industry standards deemed appropriate by the Society, and are to be at least based on the minimum breaking strength of mooring line according to **2.1.5**.

(2) When mooring fittings are not selected from industry standards deemed appropriate by the Society, the strength of the fitting and of its attachment to the ship are to be in accordance with **-3** and **-4**. For strength assessments, beam theory or finite element analysis using net scantlings is to be applied as appropriate. At the discretion of the Society, load tests may be accepted as alternatives to strength assessments by calculations.

(3) Mooring bitts (double bollards) are to be chosen for the mooring line attached in a figure-of-eight fashion, if the industry standard distinguishes between different methods to attach the line, *i.e.* figure-of-eight or eye splice.

3 Design Load

Design load for supporting hull structures of mooring fittings are to be as specified in **(1)** to **(7)** below:

(1) The minimum design load is to be 1.15 times the breaking strength of the mooring line according to **2.1.5**.

(2) The design load is to be applied to fittings in all directions that may occur by taking into account the arrangements shown in the towing and mooring arrangements plan specified in **2.1.2, Part 2**.

(3) The point where the mooring force acts on mooring fittings is to be taken as the attachment point of the mooring line. For bollards and bitts, the attachment point of the mooring line is to be taken not less than 4/5 of the tube height above the base (See **Fig.6.2.4(a)**). If fins are fitted to the bollard tubes to keep mooring lines as low as possible, the attachment point of the mooring line may be taken as the location of the fins. (See **Fig.6.2.4 (b)**)

(4) Where the mooring line takes a turn at a fitting(See **Fig.6.2.3**), the design load is to be equal to the resultant force of design load acting on the line, but needs not exceed twice the design load on the line.

(5) Notwithstanding the requirements in **(1)** to **(4)** above, when a safe working load (*SWL*), greater than that determined according to **-5** is requested by the applicant, the design load is to be increased in accordance with the appropriate *SWL*/design load relationship given by **-3** and **-5** below.

(6) The minimum design load applied to supporting hull structures for mooring winches is to be 1.25 times the intended maximum brake holding load, where the maximum brake holding load is to be assumed not less than 80 % of the minimum breaking strength of the mooring line according to **2.1.5**.

(7) The minimum design load applied to supporting hull structures for capstans is to be 1.25 times the intended maximum hauling-in force.

4 Allowable Stresses

Allowable stresses of supporting hull structures are not to be more than the following:

(1) For strength assessments using beam theory or grillage analysis:

(a) Normal stress: 100 % of the specified minimum yield point of the material

(b) Shearing stress: 60 % of the specified minimum yield point of the material

(2) For strength assessments using finite element analysis:

(a) Equivalent stress: 100 % of the specified minimum yield point of the material

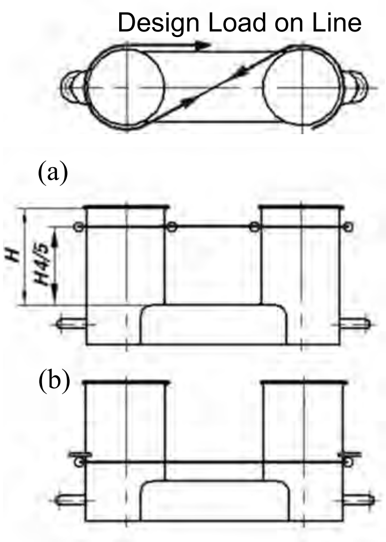
5 Safe Working Load (*SWL*)

(1) Unless a greater *SWL* is requested by the applicant according to **2.4.3-3(5)**, *SWL* is not to exceed the minimum breaking strength of the mooring line according to **2.1.5**.

(2) The *SWL* (in tonnes) of each fitting, excluding mooring winches and capstan, is to be marked

by weld beads and paint, or the equivalent, on the fitting. For fittings intended to be used for both towing and mooring, *TOW* according to **2.4.2-5(5)** is to be marked in addition to *SWL*.

Fig. 6.2.4 Acting Point of Mooring Force



2.4.4 Corrosion Additions

Corrosion additions are to be added to the scantlings of the supporting hull structures specified in **2.4.2** and shipboard fittings specified in as follows:

(1) Supporting hull structures: According to other rules for the surrounding structures

(2) Pedestals and foundations on deck, which are not a part of a fitting according to an industry standard deemed appropriate by the Society: 2.0 *mm*

(3) Shipboard fittings not selected from industry standards deemed appropriate by the Society: 2.0 *mm*

2.4.5 Wear Allowances

In addition to the corrosion additions referred to in **2.4.4**, the wear allowances for shipboard fittings not selected from industry standards deemed appropriate by the Society specified in **2.4.1-5** are not to be less than 1.0 *mm*, added to surfaces which are intended to regularly contact the line.

Table 6.2.1 Anchors, Chain Cables and Ropes

Equipment Letter	Equipment number		Anchor		Chain cable for anchor (Stud anchor for chain)				Tow line	
			Number	Mass per anchor (stock-less anchor)	Total length	Diameter			Length	Breaking load
						Grade 1	Grade 2	Grade 3		
	Over	Up to		*kg*	*m*	*mm*	*mm*	*mm*	*m*	*kN*
*A*1	50	70	2	180	220	14	12.5		180	98
*A*2	70	90	2	240	220	16	14		180	98
*A*3	90	110	2	300	247.5	17.5	16		180	98
*A*4	110	130	2	360	247.5	19	17.5		180	98
*A*5	130	150	2	420	275	20.5	17.5		180	98
*B*1	150	175	2	480	275	22	19		180	98
*B*2	175	205	2	570	302.5	24	20.5		180	112
*B*3	205	240	2	660	302.5	26	22	20.5	180	129
*B*4	240	280	2	780	330	28	24	22	180	150
*B*5	280	320	2	900	357.5	30	26	24	180	174
*C*1	320	360	2	1020	357.5	32	28	24	180	207
*C*2	360	400	2	1140	385	34	30	26	180	224
*C*3	400	450	2	1290	385	36	32	28	180	250
*C*4	450	500	2	1440	412.5	38	34	30	180	277
*C*5	500	550	2	1590	412.5	40	34	30	190	306
*D*1	550	600	2	1740	440	42	36	32	190	338
*D*2	600	660	2	1920	440	44	38	34	190	370
*D*3	660	720	2	2100	440	46	40	36	190	406
*D*4	720	780	2	2280	467.5	48	42	36	190	441
*D*5	780	840	2	2460	467.5	50	44	38	190	479
*E*1	840	910	2	2640	467.5	52	46	40	190	518
*E*2	910	980	2	2850	495	54	48	42	190	559
*E*3	980	1060	2	3060	495	56	50	44	200	603
*E*4	1060	1140	2	3300	495	58	50	46	200	647
*E*5	1140	1220	2	3540	522.5	60	52	46	200	691
*F*1	1220	1300	2	3780	522.5	62	54	48	200	738
*F*2	1300	1390	2	4050	522.5	64	56	50	200	786
*F*3	1390	1480	2	4320	550	66	58	50	200	836
*F*4	1480	1570	2	4590	550	68	60	52	220	888
*F*5	1570	1670	2	4890	550	70	62	54	220	941
*G*1	1670	1790	2	5250	577.5	73	64	56	220	1024
*G*2	1790	1930	2	5610	577.5	76	66	58	220	1109
*G*3	1930	2080	2	6000	577.5	78	68	60	220	1168
*G*4	2080	2230	2	6450	605	81	70	62	240	1259
*G*5	2230	2380	2	6900	605	84	73	64	240	1356

Table 6.2.1 Anchors, Chain Cables and Ropes (Continued)

Equipment Letter	Equipment number		Anchor		Chain cable for anchor (Stud anchor for chain)				Tow line	
			Number	Mass per anchor (stock-less anchor)	Total length	Diameter			Length	Breaking load
						Grade 1	Grade 2	Grade 3		
	Over	Up to		*kg*	*m*	*mm*	*mm*	*mm*	*m*	*kN*
*H*1	2380	2530	2	7350	605	87	76	66	240	1453
*H*2	2530	2700	2	7800	632.5	90	78	68	260	1471
*H*3	2700	2870	2	8300	632.5	92	81	70	260	1471
*H*4	2870	3040	2	8700	632.5	95	84	73	260	1471
*H*5	3040	3210	2	9300	660	97	84	76	280	1471
*J*1	3210	3400	2	9900	660	100	87	78	280	1471
*J*2	3400	3600	2	10500	660	102	90	78	280	1471
*J*3	3600	3800	2	11100	687.5	105	92	81	300	1471
*J*4	3800	4000	2	11700	687.5	107	95	84	300	1471
*J*5	4000	4200	2	12300	687.5	111	97	87	300	1471
*K*1	4200	4400	2	12900	715	114	100	87	300	1471
*K*2	4400	4600	2	13500	715	117	102	90	300	1471
*K*3	4600	4800	2	14100	715	120	105	92	300	1471
*K*4	4800	5000	2	14700	742.5	122	107	95	300	1471
*K*5	5000	5200	2	15400	742.5	124	111	97	300	1471
*L*1	5200	5500	2	16100	742.5	127	111	97	300	1471
*L*2	5500	5800	2	16900	742.5	130	114	100	300	1471
*L*3	5800	6100	2	17800	742.5	132	117	102	300	1471
*L*4	6100	6500	2	18800	742.5		120	107	300	1471
*L*5	6500	6900	2	20000	770		124	111	300	1471
*M*1	6900	7400	2	21500	770		127	114	300	1471
*M*2	7400	7900	2	23000	770		132	117	300	1471
*M*3	7900	8400	2	24500	770		137	122	300	1471
*M*4	8400	8900	2	26000	770		142	127	300	1471
*M*5	8900	9400	2	27500	770		147	132	300	1471
*N*1	9400	10000	2	29000	770		152	132	300	1471
*N*2	10000	10700	2	31000	770			137	300	1471
*N*3	10700	11500	2	33000	770			142	300	1471
*N*4	11500	12400	2	35500	770			147	300	1471
*N*5	12400	13400	2	38500	770			152	300	1471
*O*1	13400	14600	2	42000	770			157	300	1471
*O*2	14600	16000	2	46000	770			162	300	1471

Notes:

1 Length of chain cables may include shackles for connection.

2 Values given for anchoring equipment in this table are based on an assumed maximum current speed of 2.5 *m/s*, a maximum wind speed of 25 *m/s* and a minimum scope of chain cable of 6, the scope being the ratio between the paid-out length of the chain and water depth.

3 The tow lines may be omitted for ships with L_1 exceeding 180 *m*.

Table 6.2.2 Mooring Lines for Ships with Equipment Number ≦ 2,000

Equipment Letter	Equipment number		Mooring line		
			Number	Length of each line	Breaking load
	Over	Up to		*m*	*kN*
*A*1	50	70	3	80	37
*A*2	70	90	3	100	40
*A*3	90	110	3	110	42
*A*4	110	130	3	110	48
*A*5	130	150	3	120	53
*B*1	150	175	3	120	59
*B*2	175	205	3	120	64
*B*3	205	240	4	120	69
*B*4	240	280	4	120	75
*B*5	280	320	4	140	80
*C*1	320	360	4	140	85
*C*2	360	400	4	140	96
*C*3	400	450	4	140	107
*C*4	450	500	4	140	117
*C*5	500	550	4	160	134
*D*1	550	600	4	160	143
*D*2	600	660	4	160	160
*D*3	660	720	4	160	171
*D*4	720	780	4	170	187
*D*5	780	840	4	170	202
*E*1	840	910	4	170	218
*E*2	910	980	4	170	235
*E*3	980	1060	4	180	250
*E*4	1060	1140	4	180	272
*E*5	1140	1220	4	180	293
*F*1	1220	1300	4	180	309
*F*2	1300	1390	4	180	336
*F*3	1390	1480	4	180	352
*F*4	1480	1570	5	190	352
*F*5	1570	1670	5	190	362
*G*1	1670	1790	5	190	384
*G*2	1790	1930	5	190	411
*G*3	1930	2000	5	190	437

Chapter 3 STEERING GEARS

3.1 General

3.1.1 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 **Chapter 11**, this Part and **Chapter13, Part 7**.

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.

3.1.2 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)** above: 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.

3.1.3 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.

3.1.4 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 **3.3.1-4**, appropriate instructions for emergency procedures related to such alarms are to be permanently displayed on the navigation bridge.

3 Notwithstanding **-1** or **-2** above, if it is inappropriate for ships to display such drawings onboard, it may be omitted upon approval of the Society.

3.1.5 Operating and Maintenance Instructions for Steering Gears

Operating and maintenance instructions and engineering drawings for steering gears are to be provided and written in a language understandable by any officers and crew members who are required to understand such information in the performance of their duties.

3.2 Performance and Arrangement of Steering Gears

3.2.1 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 **3.2.2(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.

3.2.2 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 **2.3.18, 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)** above or

when the diameter of the upper stock is required in **Chapter 3, Part C of the Rules for the Survey and Construction of Steel Ships** 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.

3.2.3 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 **2.3.18, 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)** above and in any case when the diameter of upper stock is required in **Chapter 3, Part C of the Rules for the Survey and Construction of Steel Ships** to be over 230 *mm*.

3.2.4 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 A fixed storage tank having sufficient capacity to recharge at least one power actuating system including the reservoir, in cases where the main steering gear is operated by hydraulic power. This storage tank is to be permanently connected by piping in such a manner that the hydraulic system can be readily recharged from a position within the steering gear compartment and is to be provided with a contents gauge.

7 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.

3.2.5 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 navigation bridge. In the event of a power failure to any one of the power units, an audible and visual alarm is to be given on the navigating bridge.

3.2.6 Alternative Source of Power

In cases where the diameter of upper stock is required in **Chapter 3, Part C of the Rules for the Survey and Construction of Steel Ships** 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; 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 **3.2.3(1)** can be regained. Alternative sources of power are to have the capacity for at least 30 *minutes* of continuous operation of the steering gear. Depending on the use of ships, capacity of alternative sources of power may be longer or shorter than 30 *minutes*.

(3) Automatic starting arrangements for generators or prime movers of pumps used as the independent source of power specified in **(1) (b)** above are to comply with the requirements for starting devices and performance in **3.4.1, Part 8**.

3.2.7 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. However, one of these circuits may be supplied through the emergency 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 Short circuit protection and overload alarms are to be provided for such circuits and motors. The overload alarm is to be both audible and visible and to be situated in a conspicuous position in the place from where the main engine is normally controlled.

6 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.

7 In cases where a three-phase AC supply is used, an alarm is to be provided that will indicate failure of any one of the supply phases. The alarm is to be both audible and visible and to be situated in a conspicuous position in the place from where the main engine is normally controlled.

8 When any auxiliary steering gear, in ships of less than 1,600 *estimated gross tonnage*, which is required by **3.2.3(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** to **-7** may be waived if the Society is satisfied that these protection arrangements are in accordance with the requirements in **3.2.5** and **3.3.1-1(3)** for auxiliary steering gear.

9 For ships with *estimated gross tonnage* less than 1,600 *tons* 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.

3.2.8 Position of Steering Gears

1 Steering gear is to be installed in an enclosed compartment readily accessible, and, as far as possible, separated from any machinery spaces.
2 The steering room is to be large enough to operate the steering system effectively.
3 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 non-slip surfaces to ensure suitable working conditions in the event of hydraulic fluid leakage.

3.2.9 Means of Communication

A means of communication is to be provided between the navigating bridge and the steering gear compartment.

3.2.10 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.

3.3 Controls

3.3.1 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 **3.2.1-2**, 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 Cables and pipes of control systems required to be in duplicate by this Chapter are to be separated as far apart as is practicable throughout their entire length.
4 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.

3.3.2 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.

3.4 Materials, Constructions and Strength of Steering Gears

3.4.1 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 **3.2.2(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.

3.4.2 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 10, Part 7**.

2 In the strength calculations specified in **-1** above, the allowable stress for any equivalent primary general membrane stress is to be not greater than the following values **(1)** or **(2)**, whichever is smaller:

(1) $\frac{\delta_B}{A}$

(2) $\frac{\delta_Y}{B}$

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 6.3.1**

Table 6.3.1 A and B

	Rolled or Forged Steel	Cast Steel	Nodular Cast Iron
A	3.5	4	5
B	1.7	2	3

3.4.3 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.

3.4.4 Flexible Hose Assembly

Flexible hose assemblies specified in **13.4.4, Part 7** are to be used in piping systems in cases where flexibility is required.

3.4.5 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 **3.3, Part C of the Rules for the Survey and Construction of Steel Ships** (N-m).

K : Material coefficient of the tiller, specified in **3.1.2, Part C of the Rules for the Survey and Construction of Steel Ships**

2 Notwithstanding the requirement specified in **-1** above, 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 **3.3, Part C of the Rules for the Survey and Construction of Steel Ships** (N-m).

K : Material coefficient of the tiller, specified in **3.1.2, Part C of the Rules for the Survey and Construction of Steel Ships**

(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 **3.3, Part C of the Rules for the Survey and Construction of Steel Ships** (N-m).

K : Material coefficient of the tiller, specified in **3.1.2, Part C of the Rules for the Survey and Construction of Steel Ships**

(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 **3.3, Part C of the Rules for the Survey and Construction of Steel Ships** (N-m).

K : Material coefficient of the tiller, specified in **3.1.2, Part C of the Rules for the Survey and Construction of Steel Ships**

(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)** above to a value recognized by the Society.

3 Notwithstanding the requirement specified in **-1** above, 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 **3.4.4**.

(1) Scantlings of the boss are to comply with the requirement specified in **-2(1)** above.

(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 **3.3, Part C of the Rules for the Survey and Construction of Steel Ships** (N-m).

K : Material coefficient of the vane, specified in **3.1.2, Part C of the Rules for the Survey and Construction of Steel Ships**

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 **3.3, Part C of the Rules for the Survey and Construction of Steel Ships** (N-m).

K : Material coefficient of the bolt, specified in **3.1.2 Part C of the Rules for the Survey and Construction of Steel Ships**

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/mm²)*, or shearing stresses exceeding $54/K$ *(N/mm²)* under the rudder torque T_R applied. Alternatively, the scantlings may be determined according to the requirements specified in **-3** above, using 1.2 times the rudder torque T_R specified in **3.3, Part C of the Rules for the Survey and Construction of Steel Ships** as rudder torque for calculating.

3.4.6 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.

3.4.7 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.

3.5 Testing

3.5.1 Shop Tests

1 Pressure vessels and piping systems are to be subjected to tests in accordance with the requirements in **10.8** and **13.15, Part 7** in addition to the tests specified in **3.5**.

2 All pressure parts are to be subjected to pressure tests with a pressure equal to 1.5 times the design pressure.

3 Each type of pump used as a power unit is to be subjected to a running test for the duration of not less than 100 *hours*. Test arrangements are to be such that the pump may run in idle condition, and at maximum delivery capacity at maximum working pressure. The passage from one condition to another is to occur at least as quickly as on board. During the test, idling periods are to be alternated with periods at maximum delivery capacity at maximum working pressure. During the whole test no abnormal heating, excessive vibration or other irregularities are permitted. After the test, the pump is to be disassembled to ascertain that there are no abnormalities. The test may be waived for a power unit which has been proved to be reliable in marine service.

Chapter 4 HANDRAIL, MEANS OF ACCESS AND DOORS

4.1 General

The terms used in this Chapter are defined as follows:

(1) Main corridor is weather deck and the corridor which runs fore and after on the deck immediately below the bulkhead deck such as a damage control deck.

4.2 Corridors

1 When installing two main corridors, the corridors are to keep distance from each other as far as possible to the port side and the starboard side. For only one corridor, it is to be installed on the centre line as far as possible.

2 The main corridor on the deck immediately below the bulkhead deck, such as a damage control deck, is to be a straight, as far as possible, corridor with a width of 1,200 *mm* at least.

3 In general, means of access are to be installed as to directly access to various places within one watertight transverse bulkhead subdivision on the deck immediately below the bulkhead deck, such as a damage control deck, without going through decks or other subdivisions as possible.

4 Corridors below the deck immediately below the bulkhead deck, such as a damage control deck, are not to be installed running through a watertight transverse bulkhead.

5 There are to have no protrusions preventing smooth access at the corridor.

6 For any dangerous equipment directly facing the corridor, they are to be covered appropriately or some protection means, such as guard rails, needs to be installed.

7 More than one access opening are to be arranged in the readily accessible position, as far as possible of each compartment.

8 Two or more access opening, separated from each other, including those for evacuation are to be installed in compartments with a lot of staff or accommodation space always with many people.

9 In general, there are to be at least one route people can access to exposed parts from the spaces mentioned in **-8** above, without passing through the neighboring watertight transverse bulkheads.

10 In the escape routes that are obstructed by flooding, steam, fire, etc., the routes are to be enclosed with watertight or airtight trunks. These trunks are to be equipped with doors or hatches to the decks necessitating them.

4.3 Doors and Hatches

4.3.1 Watertight Doors and Hatches

1 Doors and hatches are to be fitted to the positions where strength of structure will not be influenced. Their shapes also are to be considered.

2 Openings, including doors and hatches, to be fitted to the places which influence structural strength of watertight transverse bulkheads is to satisfy the required structural strength.

3 The standards of watertight and airtight capabilities are to be in accordance with the following requirements:

(1) Doors and maintenance hatches to be fitted to the bulkheads or trunks are to withstand 150 % of uniformly distributed load of water pressure applied to the lower end of openings both from inside and outside due to design water head of the doors and maintenance hatches.

(2) Hatches and manholes to be fitted to the decks and platforms are to withstand 150 % of uniformly distributed load applied to the hatches and manholes both from inside and outside.

(3) Doors and manholes fitted to the walls surrounding the superstructure are to withstand

whichever is greater of 0.019 *MPa* or 150 % of specified outer pressure of the water head for walls surrounding the superstructure.

(4) Doors exposed to direct impacts from blast resulting from weapon releases are to withstand the blast pressure in addition to **(3)** above.

(5) The degree of airtightness of doors in the airtight compartments is to be in accordance with **(1)** and **(2)** above.

4 In general, the standard airtight and watertight doors and hatches are to be the clip type or simultaneous closing clips type in which they close from both sides. However, infrequently used warehouse hatches and the hatches with evacuation openings may be the one-side closing type fixed with wing screws.

5 Watertight doors and hatches that are in the main corridor, in the busy areas and for escape are to be the simultaneous closing clips type.

6 The standard dimensions of watertight doors are to be 1,650 *mm* × 600 *mm*, provided that the dimensions may be changed upon approval of the Society. However, the dimensions of watertight doors in the most fore end and most aft end of the watertight transverse bulkheads are to be 800 *mm*×600 *mm*.

7 The height of sill of watertight doors is to be as follows:

(1) Watertight doors of fore and after ends of watertight transverse bulkhead: 950 *mm*

(2) Other watertight and airtight doors: 200 *mm*

8 Depending on the place of installation, hatch dimensions are to be as follows. However, the dimensions may be changed upon approval of the Society.

(1) Openings on or above the bulkhead deck: 1,200 *mm* × 700 *mm* (non-watertight flameproof cover)

(2) Main corridors below the bulkhead deck: 1,200 mm × 700 mm (with simultaneous closing clips)

(3) Corridors other than the main corridors below the bulkhead deck: 1,050 *mm* × 600 *mm* (with simultaneous closing clips) and 850 *mm* × 600 *mm*

(4) Access openings below the bulkhead deck, other than those described in **(2)** or **(3)**: 600 *mm* × 600 *mm*

(5) Hatches exclusively used for escape (including those on the lateral walls): φ500 *mm* (with simultaneous closing clips)

4.3.2 Watertight Sliding Doors

1 Types of Watertight Sliding Doors

(1) In addition to the hinge type watertight doors described in **4.3.1**, watertight doors are to be of a sliding type, provided remote closing is required.

(2) Notwithstanding the provisions in **(1)** above, watertight sliding doors or ramps fitted to internally subdivided cargo spaces may be of a type other than the sliding type.

(3) Doors which are closed by dropping or by the action of a dropping weight are not permitted.

2 Strength and Watertightness

(1) Watertight sliding doors are to be of ample strength and watertightness for water pressure to a head up to the bulkhead deck, and door frames are to be effectively secured to the bulkheads. Where deemed necessary by the Society, watertight sliding doors are to be tested by water pressure before they are fitted.

(2) Where watertight sliding doors are provided in cargo spaces, such doors are to be protected by suitable means against damage from items such as cargoes.

3 Control

(1) All watertight sliding doors, except those which are to be permanently closed at sea, are to be capable of being opened and closed by hand locally, from both sides of the doors, with the ship listed 30 *degrees* to either side.

(2) In addition to the requirements of **(1)** above, watertight sliding doors which are used at sea or normally open at sea are to be capable of being remotely closed by power from the navigation bridge.
(3) Watertight sliding doors are not to be able to be opened remotely.
4 Indication
(1) Watertight sliding doors, except those permanently closed at sea, are to be provided with position indicators showing whether the doors are open or closed on the bridge and at all operating positions.
(2) In addition to the requirements of **(1)** above, for watertight sliding doors which are to be capable of being remotely closed, an indication is to be placed locally showing that the door is in remote control mode.
5 Alarms
(1) Watertight sliding doors which are capable of being remotely closed are to be provided with an audible alarm which will sound at the door position whenever such a door is remotely closed.
6 Source of Power
(1) The remote controls, indications and alarms required in **-3** to **-5** above are to be operable in the event of main power failure.
(2) Electrical installations for devices specified in **(1)** above except those of a water-proof type approved by the Society are not to be under the bulkhead deck.
(3) Cables for devices specified in **(1)** above are to comply with the requirements of **2.9.11-2, Part 8**.
7 Notices
(1) Watertight sliding doors which are to be normally closed at sea but not provided with a means of remote closure are to have notices fixed to both sides of the doors stating "To be kept closed at sea".
(2) Watertight sliding doors which are to be permanently closed at sea are to have notices fixed to both sides stating "Not to be opened at sea". Such doors which are accessible during the voyage are to be fitted with a device which prevents unauthorized opening.

4.4 Ladders, Steps and Guardrails

4.4.1 Ladders and Steps

1 Ladders are to be removable as required and installed in the fore and aft direction as much as possible.
2 Ladders installed in the following areas are to be inclined ladders.
(1) Ladders to the hatches from regularly used corridors
(2) Ladders installed in the accommodation spaces for regular use
(3) Ladders installed in the warehouse and machinery compartments such as the machinery space of category *A* for regular use
3 When ladders are installed by necessity in **-2(3)**, and in the areas other than those described in **-2(1)** and **(2)**, they are to be vertical ladders.
4 The standard angle of ladders described in **-2** above (the angle formed by the ladder and a vertical line) and the width are to be in compliance with the following requirements:
(1) Main corridors Inclined angle: 28° Width: 520 *mm*
(2) Corridors other than mains Inclined angle: 20° Width: 460 *mm*
(3) For ships, which are intended to navigate in the threat sea areas, ladders with hatches on the top for escape, notwithstanding the requirements of **11.3.2, Part 9**, are to apply with **(1)** and **(2)** above.

5 Peak tanks, deep tanks, cofferdams, cargo oil tanks, cargo holds with relative high bilge hopper tanks, and other similar enclosed spaces are to be provided with means of access, *i.e.*, stages, ladders, steps or other similar facilities for internal examinations in safety.
6 In general, access to the forepeaks, after peaks, deep tanks, cofferdams, cargo oil tanks, cargo holds, as well as similar enclosed compartments, is to be direct access from the open deck through at least a pair of hatches or maintenance hatches and ladders.
7 Safe access to peak tanks, deep tanks, cofferdams, cargo oil tanks, cargo holds and other similar enclosed spaces is to be, in general, direct from the open deck and served by at least one access hatchway or manhole and ladder.

4.4.2 Guardrail

1 General
(1) Efficient guardrails or bulwarks are to be provided around all exposed decks.
(2) Guardrails specified in **(1)** above are to comply with the following.
(a) Fixed, removable or hinged stanchions are to be fitted about 1.5 *m* apart. Removable or hinged stanchions are to be capable of being locked in the upright position.
(b) At least every third stanchion is to be supported by a bracket or stay. Alternatively, measures deemed appropriate by the Society are to be taken.
(c) Where necessary for the normal operation of the ship, steel wire ropes may be accepted in lieu of guardrails. The wires are to be made taut by means of turnbuckles.
(d) Where necessary for the normal operation of the ship, chains fitted between two fixed stanchions and/or bulwarks are acceptable in lieu of guardrails.
(e) Provided handrail posts cause radio disturbance of installed equipment, such posts need to be made of synthetic resin.
(3) Guardrails around the helideck, etc. are to be an outward retractable type, which can also work as safety nets. Safety nets are to be designed in a way that while retractable hinges are installed below outer side deck and the nets are set down, they incline for approximately 5° in an outer upwards direction from the horizontal line and their outer edges are located below the slant line which is 5° downwards from the horizontal line from the deck edge. When they rise, they are 1,000 *mm* above the deck (1,100 *mm* above the bulkhead deck) and when they are set down, their projection width is to be 1,400 *mm* or greater.

4.4.3 Means of Embarkation and Disembarkation

Ships of not less than 300 *estimated gross tonnage* are to be provided with appropriate means of embarkation on and disembarkation from ships for use in port and in port related operations, unless specially approved by the Society.

4.5 Bow Door and Inner Door

4.5.1 Application

Bow doors and inner doors to be fitted above the bulkhead decks are to comply with **23.3 Bow Doors and Inner Doors, Part C of the Rules for the Survey and Construction of Steel Ships**. This section does not apply to the bow doors and inner doors fitted in the compartments not considered buoyant in stability calculations.

4.6 Side Door and Stern Door

4.6.1 Application

The side doors and stern doors leading to enclosed superstructures are to comply with **23.4 Side Sell Doors and Stern Doors, Part C of the Rules for the Survey and Construction of Steel**

Ships.

Chapter 5 SIDE SCUTTLES AND RECTANGULAR WINDOWS

5.1 General Application

1 The requirements in this chapter apply to side scuttles and rectangular windows on the side shell, superstructures and deckhouses up to the third tier above the bulkhead deck. The requirements for the side shell, superstructures and deckhouses above the third tier are to be as deemed appropriate by the Society.
2 Notwithstanding **-1** above, windows on the deckhouse up to the third tier above the bulkhead deck may be as deemed appropriate by the Society for windows that do not interfere with the watertightness of the ship and are deemed as necessary for the ship's operation such as those on the navigation bridge
3 For windows of area exceeds 0.16 m^2, they are to be rectangular windows

5.2 Side Scuttles

5.2.1 General Requirement for Position of Side Scuttles

1 No side scuttle is to be provided where its sill is below a line drawn parallel to the bulkhead deck at side and having its lowest point 2.5 % of waterline(B_{WL}) or 500 *mm*, whichever is greater, above the designed maximum load line. Side scuttles that have their sill below the bulkhead deck and which are of a hinged type glass covers are to be provided with locking arrangements.
2 Notwithstanding the requirement of **-1** above, no side scuttle is to be provided at any space solely engaged in the carriage of cargoes.
3 The deadlights of side scuttles deemed appropriate by Society may be portable, provided that such scuttles comply with the following requirements **(1)** to **(4)**:
(1) Fitting class *A* side scuttles or class *B* side scuttles is not required.
(2) Such side scuttles are fitted abaft one eighth of length waterline (L_{WL}) from the forward perpendicular.
(3) Such side scuttles are fitted above a line drawn parallel to the bulkhead deck at side and at a height of 3.7 plus 2.5 % B_{WL} *(m)* from the designed maximum load draught.
(4) Such portable deadlights are to be stowed adjacent to the side scuttles they serve.
4 Automatic ventilating side scuttles is not to be fitted in the shell plating below the bulkhead deck.

5.2.2 Application of Side Scuttles

1 Side scuttles inboard are to be class *A* side scuttles, class *B* side scuttles, or class *C* side scuttles complying with the requirements in **Chapter 7, Part L of the Rules for the Survey and Construction of Steel Ships** or equivalent thereto. In general, the side scuttles are to be the fixed type.
2 Class *A* side scuttles, class *B* side scuttles and class *C* side scuttles are to be so arranged that their design pressure is less than the maximum allowable pressure determined by their nominal diameters and grades. (See **5.2.4**)
3 Side scuttles to spaces below the bulkhead deck and those provided to sunken poops are to be class *A* side scuttles, class *B* side scuttles or equivalent thereto.
4 Side scuttles exposed to direct impact from waves or blast, or that are to spaces within the first tier of side shell or superstructures, first tier deckhouses on the bulkhead deck which have unprotected deck openings leading to spaces below the bulkhead deck inside, or deckhouses considered buoyant in stability calculations, are to be class *A* side scuttles, class *B* side scuttles or equivalent thereto.

5 Where an opening in the superstructure deck or in the top of the deckhouse on the bulkhead deck which gives access to a space below the bulkhead deck or to a space within an enclosed superstructure is protected by the deckhouse or companion, the side scuttles fitted to those spaces which give direct access to an open stairway are to be class *A* side scuttles, class *B* side scuttles or equivalent thereto. Where cabin bulkheads or doors separate side scuttles from a direct access leading below the bulkhead deck, application of side scuttles is to be as deemed appropriate by the Society.

6 Side scuttles to the spaces in the second tier on the bulkhead deck considered buoyant in stability calculations are to be class *A* side scuttles, class *B* side scuttles or equivalent thereto.

5.2.3 Protection of Side Scuttles

All side scuttles in way of the anchor housing and other similar places where they are liable to be damaged are to be protected by strong gratings.

5.2.4 Design Pressure and Maximum Allowable Pressure of Side Scuttles

1 The design pressure of side scuttles is to be less than the maximum allowable pressure (See **Table 6.5.1**) determined by their nominal diameters and grades. The design pressure P is to be determined using the following equation.

$P = 10ac(bf - y)$ (kPa)

a, b, c and f: As specified in **19.2.1-1, Part C of the Rules for the Survey and Construction of Steel Ships**

y: Vertical distance (m) from side scuttle sill to the designed maximum load line.

2 Notwithstanding the provision of **-1** above, the design pressure is not to be less than the minimum design pressure given in **Table 6.5.2**.

Table 6.5.1 Maximum Allowable Pressure of Side Scuttles

Class	Nominal diameter (*mm*)	Glass thickness (*mm*)	Maximum allowable pressure (*kPa*)
A	200	10	328
	250	12	302
	300	15	328
	350	15	241
	400	19	297
B	200	8	210
	250	8	134
	300	10	146
	350	12	154
	400	12	118
	450	15	146
C	200	6	118
	250	6	75
	300	8	93
	350	8	68
	400	10	82
	450	10	65

Table 6.5.2 Minimum Design pressure

	L is 250 m and under	L exceeds 250 m
Exposed front bulkhead of the first tier superstructure	$25 + L/10$ (*kPa*)	50 (*kPa*)
Other places	$12.5 + L/20$ (*kPa*)	25 (*kPa*)

5.3 Rectangular Windows

5.3.1 General Requirement for Position of Rectangular Windows

No rectangular window is to be provided to spaces below the bulkhead deck, the first tier of superstructures, and the first tier of deckhouses considered buoyant in stability calculations or which protect deck openings leading to spaces below the bulkhead deck inside.

5.3.2 Application of Rectangular Windows

1 Rectangular windows inboard are to be class *E* rectangular windows and class *F* rectangular windows complying with the requirements in **Chapter 8, Part L of the Rules for the Survey and Construction of Steel Ships** or equivalent thereto.
2 Class *E* rectangular windows and class *F* rectangular windows are to be so arranged that the design pressure is less than the maximum allowable pressure determined by their nominal sizes and grades. (See **5.3.3**)
3 Rectangular windows to spaces in the second tier of the bulkhead deck which gives direct access to spaces within the first tier of enclosed superstructures or below the bulkhead deck are to be provided with hinged deadlights or externally fixed shutters. Where cabin bulkheads or doors separate the space within the second tier from spaces below the bulkhead deck or spaces within the first tier of enclosed superstructures, application of rectangular windows to the spaces within the second tier is to be as deemed appropriate by the Society.
4 Rectangular windows to spaces in the second tier of the bulkhead deck considered buoyant in stability calculations are to be provided with hinged deadlights or externally fixed shutters.

5.3.3 Design Pressure and Maximum Allowable Pressure of Rectangular Windows

1 The design pressure of rectangular windows is to be less than the maximum allowable pressure (See **Table 6.5.3**) determined by their nominal sizes and grades. The design pressure P is to be determined using the following equation.

$$P = 10ac(bf - y) \quad (kPa)$$

a, b, c and f: As specified in **19.2.1-1, Part C of the Rules for the Survey and Construction of Steel Ships**

y: Vertical distance (m) from side scuttle sill to the designed maximum load line.

2 Notwithstanding the provision of **-1** above, the design pressure is not to be less than the minimum design pressure as given in **Table 6.5.2**.

Table 6.5.3 Maximum Allowable Pressure of Rectangular Windows

Class	Nominal size Width (*mm*)×height (*mm*)	Glass thickness (*mm*)	Maximum allowable pressure (*kPa*)
E	300×425	10	99
	355×500	10	71
	400×560	12	80
	450×630	12	63
	500×710	15	80
	560×800	15	64
	900×630	19	81
	1000×710	19	64
F	300×425	8	63
	355×500	8	45
	400×560	8	36
	450×630	8	28
	500×710	10	36
	560×800	10	28
	900×630	12	32
	1000×710	12	25
	1100×800	15	31

5.4 Navigation Bridge Windows

5.4.1 General

1 The height of the lower edge of the navigation bridge front windows above the bridge deck is to be kept as low as possible. The lower edge is not to obstruct the forward view in any case.

2 The upper edges of bridge front windows are to allow a forward view of the horizon, for a person with a height of eye of 1,800 *mm* above at the main conning position, when the ship is pitching in heaving seas. The flag Government, if satisfied that a 1,800 *mm* height of eye is unreasonable and impractical, allows reduction of the height of eye but not less than 1,600 *mm*.

3 Framing between bridge windows is to be kept to a minimum and is not to be installed immediately forward of any workstation.

4 To help avoid reflections, bridge front windows are to be inclined from the vertical plane top out, at an angle of not less than 10° and not more than 25°.

5 Polarized and tinted windows are not to be fitted.

6 As required, fresh water cleaning equipment to clean outside of the windows, wipers and anti-freeze heaters are to be installed.

Chapter 6 CARGO HANDLING APPLIANCES

6.1 General

6.1.1 General Application

1 The requirements in this Chapter apply to cargo handling appliances which are installed on the Government and naval ships classed with **2.2.1 (1), Part 1**, and intended to be registered under **1.2.12-2, Part 1**.

2 As for the cargo gear, cargo ramps and loose gear, precautions are to be taken to any manners of their treatment different from the requirements of the Rules in the flag state of the ship or state of call.

3 The Society may carry out inspection and issue necessary certificates for the cargo handling appliances according to the designated rules in the capacity of the government of the state concerned or other organization under the authorization by such state or organization.

6.1.2 Terminology

For the purpose of the Rules, the terms are defined as given in **(1)** through **(15)** below unless otherwise defined:

(1) Cargo handling appliances are lifting appliances and loose gear.

(2) Lifting appliances are cargo gears and cargo ramps include their installations of driving systems and cargo fittings.

(3) Cargo gears are cranes, cargo lifts and other machinery used for the loading and unloading of cargo and other articles except cargo ramps, and include their installations of driving systems and cargo fittings.

(4) Structural members are those of cargo handling appliances carrying the safe working load, including cargo fittings and cargo blocks permanently incorporated in the cargo gear and the cargo ramps.

(5) Cargo fittings are goose neck brackets, topping brackets, fittings at the derrick boom head, derrick heel lugs, guy cleats, eye fittings, etc. which are permanently fitted to the structural members or the hull structure for the purpose of cargo handling.

(6) Loose gears are blocks, ropes, chains, rings, hooks, shackles, swivels, clamps, grabs, lifting magnets, spreaders, etc. which are removable parts used for transmitting the loads of cargo to the structural members.

(7) Safe working load is the maximum allowable mass of cargoes specified by the Rules with which the cargo gear and the cargo ramp can be safely operated. It is abbreviated to "*SWL*" and expressed in *tons* (*t*)

(8) Maximum slewing radius is the radius at which a jib crane is permitted to operate under the safe working load, and expressed in *meters* (*m*).

(9) Safe working load, etc. are safe working load, maximum slewing radius and other restrictive conditions in case of the jib cranes, safe working load and other restrictive conditions deemed necessary by the Society in case of other machinery used for the loading and unloading of cargo, and safe working load and other restrictive conditions deemed necessary by the Society in case of the cargo ramps.

(10) Safe working load of a loose gear is the maximum allowable mass of cargoes specified by this chapter with which the loose gear can be used safely. It is abbreviated to "*SWL*" and expressed in *tons* (*t*). For sheave blocks, the safe working load is defined according to **(a)** or **(b)** below:

   (a) The safe working load of a single sheave block is the maximum mass of cargoes that can be safely lifted by that block when it is suspended by its head fitting and the mass is secured to a wire rope passing round its sheave.

(b) The safe working load of a multiple sheave block is the maximum mass of cargoes that may be applied to its head fitting of the block.

(11) Cranes cover jib cranes, gantry cranes, overhead cranes and hoists, cargo davits, etc. and are capable of performing the works of cargo or goods loading and unloading, slewing and/or horizontal movement simultaneously or separately.

(12) Cargo lifts are the installations designed to contain the cargo or goods including provisions, in their main structure for loading and unloading the cargo or goods including provisions.

(13) Cargo ramps are the installation mounted on the shell or provided in the ship, and arranged to permit passage of vehicles, etc. as cargo or vehicles, etc. loaded with cargo or goods on themselves and having mechanism enabling its opening and closing or turning.

(14) Lifting load is the sum of the safe working load defined as the maximum mass of cargoes themselves to be suspended and the mass of accessories such as hooks, cargo blocks, grabs, buckets, lifting beams, spreaders, etc. Unless otherwise deemed necessary by the Society, the mass of wire ropes used as cargo falls need not be taken into account except when the installation is designed for a lift of 50 *m* or more.

(15) The acceleration of gravity is to be equal to 9.81 m/sec^2.

6.1.3 Arrangement

1 The arrangement and dimensions of the cargo gear and the cargo ramps are to be determined with due consideration given to avoid interference with manoeuvring lights, navigation lights and other functions of the ship.

2 When same parts of the cargo gear are utilized commonly for other functions, such as ventilators, or important systems or equipment designed for other purposes, or further, when some systems or equipment for other purposes are mounted on them, due considerations are to be given to avoid undue interference with each other in relation to their functions and strength.

3 When any parts of the cargo gear and the cargo ramps project beyond the ship's side under the working condition, it is recommended that such parts are to be of retractable, foldable or removable type designed for stowing within the line of ship's side when not in use.

4 The cargo gear and the cargo ramps are to be provided with equipment for securing the movable parts when not in use.

6.1.4 General Construction

1 The cargo gear and the cargo ramps other than those used ordinary trim and heel in calm weather and sea states are to comply with, in addition to the requirements in the Rules, such additional requirements as considered appropriate by the Society for the actual working condition.

2 The requirements in **6.2** and **6.4** assume the use of hull structural rolled steels specified in **2.1.2, Part 3**. High tensile steels used in the structural members, if any, are to comply with requirements specially made up by the Society. The construction and dimensions of the structural members containing or made of materials other than those steel specified are to be specially considered by the Society.

3 The structural members are to be designed to avoid structural discontinuities and abrupt change of sections as far as practicable. The welded joints are to be arranged to avoid the parts where concentration of stress is expected.

4 Corners of openings in the structural members are to be appropriately rounded off.

5 Openings causing dimensional anisotropy in the structural members are to be so arranged as their long sides or long axes may assume parallel to the direction of principal stresses.

6 Where two members having remarkably different stiffness are directly connected with each other, proper reinforcement is to be made by means of brackets, etc. to maintain the continuity of stiffness. Special consideration is to be given to the connection to the hull structures.

6.1.5 Prevention of Corrosion

1 The structural members are to be protected against corrosion with coating of a good quality or using other proper means.

2 Any parts liable to the accumulation of rainwater or dew condensation are to be provided with proper draining means.

6.2 Canes

6.2.1 Design Loads

1 Load Considerations

The loads to be taken into the calculation of dimensions of structural members are to be those related to the crane concerned among the items enumerated from **(1)** to **(11)** below:

(1) Safe working load of the cranes
(2) Additional impact loads
(3) Self-weight of crane system and cargo fittings attached thereto
(4) Self-weight of loose gear
(5) Friction of cargo blocks
(6) Horizontal forces
(7) Wind loading
(8) Buffer forces
(9) Loads due to ship inclination
(10) Loads due to ship motion
(11) Other loads considered necessary by the Society

2 Additional Impact Loads

(1) The additional impact load is to be the product of the hoisting load and the impact load coefficient given in **Table 6.6.1** depending on the type of cranes. When the stress due to hoisting of cargo and the stress due to the self-weight have different signs in a member, 50 % of additional impact load is to be taken into account in addition to the self-weight, considering the shock due to unloading.

(2) Notwithstanding the requirements specified in **(1)** above, additional impact load coefficient based on actual measurements taking into account the hoisting speed, deflections of girders, length of ropes, etc. may be used in place of the values given in **Table 6.6.1**.

Table 6.6.1 Additional Impact Load Coefficient

Types of cranes	Additional impact load coefficient
Provision handling crane, Machinery handling crane, Maintenance crane and Hose handling crane	0.10
Jib crane and gantry crane for cargo handling	0.25
Jib crane and gantry crane occasionally used with hydraulically operated of rope-operated bucket, etc. for cargo handling	0.40
Jib crane and gantry crane always using grab, lifting magnet, etc. for cargo handling and Offshore jib crane	0.60

3 Friction of Cargo Blocks

In calculating the load at the rope end, the following friction load coefficients are to be taken into account depending on the types of bearing:

Bush bearing: 0.05
Roller bearing: 0.02

4 Horizontal Forces

(1) In track-mounted cranes, the transverse forces due to travel motion are to be taken into consideration as a factor of horizontal force in addition to the inertial force and centrifugal force.

(2) The inertial force is to be obtained by multiplying the sum of the mass of the moving parts and the hoisting load (in slewing motion, the load is assumed to be at the top of jib) by the following coefficient depending on the condition of motion. In the case of travelling by driven wheels, however, this inertial force need not exceed 15 % of the driving wheel load.

Level luffing motions : $0.01\sqrt{V}$

Traversing or travelling motions : $0.008\sqrt{V}$

Slewing motions : $0.006\sqrt{V}$

where

V : Velocity of motion concerned to be determined by the designer (m/min)

(3) Notwithstanding the requirements in **(2)** above the values of the actual acceleration deceleration characteristics, the actual braking time, etc. for the mode of motion concerned may be used as the inertial forces, if such values are known.

(4) For a system having structural members, which will make slewing motions while supporting the safe working load, the centrifugal force determined from following formula is to be taken into consideration.

$\frac{Wv^2}{R}(kN)$

where

W : Safe working load (t)

R : Slewing radius (m)

v : Circular speed (m/sec)

(5) The transverse force due to travel motions is to be calculated from the following formula:

λD (kN)

where

D : Wheel load (kN)

λ : Transverse force coefficient to be determined from the following formula depending on the value of l/a. However, λ need not exceed 0.15:

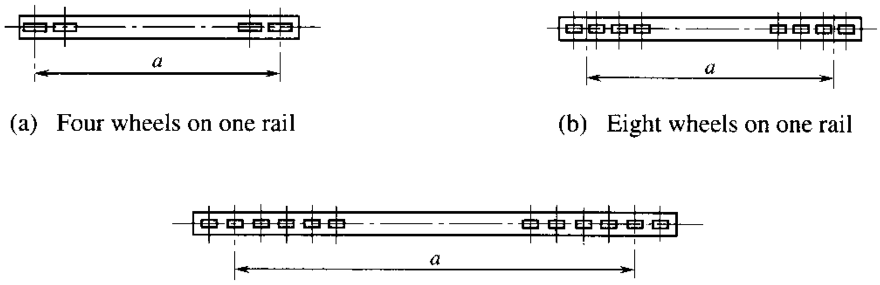
0.05 for $\frac{l}{a} \leq 2$

$\frac{1}{60}\left(\frac{l}{a}+1\right)$ for $\frac{l}{a} > 2$

l : Span of rails (m)

a : Effective wheel base to be determined according to **Fig. 6.6.1** (m)

Fig. 6.6.1 Measurement of Effective Wheel Base



(a) Four wheels on one rail (b) Eight wheels on one rail

(c) More than eight wheels on one rail

5 Wind Loading

(1) The wind loading is to be calculated by the following formula:

$F=PA\times 10^{-3}$ (kN)

where

F : Wind loading (kN)

A : Sum of structural members and cargo under wind pressure in projection in respective wind direction, corresponding to respective conditions of the cargo gear (m^2). When a girder is wholly or partly protected from wind by another girder, the areas of the superposed portions may be multiplied by the reduction factor (η) obtained from **Fig. 6.6.2**. The distance b between girders is to be as given in **Fig. 6.6.3**.

P : Wind pressure calculated by the following formula (Pa).

$\frac{1}{16}C_h C_s g V^2 (Pa)$

where

V : Wind velocity according to **(a)** and **(b)** below (m/sec):

(a) The velocity of wind giving effect on the structural members and cargo in the service conditions is to be the design wind velocity specified by the applicant, but not be less than 16 m/sec.

(b) The velocity of wind giving effect on the structural members in the stowage conditions is to be the design wind velocity specified by the applicant. In no case is the design wind velocity to be less than 51.5 m/sec. In ships with restricted navigation areas, however, the design wind velocity may be decreased according to the degree of restriction as approved by the Society in the range down to 25.8 m/sec.

C_h : "Height factor" to be determined according to **Table 6.6.2** depending on the height of the position is question from the lightweight waterline.

C_s : "Shape factor" to be determined according to **Table 6.6.3** depending on the shapes of various parts of the cargo gear and the cargo.

(2) Notwithstanding the requirements in **(1)** above, the data on wind loading obtained by wind tunnel tests for the structural members and cargo may be used for calculations.

Fig. 6.6.2 Repleteness Ratio, ϕ versus two Neighbouring Reduction Factor, η

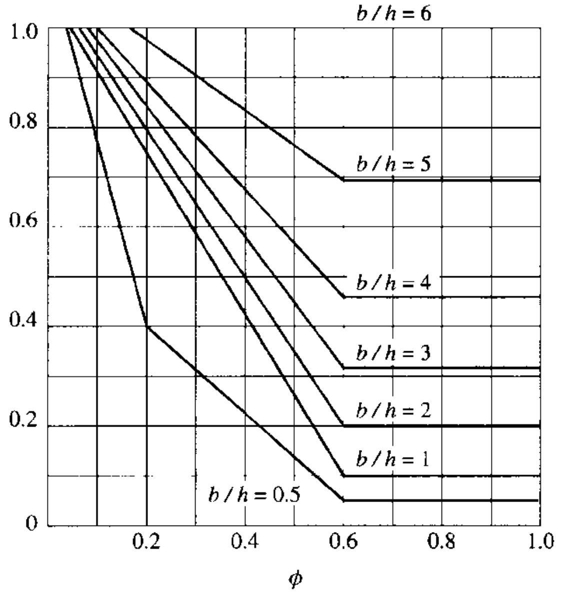
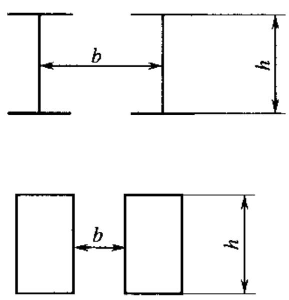


Fig. 6.6.3 Distance between Girders, b



6 Buffer Forces

(1) The buffer forces are assumed to be the loads in the crane system originating from collision with buffer at a speed equal to 70 % of the rated speed when no cargo is suspended from the crane. In a crane system having a rigid guide, etc. to limit the swinging of suspended cargo due to collision, the influence of the cargo weight is also to be taken into consideration.

(2) Notwithstanding the requirement in **(1)** above, in a crane system designed to be automatically decelerated before colliding the buffer, the speed after deceleration may be regarded as the rated speed in the requirement in **(1)**.

7 Loads due to Ship Inclination

The angles of inclination used for the calculation of loads due to ship inclination are not to be less than the values specified below:

However, provided data on the angle of inclination of the ship concerned is submitted and is deemed appropriate by the Society, those values may be used.

In service conditions: 5 *degrees* in angle of heel and 2 *degrees* in angle of trim occurring simultaneously

In stowage conditions: 30 *degrees* in angle of heel

8 Loads due to Ship Motion

The accelerations used for the calculation of loads due to ship motion are the severest of the combinations **(1)** or **(2)** below for the stowage condition, and values recognized by the Society to be appropriate for the service condition. If data on the ship's motions are submitted and recognized by the Society to be appropriate, the values in such data may be used in the calculations.

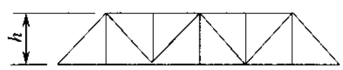
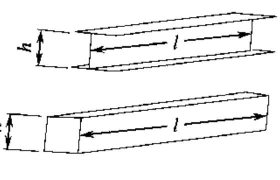
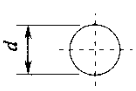
(1) ±1.0 g in the direction normal to the deck and ±0.5 g in the longitudinal direction parallel to the deck

(2) ±1.0 g in the direction normal to the deck and ±0.5 g in the transverse direction parallel to the deck

Table 6.6.2 Height Factor C_h

Vertical height h (m)	C_h
h<15.3	1.00
15.3≤h<30.5	1.10
30.5≤h<46.0	1.20
46.0≤h<61.0	1.30
61.0≤h<76.0	1.37
76.0≤h	Value as considered appropriate by the Society

Table 6.6.3 Shape Factor C_s

Type of area under wind pressure			C_s
Truss of angle		$\phi < 0.1$	2.0
		$0.1 \leqq \phi < 0.3$	1.8
		$0.3 \leqq \phi < 0.9$	1.6
		$0.9 \leqq \phi$	2.0
Plate girder or Box girder		$\frac{l}{h} < 5$	1.2
		$5 \leqq \frac{l}{h} < 10$	1.3
		$10 \leqq \frac{l}{h} < 15$	1.4
		$15 \leqq \frac{l}{h} < 25$	1.6
Cylindrical member or truss of cylindrical member		$d \ q < 1.0$	1.2
		$1.0 \leqq d \ q$	0.7

Notes:

ϕ : Repleteness ratio equal to the ratio of projected area under wind pressure to the projected area surrounded by the outer contour of the area under wind pressure

l : Length of plate girder or box girder (m)

h : Height of plate girder or box girder looked at from windward (m)

d : Outer diameter of cylindrical member (m)

q : Value calculated by the following formula:

$\frac{1}{16} C_h \cdot gV^2 \times 10^{-3} (kPa)$

9 Load Combinations

(1) The load to be used in the strength analysis of structural members is to be such a combined load that these members may be put in the severest loading condition considering the loads specified in **(2)** through **(4)** below.

(2) When the wind loading is not taken into account in service condition, the sum of loads from **(a)** to **(i)** below multiplied by a work coefficient given in **Table 6.6.4** according to the type of crane concerned is to be considered.

(a) Safe working load of the cranes
(b) Additional impact loads
(c) Self-weights of crane system and cargo fittings attached thereto
(d) Self-weights of loose gear
(e) Friction of cargo blocks
(f) Horizontal loads
(g) Loads due to ship inclination
(h) Loads due to ship motion (except those intended to cargo handling in harbours only)
(i) Other loads considered necessary by the Society

(3) When the wind loading is to be taken into consideration in the service conditions, the wind loading is to be added to the design load as specified in **(2)** above.

(4) In stowage condition, the loads from **(a)** to **(e)** below are to be considered

(a) Self-weights of crane system and cargo fittings attached thereto
(b) Wind loading in the stowage conditions
(c) Loads due to ship inclination in the stowage conditions
(d) Loads due to ship motion stowage conditions
(e) Other loads considered necessary by the Society

Table 6.6.4 Work Coefficient of Crane Systems

Type of crane	Work coefficient
Provision handling crane, Machinery handling crane, Maintenance crane and Hose handling crane	1.00
Jib crane and gantry crane for cargo handling	1.05
Jib crane and gantry crane occasionally used with hydraulically operated or rope-operated bucket, etc. for cargo handling	1.10
Jib crane and gantry crane always using grab, lifting magnet, etc. for cargo handling and Offshore jib crane	1.20

6.2.2 Strength and Construction

1 General

(1) The strength of structural members is to be analyzed on the load conditions specified in **6.2.1-9** to determine their dimensions according to requirements in **6.2.1-2** through **6.2.1-9**.

(2) For structures connected by bolts and nuts, proper considerations are to be given to the decrease of effective sectional areas.

(3) When considered necessary the Society may require the confirmation of the appropriateness of strength analyses by examination of models or the things in question.

2 Allowable Stress for Combined Loads

(1) The allowable stress given in **Table 6.6.5** are to be used for components subjected to combined loads.

(2) The strength of the fixed posts are to be according to **3.3.2 of the Rules for Cargo Handling Appliances**.

3 Buckling Strength

For members subjected to compression, the values obtained from the following formula are not to exceed the allowable compressive stress given in **Table 6.6.5**.

$\omega\sigma_c$ (N/mm^2)

where

ω and σ_c : As specified in **3.4.3 of the Rules for Cargo Handling Appliances**

Table 6.6.5 Allowable Stress σ_a

Load Condition	Kind of stress					
	Tension	Bending	Shear	Compression	Bearing	Combined stress
Condition specified in **6.2.1-9(2)**	$0.67\sigma_y$	$0.67\sigma_y$	$0.39\sigma_y$	$0.58\sigma_y$	$0.94\sigma_y$	$0.77\sigma_y$
Condition specified in **6.2.1-9(3)**	$0.77\sigma_y$	$0.77\sigma_y$	$0.45\sigma_y$	$0.67\sigma_y$	$1.09\sigma_y$	$0.89\sigma_y$
Condition specified in **6.2.1-9(4)**	$0.87\sigma_y$	$0.87\sigma_y$	$0.50\sigma_y$	$0.76\sigma_y$	$1.23\sigma_y$	$1.00\sigma_y$

Notes:

1. σ_y: The yield point or proof stress of material (*N/mm*^{2})
2. The combined stress is to be the value obtained from the following formula:

$\sqrt{\sigma_x^2 + \sigma_y^2 - \sigma_x\sigma_y + 3\tau_{xy}^2}$ (*N/mm*^{2})

where

σ_x : Applied stress in *x*-direction at the middle of plate thickness (*N/mm*^{2})

σ_y : Applied stress in *y*-direction at the middle of plate thickness (*N/mm*^{2})

τ_{xy} : Applied shear stress in the *x*-*y* plane (*N/mm*^{2})

4 Combined Compressive Stress

When the compressive stress of a member is determined as a combination of compressive stress due to axial compression and that due to bending moment such a compressive stress is to comply with the following formula:

$$\frac{\sigma_c}{\sigma_{ca}} + \frac{\sigma_b}{\sigma_a} \leq 1.0$$

where

σ_b : Compressive stress due to bending moment (*N/mm*^{2})

σ_c : Compressive stress due to axial compression (*N/mm*^{2})

σ_a : Allowable bending stress given in **Table 6.6.5** (*N/mm*^{2}). For fixed posts at the base, however, the allowable stress σ_a in **Table 6.6.6** is to be used.

σ_{ca} : Allowable compressive stress given in **Table 6.6.5** (*N/mm*^{2}). For fixed post at the base, however, the allowable stress (*N/mm*^{2}) is to be taken equal to the allowable stress in **Table 6.6.6** divided by 1.15.

Table 6.6.6 Allowable Stress σ_a

Safe working load W (t)	Allowable stress σ_a (N/mm^2)
W<10	$0.50\sigma_y$
10≤W<15	$(0.016W+0.34)\ \sigma_y$
15≤W<50	$0.58\sigma_y$
50≤W<60	$(0.005W+0.33)\ \sigma_y$
60≤W	$0.63\sigma_y$

Note: σ_y : The yield point or proof stress of material (N/mm^2)

5 Fatigue Strength

Where the influence of repeated stress cannot be neglected, the member is to have an ample strength against fatigue with due consideration for the magnitude and frequency of repeated stress, the form of the member in question, etc.

6 Minimum Thickness

The thickness of structural members is not to be less than 6 *mm*.

7 Strength of Bolts, Nuts and Pins

Bolts, nuts and pins are to have sufficient strength for the magnitudes and directions of the loads they are subjected to.

8 Fixed Posts

(1) The fixed posts are to be effectively connected to the hull structure in accordance with the requirements in **3.3.4-1 of the Rules for Cargo Handling Appliances**.

(2) The upper part of fixed post where the flange is attached is to be sufficiently reinforced by increasing the plate thickness or by providing of brackets.

9 Slewing-ring Fixing Bolts

(1) Any material having a tensile strength exceeding 1.18 kN/mm^2 and yield stress exceeding 1.06 kN/mm^2 is not to be used for the bolts fixing the slewing-rings except when special considerations have been given to the strength characteristics of the bolts.

(2) Special considerations are to be given to the tightening force of fixing bolts.

(3) The stress generated in fixing bolts is not to exceed the allowable stress given in **Table 6.6.7** according to the load conditions specified in **-9**. In this case, the stress in bolts is taken as the value of the axial compression determined by the following formula divided by the minimum sectional area of fixing bolts.

$$\frac{4M}{D \cdot N} - \frac{W}{N} (N)$$

where

M : Upsetting moment ($N \cdot mm$)

D: Pitch circle diameter of fixing bolts (mm)

N: Number of fixing bolts

W: Axial compression on the slewing-ring (N)

Table 6.6.7 Allowable Stress of Fixing Bolts σ_a

Load condition	σ_a
Condition specified in **4.2.9-2** and -3	$0.4\sigma_y$
Condition specified in **4.2.9-5**	$0.54\sigma_y$

Note:

σ_y : The yield point or proof stress of the material (N/mm^2)

6.3 Machinery, Electrical Installations and Control Engineering Systems

6.3.1 General

1 Application

The requirements in this Section apply to the machinery, electrical installations and control engineering systems used in the cargo handling appliances. However, in applying the requirements in this Section to winches used for cargo ramps, they may be suitably modified.

6.3.2 Machinery

1 General

The driving systems of the cargo handling appliances are to be steadily operated at the rated speed under the safe working load.

2 Hoisting Machinery

(1) The construction of the hoisting machinery is to comply with the following requirements **(a)** through **(f)**:

(a) The drum end flange diameter is to have an allowance corresponding to not less than 2.5 times the rope diameter as measured from the outer rim of the outermost layer of ropes in service condition. However, where rope disengagement prevention system is provided or in case of single layer winding on the drum, this requirement may be dispensed with.

(b) The pitch circle diameter of winch drum is to be not less than 18 times the rope diameter.

(c) Winches are to be installed on the winch foundation with foundation bolts having sufficient proof strength against the drum load (the maximum rope tension applied on the drum when the rope is wound under the single winding at a nominal rope hoisting speed) created when the safe working load is applied to the cargo handling appliances.

(d) Braking system complying with the following requirements **i)** through **iii)** is to be provided:

i) The braking system is to be able to exert a breaking torque 50 % in excess of the torque required when the safe working load is applied to the cargo handling appliances.

ii) The power operated braking system is to operate automatically when the manoeuvring is returned to its neutral position.

iii) The power operated braking system is to operate automatically when there is any failure in the power supply. In this case, emergency retrieval for cargo lowering is to be provided.

(e) Clutchable drums are to be provided with effective locking system capable of restricting rotation of the drum. The locking system is be, as a rule, capable of resisting the torque not less than 1.5 times the torque required when the safe working load is applied to the cargo handling appliances.

(f) Rope guards or suitable other means of protection are to be provided.

(2) The rope at its end is to be secured to the drum in such a manner that will not damage any part of the rope and to have such a length that not less than 3 complete turns in case of an ungrooved drum, or 2 complete turns in case of a grooved drum are remaining on the drum when the complete working length of rope has been paid out.

6.3.3 Power Supply

1 General

(1) The equipment, piping and cables consisting of the electric, hydraulic, pneumatic or steam power supply system and their arrangements are, as a rule, to comply with the relevant requirements of **the Rules for the Survey and Construction of Steel Ships**.

(2) The construction, dimensions, materials, etc. of internal combustion engine used as the prime mover are to comply with the requirements in **Part D of the Rules for the Survey and**

Construction of Steel Ships.

6.3.4 Control Engineering Systems

1 General

(1) The electric, hydraulic or pneumatic equipment used for the control, alarm and safety systems are, as a rule, to comply with the relevant requirements of **the Rules for the Survey and Construction of Steel Ships**.

(2) The control, alarm and safety systems are to be designed on the basis of the principle of fail-safe.

2 Control System

(1) Control systems are to be so arranged as not interfere with the operator or qualified other personnel giving signals for operation.

(2) Control systems are, as a rule, to be of such design that controls automatically return to the neutral position when control operation by the operator is interrupted.

(3) For electric winches, local power disconnecting switch is to be provided at the position in the proximity of the place of operation.

(4) Cranes and cargo lifts are to be provided with emergency switch capable of stopping all the motions at the position readily accessible for the operator.

(5) Cargo lifts are to be provided with a suitable automatic speed control system that reduces the starting acceleration and stopping deceleration as far as practicable.

(6) Cargo lifts are to be provided with a suitable control system that stops the lift at the specified deck position.

(7) Where cargo lifts are secured by locking latches, suitable means is to be provided so as to prevent the impact load to be induced on the lift in case of withdrawal of the latches.

3 Safety System

(1) The cargo handling appliances are, as a rule, to be provided with an overload protection system.

(2) The cargo handling appliances are to be provided with suitable safety systems capable of preventing the abnormalities given in the following **(a)** through **(d)** according to kind of appliances and their motion:

(a) Over hoisting
(b) Over slewing
(c) Over luffing
(d) Other items of abnormality recognized by the Society

(3) In cranes where the safe working load varies according to the operating radius, rating chart showing the relationship between the operating radius and safe working load are to be provided in the control cab and in addition, equipment satisfying the following **(a)** and **(b)** or **(c)** is, as a rule, to be provided:

(a) Operating radius indicator
(b) Hoisting load indicator
(c) Overload preventor with respect to the safe working load according to the operating radius

4 Protection System

(1) For the rotating parts of the driving machinery, electrical installations and steam pipes, necessary means to protect the operator are to be provided.

(2) Steam winches are to be arranged not to interfere with the operator's field of vision by the steam.

(3) Cargo lifts are to be provided with the protection systems given in the following **(a)** through **(d)**:

(a) Protective barriers of a height of not less than 1 *m* above deck level around the deck opening provided for lift platform.

(b) Interlocking system so that cargo lifts cannot be moved unless the barriers are all closed.

(c) Interlocking system that prevents opening of protective barriers unless cargo lifts are at the opening position of the barriers.

(d) Warning lights or suitable other warning signs at the boarding place of cargo lifts.

6.4 Cargo Lifts and Cargo Ramps

6.4.1 Application

Cargo lifts and cargo ramps to be installed to the Governmental and Naval Ships are to be applied with the requirements of **Chapter 8, Cargo Lifter and Cargo Lifter, of the Rules for Cargo Handling Appliances**.

6.5 Certification, Marking and Documentation

6.5.1 General

1 Application

The requirements in this Section apply to the certification, marking and documentation of the cargo handling appliances.

6.5.2 Assignment of Safe Working Load, etc.

1 General

The Society assigns the safe working load, etc., for the cargo handling appliances that have passed the inspection and load tests specified in **2.1.4-4, Part 2**.

2 Duplicated Assignment of Safe Working Load, etc.

The Society will assign, at the application of the shipowner, the following **(1)** in addition to the safe working load, etc. in accordance with the requirements in **6.5.2-1**:

(1) The maximum load corresponding to a radius exceeding the assigned maximum slewing radius in case of jib cranes

6.5.3 Marking of Safe Working Load, etc.

1 Marking for Cargo Gear and Cargo Ramps

(1) On the cargo gear and cargo ramps assigned by the requirements specified in **6.5.2** above, the safe working load, allowable minimum angle, maximum slewing radius and other restrictive conditions are to be marked by using stamps in accordance with the following requirements in **(a)** and **(b)**:

(a) Jib cranes

At the conspicuous place of the base of jib or the similar position, the stamp mark of the Society, the safe working load, the maximum slewing radius and other restrictive conditions are to be marked.

(b) Other cargo gear and cargo ramps

At the conspicuous place which is hardly fouled, the stamp mark of the Society, the safe working load and other restrictive conditions are to be marked.

(2) In the case of the duplicated assignment of safe working loads are assigned to jib cranes in accordance with the requirements of **6.5.2-2**, the necessary markings for respective combinations are to be made correspondingly according to the requirements of **(1)** above.

(3) For the cargo gear which is used with grabs, lifting beams, lifting magnets, spreaders and similar other loose gear and assigned the maximum cargo load excluding the self-weight of such loose gear to safe working load, the notation in this connection to be marked as other restrictive conditions correspondingly according to **(1)** above.

(4) The stamp marks, according to **(1)**, **(2)** and **(3)** above**,** are to be coated with anti-corrosive paint and framed with paint for easy recognition.
(5) In addition to the stamp marks specified in **(1)**, **(2)** and **(3)** above, the same markings (except for the stamp mark of the Society) are to be made so as to be permanently and easily visible at conspicuous places using welded bead and paint or methods recognized by the Society to be equivalent.
(6) The size of the letters used in the markings specified in **(5)** above is not to be less than 77 *mm* in height.

2 Marking for Loose Gear

(1) On the loose gear other than wire ropes and fibre ropes, the test load, the safe working load and the identification symbols are to be marked by using stamps at the conspicuous place and no adverse effects are to be caused for both their strength and service. On grabs, lifting beams, lifting magnets, spreaders and similar other loose gear, the self-weight of them are to be stamped additionally.
(2) The stamp marks, according to **(1)** above**,** are to be coated with anti-corrosive paint and framed with paint for easy recognition.
(3) In addition to the markings specified in **(1)** above, grabs, lifting beams, lifting magnets, spreaders and similar other loose gear are to be marked with the safe working load and the self-weight of them with paint, etc. In this case the size of letters should not be less than 77 *mm* in height.
(4) Notwithstanding the requirements in **(1)** and **(3)** above, where it is difficult to make direct stamp mark or marking with paint, other means may be taken when approved by the Society.

6.5.4 Documentation

1 Kinds of Documents

The kinds of the documents issued by the Society for cargo gears, cargo ramps and loose gear are to be as specified in the followings:

(1) Register of Ship's Lifting Appliances and Items of Loose Gear (*ILO Form 1*) (CG.1)
(2) Certificate of Test and Thorough Examination of Cranes or Hoists and their Accessory Gear (*ILO Form 2*) (CG.3)
(3) Certificate of Test and Thorough Examination of Cargo Lifts/Cargo Ramps and their Accessory Gear (CG.3LR)
(4) Certificate of Test and Thorough Examination of Loose Gear (*ILO Form 3*) (CG.4)
(5) Certificate of Test and Thorough Examination of Wire Rope (*ILO Form 4*) (CG.5)

2 Timing of Issuance of Documents

The timing of issuance of documents specified in **-1** above is to be as given in **Table 6.6.8** depending on the tests and survey.

Table 6.6.8 Timing of Issuance

Kind of Documents		Timing of Issuance
A	Document in **6.5.4.1(1)**	When the application for assignment is made and the ship passes the Registration Survey for the first time
B	Document in **6.5.4.1(2)**	(1) When Category *A* applies. (2) When the cargo handling appliances that are installed additionally pass the Registration Survey (3) When the safe working load, etc. is altered (4) When the ship passes the load tests specified in **2.1.4-4, Part 2**
	Document in **6.5.4.1(3)**	
C	Document in **6.5.4.1(4)**	(1) When Category *A* applies. (2) When the cargo handling appliances that are installed additionally pass the Registration Survey (3) When loose gear is replaced or repair at time of the Periodical Surveys and the Occasional Survey, or autonomous inspection took place in accordance with **3.5, Part 2**, and when the contents of autonomous inspection is recognized appropriate by the Society
	Document in **6.5.4.1(5)**	

3 Revocation of the Documents

(1) The whole or part of the certificates specified in **-1** above will be revoked when either of the following **(a)** through **(i)** is relevant:

(a) When application is made by the shipowner for cancellation or alteration of the assignment of the safe working load, etc.
(b) When the construction, arrangement or rigging of the cargo handling appliances are altered
(c) When the cargo handling appliances are removed
(d) When the surveys specified in **3.5** and **5.6, Part 2** are not subjected to
(e) When the cargo handling appliances are considered to be unserviceable by the Surveyor
(f) When the contents the certificates are intentionally altered
(g) When the contents in the certificates have become illegible due to foul or damage
(h) When the specified fee covering the survey is not paid
(i) In case where the Society has a doubt on the effectiveness of the certificates, etc.

(2) The certificates which become invalid in accordance with the provisions in **(1)** above are to be returned to the Society without delay.

4 Reissuance and Corrections of Documents

In case where the certificates, etc. become invalid in accordance with the provisions of the preceding **-3(1)** above or lost, the Society will reissue the certificates or make necessary corrections thereto depending on the circumstances involved.

6.5.5 Preservation of Documents

1 General

The Certificates issued depend on the requirements in **6.5.4** above by the Society and the instruction manual for cargo handling appliances are to be preserved aboard the ship or by shipowner's responsible person in case of towing boat not manned.

2 Instruction Manual

The instruction manual mentioned in **-1** above is to note essential items necessary for operation and maintenance of the cargo handling appliances among those given in the following **(a)** through **(h)**:

(a) General arrangement of cargo gear and cargo ramps
(b) Arrangement drawing of loose gear (including rigging arrangement)
(c) List of loose gear
(d) Design conditions (including safe working load, wind speed, trim and heel of ship, etc.)

(e) List of materials
(f) Operation manual (including functions of safety systems and protective systems)
(g) Load testing procedure
(h) Maintenance and control procedures

Chapter 7 MAST EQUIPMENT

7.1 General

7.1.1 Application

The requirements in this Chapter apply to the mast equipment equipped with instruments and antennas at a high place.

7.1.2 Terminology

The terms used in this Chapter are defined as follows:

(1) The enclosed mast is the mast whose support circumferences are enclosed by flat plates.

(2) The truss mast is the mast which utilizes the truss structure composed of members in a form of continuing triangle shapes. The standard structure of truss mast is three-dimension truss using 3-face or 4-face planar trusses.

(3) The pole mast is the mast composed of one pole and members or tension cables, which reinforce the pole.

7.2 Arrangements, Type and Shape, etc.

7.2.1 Arrangements, type and shape

The arrangement, type and shape of mast equipment are to be determined in accordance with the following requirements.

(1) In general, except for special cases, the position of mast is to be arranged on the midship line.

(2) In general, both ends of the mast yard are to be arranged inside of the plane 5° inwards with respect to the perpendicular from the hull's widest side of the maximum breadth.

(3) The mast is to be structure which has sufficient capabilities to exert their respective functions, for the antennas for radio equipment, electrical signal equipment, acoustic signal equipment, flag hoist gear, search lights, and navigation equipment, which to be installed on the mast.

(4) Disturbances of helicopter takeoff and landing, effective range of equipment in which radio wave and optical instruments are installed, and the view from the navigation bridge and bridge wings are to be minimal as possible.

(5) The mast is to be arranged in the position which considers relation to the funnel, so that smoke damage, heat damage, etc. to equipment, electric wires and signal flag are to be minimal as possible.

7.2.2 Ancillary Equipment

Mounts, seats, supporting ropes, cargo handling ropes (when also used as handling equipment), operation ropes and fittings, handrail equipment, ventilator head appliances (when also used as ventilation equipment), holding equipment installed to the means of access, fittings for replenishment at sea (*RAS*), full dressing ship, and other appliances are to be installed, as required.

7.3 Strength

7.3.1 Design Loads

The load specified below is to be applied to all structure members of mast and all installed equipment, and the maximum combination load is to be the design loads.

(1) Static load applied to the mast structure members and installed equipment in the vertical and horizontal directions at the time of roll and heave of ships.

(2) Inertial force applied to the mast structure members and installed equipment in the vertical

and horizontal directions at the time of roll and heave of ships.

(3) Wind pressure applied to the mast structure members and installed equipment.

7.3.2 Calculation Procedures

1 Enclosed Mast

(1) Bending stress of cantilever beams is to be calculated considering the stiffness of areas around connection. The calculation for buckling of flat plates and reinforcement resulting from bending stress are to be in according to the calculation method of hull structure members.

(2) The standard calculation method is to consider that the vertical wind pressure gives effect on the surface opposing to the specified wind direction.

2 Truss Mast

(1) The strength calculation is to be based on the entire mast as a steric rahmen structure. The load of members and equipment located between node points are to be distributed to both node points. The maximum load applied to the truss members is to be not more than 50% of buckling stress σ_{cr} determined by the following formula.

$$\sigma_{cr} = \frac{\pi^2 E}{(l/k)^2} \ (\sigma_{cr} < \frac{\sigma_y}{2}))$$

$$\sigma_{cr} = \sigma_y - \frac{(l/k)^2}{4\pi^2 E} \ {\sigma_y}^2 \ (\sigma_{cr} < \frac{\sigma_y}{2}))$$

where

σ_{cr} : Compressive buckling stress applied to the both ends supported and compressed long tubes with even cross sections (N/mm^2)

E : Modulus of longitudinal elasticity (N/mm^2)

ℓ : Length of long tube (mm)

k : Least radius of gyration of area (mm)

σ_y : Yield stress (N/mm^2)

(2) Round tubes are the standard members to be used for trusses. The round tubes tend to cause local buckling, therefore, appropriate reinforcement is to be required at node points of trusses and mounting positions of equipment.

(3) Axial force and shearing stress are to be considered on the hull of truss mast or mounting positions of superstructures.

3 Pole Mast

(1) Round tubes or polygonal tubes are to be used for the main mast. The main mast is to be installed in the way that its mounting part satisfies the fixation requirements by passing through the foundation structure or mounting appropriate support members.

(2) Mounting part of the main mast is to be deemed fixed appropriately when calculating its strength. When there are no reinforcement members or tension cables for the main mast, the maximum allowable stress is to be not more than 80 % of the yield stress of materials used, while it is to be not more than 50% when the reinforcement members or tension cables are available.

(3) The standard outer diameter of round tubes for main mast members is to be not more than 40 times these round tubes thickness.

(4) When tension cables are used as reinforcement, the cables are to be installed in a symmetrical arrangement about the mast centre line and initial tension needs to be given. The tension of the tension cables, including the initial tension, is not to be exceeding 40% of cable's breaking force.

7.4 Vibrations

7.4.1 General

1 In general, the mast structure is to be designed appropriately so that the structure does not synchronize with frequencies of the vibration sources.

2 As required, the mast structure is to be designed appropriately, considering the transient vibration caused by wave impacts and fluctuation force resulting from flutter.

Chapter 8 REPLENISHMENT AT SEAT (RAS) SYSTEM

8.1 General

8.1.1 General Application

1 The requirements in this Chapter apply to the equipment to be used to receive and supply solid goods such as provisions, fuels, freshwater, as well as personnel, between ships navigating at sea.

2 Procedures of replenishment at sea and the system of such equipment are to be in accordance with the requirements, etc. specified by the owners.

8.1.2 Terminology

The terms used in this Chapter are defined as follows:

(1) "Replenishment at sea" (hereinafter referred to as "*RAS*") means to receive and supply solid goods such as provisions, fuels, freshwater, as well as personnel, between ships navigating at sea.

(2) "*RAS* System" means the equipment and systems to be installed for *RAS*.

(3) "*RAS* Station" means the place of operation on the deck, etc. where receiving and supplying are conducted using the *RAS* system.

8.2 Arrangement

8.2.1 General

1 *RAS* stations are to be arranged considering the navigation bridge, means of access and hatches, *RAS* stations of the target ships for *RAS* at replenishment.

2 The operation areas of each *RAS* station are to be arranged appropriately to not interrupt the operation mutually, and the *RAS* station for fuels is, in general, to be installed separately from stations for personnel and solid goods.

3 Among the *RAS* stations, at least one station is to be located in the position directly monitorable from the navigation bridge, considering transportation of personnel.

4 Equipment, etc. of *RAS* system is to be arranged in the way that performance and operation of other equipment, etc. are not to be diminished when they are not in use for the replenishment.

5 Equipment, etc. of *RAS* system is to be arranged appropriately so that they do not interrupt passing personnel and operations when they are not in use for the replenishment. When such arrangement is unavoidable, the equipment is to be removable, with appropriate covers or equipped with guardrails.

6 *RAS* system is to be installed to fulfill the following conditions:

(1) For ships which are dedicated to replenishment (hereinafter referred to as "supplying ship")
- (a) In general, replenishment is to take place simultaneously for receiving ships on the both sides of the supplying ship.
- (b) Replenishment is to be carried out in as many *RAS* stations of receiving ships as possible on a simultaneous basis.
- (c) For oil filling stations, dual-hose supply systems, which allow supplying different types of fuel at the same station, may be adopted.

(2) Receiving ship
- (a) *RAS* system is to have a function to perform its tasks at both sides of a ship.
- (b) *RAS* is to be conducted at the *RAS* station only on one side.
- (c) *RAS* is to be made possible, on a simultaneous basis, at as many *RAS* stations as possible.
- (d) Transfer at sea is to be conducted at one *RAS* station.

(e) Force fitting system is to be the standard refueling system. Required hose connectors (probe coupling, flange coupling, etc.) are to be installed, each is replaceable.
(f) The pad eyes for transportation system are to be either one of liftable, fixed and retractable types.

8.3 Load

8.3.1 General

1 The load applies to the pad eyes and ring plates, etc. used for *RAS* system is to be calculated considering the navigation conditions and the maximum weight by the requirements, etc. specified by the owners.

2 Equipment of *RAS* system is to be protected from being damaged by blast pressure when not in use for the replenishment.

Chapter 9 HELICOPTER FACILITIES

9.1 General

9.1.1 Application

1 The requirements in this Chapter apply to helicopter facilities for ships of helicopter operations of class notation *HF* or *HD*.

2 The helicopter facilities provided for units are to be according to this Chapter. In addition, attention is to be paid to complying with the National Regulations of the flag state and the coastal state.

9.1.2 General

1 Facilities related to helicopters are to be designed appropriately so that the functions and performance of all taking-off and landing helicopters will not be interrupted, while allowing their functions to be exerted sufficiently.

2 Facilities related to helicopters are to be determined appropriately for safe, reliable and prompt operation for taking-off and landing of helicopters, transportation and tying down, maintenance and replenishment, etc.

9.2 Helideck Arrangement and Facilities

9.2.1 General

1 Arrangements of helideck are to be designed appropriately for influence, etc., of air turbulence caused by ship structure, etc., and thermal influence of exhausted gas from funnel.

2 In addition to having sufficient areas, the helideck is to be arranged in the space on the deck where the largest helicopters, which use this helideck, are able to safely take off and land.

3 In general, the surface of the helideck is to be a flat so that does not interrupt any markings visibility, taking-off and landing, transportation of helicopters and various other operations which may take place on the helideck. Even when it is unavoidable, the amount of protrusions is to be minimal as possible.

4 In general, the helideck is to have non slip paint on its surfaces.

9.2.2 Arrangement and Facilities

1 In general, helicopter recessed tie-down hardwares are to be installed at the taking-off and landing areas, hangar areas and standby areas, satisfying the following requirements.

(1) Arrangements are to be determined considering the layout of tie-down rings on their airframes and relationship between equipment and tie-down chains, etc.

(2) Strength is to be determined considering ship motion, wind pressure given to airframe and the layout of tie-down rings on the airframes, etc.

(3) When installing, the strength and water-tightness of decks and construction are to be maintained.

2 The periphery of the helideck is to be fitted with a safety net except where structural protection exists. For the net, the following requirements are to be complied with:

(1) Safety nets are to incline for approximately 5° in an outer upwards direction from the horizontal line and their outer edges are located below the slant line, which is 5° downwards from the horizontal line from the deck edge.

(2) Safety nets are to be installed in the way that its width is not less than 1,400 *mm* in the horizontal direction from the lower part of the helideck.

(3) Part of the safety net is not to be protruding upwards from the edge of helideck.

3 In general, the helideck is to have drainage systems. The drainage system is to have a function to drain sea water or other liquids directly to outboard without stagnation of such sea water or other liquids. In addition, measures are to be taken to prevent any liquids spilled on the decks from penetrating into any compartments, including hangar facilities, etc.

4 A helideck is to be provided with both a main and an emergency means of escape and access for firefighting and rescue personnel. These are to be located as far apart from each other as is practicable and preferably on opposite sides of the helideck.

5 Grounding equipment is to be provided in the taking-off and landing positions of helicopters and in the vicinity of hangar.

6 Wind Direction Indicator

(1) A wind direction indicator is to be located on the unit which, in so far as is practicable, indicates the wind conditions over the *TLOF*. The material, shape and colours, etc. of the wind direction indicator are to comply with the following **(a)** to **(c)**.
  (a) The wind direction indicator is to be made of lightweight fabric.
  (b) The shape of the wind direction indicator is to be a truncated cone. The minimum length of the truncated cone is to be 1.2 *m*, and the minimum diameters at the larger and smaller ends are to be 0.3 *m* and 0.15 *m*, respectively.
  (c) The colour of the wind direction indicator is to be a single colour, white or orange, so as to make it clearly visible and understandable from a height of at least 200 *m* above the heliport, having regard to background. However, where it is required to give adequate conspicuity against changing backgrounds, e.g. due to ageing, the wind direction indicator is to be of two colours. The following requirements **i)** and **ii)** are to be complied with.
    i) The combination of two colours is to be either orange and white or red and white.
    ii) The two colours specified in the preceding **i)** above are to be arranged in five alternate bands, the first and last band being the darker colour.

(2) The wind direction indicator is to be visible from a helicopter in flight or in a hover over the helideck. The wind direction indicator is to be located in such a way as to be free from the effects of airflow disturbances caused by nearby objects or rotor downwash.

(3) Where the *TLOF* may be subject to a disturbed air flow then additional wind direction indicators located close to the area are to be provided to indicate the surface wind on those areas.

(4) Ships on which night helicopter operations take place are to have provisions to illuminate the wind direction indicators.

7 The *TLOF* perimeter marking is to be located along the perimeter of the *TLOF* and is to consist of a continuous white line with a width of at least 0.3 *m*. However, when the owner so requests to adopt another way of marking without following this clause, such requirements of the owners are to be recorded and provided to the Society.

8 Touchdown/Positioning Marking

(1) A touchdown/positioning marking is to be located so that the following requirements **(a)** and **(b)** are complied with when the pilot's seat is over the marking.
  (a) The whole of the undercarriage is within the *TLOF*.
  (b) All parts of the helicopter are clear of any obstacle by a safe margin.

(2) In principle, the centre of the touchdown/positioning marking is to be concentric to the centre of the *TLOF*.

(3) A touchdown/positioning marking are to be a yellow circle and have a line width of 1 *m*. The inner diameter of the circle is to be half the D_H.

(4) When **(1)** to **(3)** above are not applied to the touchdown/positioning marking due to a request of the owner, such requirements of the owners are to be recorded and provided to the Society.

9 A heliport identification marking

A heliport identification marking is to be located at the centre of the touchdown/positioning marking specified in **-8** above. The heliport identification marking is to consist of a white "*H*" that is 4 *m* high, 3 *m* wide, with a stroke width of 0.75 *m*. However, when the requirements of identification markings specified in this clause above are not applied due to a request of the owner, such requirements of the owners are to be recorded and provided to the Society.

10 Ships Identification Markings

(1) The name of the ship is to be clearly displayed on unit identification panels located in such positions that the unit can be readily identified from the air and sea from all normal angles and directions of approach (*e.g.*, high up on the derrick). The height of the figures is to be at least 0.9 *m* with a line width of 0.12 *m*. The ship identification panels are to be highly visible in all light condition. Suitable illumination is to be provided for use at night and in conditions of poor visibility.

(2) In addition to the requirement of the preceding **(1)** above, the unit's name is to be provided on the helideck and be positioned on the obstacle side of the touchdown/positioning marking with characters not less than 1.2 *m* in height and in a colour contrasting with the background.

(3) When the requirements of ship identification markings specified in **(1)** to **(2)** above are not applied due to a request of the owner, such requirements of the owners are to be recorded and provided to the Society.

11 Perimeter Lights

(1) The perimeter of the *TLOF* is to be delineated by green lights visible omnidirectionally from on or above the landing area. These lights are to be above the level of the deck but are not to exceed 0.25 *m* in height for helidecks.

(2) The lights are to be equally spaced at intervals of not more than 3 *m* around the perimeter of the *TLOF*, coincident with the white line delineating the perimeter specified in **-7** above.

(3) In the case of square or rectangular decks there are to be a minimum of four lights along each side including a light at each corner of the *TLOF*.

(4) Notwithstanding the requirements of the preceding **(1)** to **(3)** above, flush fitting lights may be used at the inboard (150° limited obstacle sector origin) edge of the *TLOF* where there is a need to move a helicopter or large equipment off the *TLOF*.

(5) Perimeter lights are to meet the chromaticity characteristics given in **Table 6.9.1** and the vertical beam spread and intensity characteristics given in **Table 6.9.2**.

(6) When **(1)** to **(5)** above are not applied to perimeter lights due to a request of the owner, such requirements of the owners are to be recorded and provided to the Society.

Table 6.9.1 Perimeter Lighting Chromaticity

Boundary	Chromaticity
Yellow boundary	$x = 0.36 - 0.08y$
White boundary	$x = 0.65y$
Blue boundary	$y = 0.9 - 0.171x$

Note:
Both x and y are to be in accordance with the provisions of the *International Commission on Illumination* (*CIE*)

Table 6.9.2 Green Perimeter Lighting Intensity

Elevation	Intensity (*cd*)
Greater than 0° but not greater than 90°	60 or less
Greater than 20° but not greater than 90°	3 or more
Greater than 10° but not greater than 20°	15 or more
Greater than 0° but not greater than 10°	30 or more
Azimuth (-180° ~ +180°)	

Note:

a : If higher intensity lighting is provided to assist in conditions of poor visibility during daylight, it is to incorporate a control to reduce the intensity to not more than 60 *cd* for night use.

12 Helideck Floodlights

Helideck floodlights are to be located so as to avoid glare to pilots, and provision is to be made for periodically checking their alignment. The arrangements and aiming of floodlights are to be such that helideck markings are illuminated and that shadows are kept to a minimum. Floodlights are to conform to the same height limitations specified in **9.2.2-11(1)** for perimeter lights.

13 Obstacle Marking and Lighting

(1) Omnidirectional red lights of at least 10 *cd* intensity are to be fitted at suitable locations to provide the helicopter pilot with visual information on objects which may present a hazard to helicopters. Such lighting is to comply with the following requirements **(a)** and **(b)**. However, when deemed appropriate by the Society, alternative equivalent technologies other than those specified in **(a)** to **(b)** may be utilized.

(a) Objects which are more than 15 *m* higher than the helideck are to be fitted with intermediate red lights of the same intensity spaced at 10 *m* intervals down to the level of the helideck (except where such lights would be obscured by other objects).

(b) Structures such as towers may be illuminated by floodlights as an alternative to fitting the intermediate red lights, provided that such lights are arranged such that they will illuminate the whole of the structure and not interfere with the helicopter pilot's night vision.

(2) An omnidirectional red light of intensity 25 to 200 *cd* is to be fitted to the highest point of the ship.

14 Status Lights

Status lights are to be installed to provide warning that a condition exists on the unit which may be hazardous for the helicopter or its occupants. The status lights are to be a flashing red light (or flashing red lights), visible to the pilot from any direction of approach and on any landing heading. The system is to be automatically initiated when the toxic gas alarm is initiated as well as being capable of manual activation at the helideck. It is to be visible at a range in excess of the distance at which the helicopter may be endangered or may be commencing a visual approach.

15 Motion Sensing System

Ships are to be equipped with an electronic motion-sensing system capable of measuring or calculating the magnitude and rate of pitch roll and heave at the helideck about the true vertical datum.

16 Ships on which helicopter operations take place, as necessary, are to have arrested landing system, helicopter transportation system, *LSO* coordinate stations or helicopter coordinate stations, and helicopter maintenance equipment, etc., in the vicinity of helideck.

9.3 Helideck Strength

9.3.1 Design Loads

The design loads of helideck structure are to be whichever is greater of the following loads.

(1) Impact load at landing
The landing reaction force in each of the arrested landing and free landing is to apply to the helideck.

(2) Dynamic load of helicopter on the deck due to ship motion
When tying down helicopters with an arresting system or tie-down chains or transporting the helicopters, the loads given to the landing gears are to affect the deck due to ship motions, including rolling and pitching, etc. In addition, wind pressure is to be considered in the areas other than hangar facilities.

9.3.2 Members Scantling

1 The scantling of members of helideck structure is to be determined such that the loads specified in **9.3.1** above acts to the deck.

2 Allowable stress applied to the members of helideck structure is not to be more than the yield values of materials of the members.

9.4 Hangar Facilities (Helicopter Hangar)

9.4.1 General

1 The arrangement of helicopter hangar are to be determined sufficiently considering landing approach, transfer from the helideck to the hangar, tying- down and maintenance, etc.

2 The scantling of hangar is to be determined, in accordance with the types of helicopters, transportation and tying-down, as well as space required for maintenance within the hangar.

3 The floor deck in the hangar is to be designed in accordance with the requirements of helidecks.

4 As a rule, the entrance of hangar is to be equipped with shutters. The shutters are to be in accordance with the follows requirements:

(1) The size of shutters is to be determined by the types of helicopters and methods of transportation.

(2) As a rule, the shutters are to be slatted hoisting type.

(3) When the shutters are closed, weather tight conditions are to be referred to.

5 The design conditions for hangar shutters are to be in accordance with the follows requirements:

(1) Shutters in a closed situation are to withstand the wind pressure at a wind speed of 60 *m/s*

(2) As a rule, the average opening/closing speed is to be approximately 6.0 *m/min*

6 "NO SMOKING" or "NO FIRES" signs are to be displayed at appropriate locations.

7 Enclosed hangar facilities or enclosed spaces containing refueling installations are to be provided with mechanical ventilation. Ventilation fans are to be of non-sparking type.

8 Hangar is to be provided with fire-fighting Appliances specified in **9.6**.

9.5 Refueling Facilities for Helicopter Fuel Oil (*JP-5*)

9.5.1 General

1 Refueling facilities is to be capable of refueling and draining at both the helicopter taking-off and landing and standby positions.

2 The standard refueling methods are to be onboard pressure oiling and gravity oiling.

3 As a rule, the refueling oil capacity is to be capable of refueling approximately 2/3 of the capacity of fuel oil reservoir at the pressure required on the airframe side, within ten minutes.

4 The equipment of helicopter in flight refueling (*HIFR*) system is generally to be connected to the onboard refueling system when providing HIFR system.

5 Where portable fuel oil storage tanks are used, special attention is to be given to:
(1) Design of the tank for its intended purpose;
(2) Mounting and securing arrangements;
(3) Electric bonding; and
(4) Inspection procedures;
6 Storage tank fuel pumps are to be provided with means which permit shutdown from a safe remote location in the event of a fire. Where a gravity fed fueling system is installed, equivalent closing arrangements is to be provided to isolate the fuel source.
7 The requirements of helicopter fuel oil (*JP-5*) piping are to refer to **Chapter 11**.

9.6 Fire-fighting Appliances

9.6.1 General
1 The requirements in this Section are to apply to the fire-fighting appliances related to the helicopter facility.
2 In general, the fire-fighting appliances related to helicopter facility is to be equipped with fire extinguishing system with water jet type nozzles and water fog type nozzles, aqueous film forming foam fire extinguishing system and powder fire extinguishing system.
3 In general, crash crew waiting stations are to be located at a required area in the vicinity of helideck, which makes possible immediate damage control of helideck and hangars.
4 At least the following equipment is to be stored in a manner that provides for immediate use and protection from the elements:
(1) Fire-fighter's outfits
(2) Adjustable wrench;
(3) Blanket, fire resistant;
(4) Cutters, bolt 60 *cm*;
(5) Hook, grab or salving;
(6) Hacksaw, heavy duty complete with 6 spare blades;
(7) Ladder;
(8) Lift line 5 *mm* diameter x 15 *m* in length;
(9) Pliers, side cutting;
(10) Set of assorted screwdrivers; and
(11) Harness knife complete with sheath.

9.6.2 Fire-fighting Appliances
1 Fire extinguishing system with water jet type nozzles and water fog type nozzles
(1) Sea water for fire extinguishing system with water jet type nozzles and water fog type nozzles are to be supplied from fire hydrants which are provide inboard.
(2) In general, the nominal size of fire hydrants on the helideck is to be 65 *mm*. Fire hydrants are to be arranged appropriately so that water is to be discharged to fire at any area of the helideck by two 15 *m* canvas hoses connected at least one fire hydrant.
2 Aqueous Film Forming Foam Fire Extinguishing system
(1) As a rule, aqueous film forming foam fire extinguishing system extinguishers are to be installed to the helideck.
(2) Since simultaneous spraying of aqueous film forming form on the helideck and the helicopter hangar is not considered, the amount of undiluted solution of aqueous film forming form is to be whichever is greater of the amount for helideck or the hangar.
(3) The pumps for undiluted solution of aqueous film forming form and fire extinguishing booster pumps are to be remote controllable.

(4) The capacity of pumps for undiluted solution of aqueous film forming form solution is to be the amount whichever is greater of the capacity of pumps for solution of helideck, helicopter hangar or other compartments relevant to engine rooms, etc.
(5) The discharge pressure of pumps for undiluted solution of aqueous film forming form solution is to be the pressure higher than the sea water pressure used for fire extinguishing by 0.15 *MPa* at the inlet of regulation valves of proportional mixing unit.
(6) The pumps for undiluted solution of aqueous film forming form solution and fire extinguishing booster pumps are to be equipped with equipment which is capable of waiting operation.
(7) As a rule, the aqueous film forming foam fire extinguishing system are to be provided in the unexposed spaces where there is no risks of unacceptable hot air.

3 Powder Fire Extinguishing System

(1) As a rule, Powder fire extinguishing systems are to be provided for the helideck and helicopter hangars, etc.
(2) The fire extinguishing systems for helideck and helicopter hangars are to be provided separately from that for other compartments.
(3) In general, the amount of powder of fire extinguishing system for helicopter is not to be considered for simultaneous spray for helideck and hangars and is to be the more of the two.
(4) Powder heads are to be installed appropriately to cover the target compartments sufficiently while the heads are facing down.
(5) The equipment is to have a remote controllable feature near the hand nozzles, in addition to the feature of manual releasing on the machine side.
(6) In general, the powder container units of powder fire extinguishing systems are to be installed in the spaces where there is no risk of fire or unacceptable hot air, in particular, in the spaces at the temperature not higher than 35 ºC.

Chapter 10 AIR CONDITIONING SYSTEM AND VENTILATION SYSTEM

10.1 General

10.1.1 Application

1 The requirements in this Chapter apply to the air conditioning and ventilation systems on ships subject to this Rule.

2 As a rule, air conditioning and ventilation systems subject to this Rule are to be provided in important spaces in which electronic equipment and devices important and essential for the operation of ships are installed (hereinafter referred to as "Important Spaces"), accommodation spaces, service spaces, public spaces, control stations, coordinate stations and hazardous areas.

3 As a rule, from among the machinery spaces, air conditioning and ventilation systems are to be provided in the spaces where major electronic equipment and devices, oil filling stations (pumps, etc.), refrigerating machinery, ventilation machine and air conditioning machinery are installed.

10.1.2 General

1 The total ship design, including requirements such as watertight transverse bulkhead subdivision and stability standards, fire safety or other specific functions, is to be incorporated into the design of the air conditioning and ventilation systems.

2 Moreover, ventilation, temperature and humidity are to be adjusted to improve the workability and habitability so as to satisfy the air conditions required for equipment and crew in various operational conditions in each spaces of the ship. And the goal is to maintain the air condition on board the ship by eliminating explosive and toxic gases, dust and odors, etc.

3 So as not to degrade operation performance of ships, systems configuration and arrangements are to be determined while simplifying the operation procedures.

4 In general, the equipment and devices with rotating parts are to be installed in specific rooms, such as refrigerator rooms and air conditioner rooms, etc., for noise prevention. In addition, sufficient preventive measures are to be taken to avoid the equipment and devices from being the source of vibration and noise.

10.1.3 Terminology

1 "Mechanical ventilation system" means the ventilation system with which air is mechanically moved from outboard to inboard and vice versa.

2 "Recirculation system" means the ventilation system with which air is mechanically circulated among compartments inboard.

3 "Low pressure ventilation system" means the ventilation system with its maximum static pressure of 1.18 *kPa*.

4 "Medium pressure ventilation system" means the ventilation system with its static pressure, 1.18 *kPa* to 2.45 *kPa*.

5 "Collective protection system (*CPS*)" means the equipment installed in the ships which are operated under influence of chemical, biological or exposure to nuclear radiation to prevent air from flowing into the ship by pressurizing the air in the ships.

6 "Zones" means each space that divides the interior of the ship into several compartments when pressurizing the ship. The borders of zones coincide with the watertight transverse bulkhead, and it may include the range from keels to superstructure decks.

7 "Closed recirculation system" means, among recirculation systems, the ventilation system used by the ships which may be temporarily operated under influence of chemical, biological and/or exposure to nuclear radiation without being equipped with the collective protection system. In such cases of operation, this system is employed to circulate air inboard without taking air from outside.

8 "Natural ventilation system" means the ventilation system with which air is naturally ventilated by natural convection within compartments inboard.

9 "Fresh air" means the outside air to be replenished to maintain cleanliness of air in the compartments to be ventilated by recirculation.

10 "Preheat" means to preheat the air at the inlet port when intaking air into the ship from outside.

11 "Reheat" means to heat the air in order to prevent air from over-cooling when it is controlled with a thermostat within one system and maintain the relative humidity within a certain degree.

10.2 Ventilation System

10.2.1 General

1 Provided ventilation systems are to have an optimal ventilation system, considering the use of each space, including important spaces, accommodations spaces and service spaces, etc.

2 The ventilation fans are to be optimal considering the ventilation system and installed positions. As necessary, the fans are to be supported by anti-vibration supports, etc., as anti-vibration countermeasures.

3 The materials and characteristics of ventilating ducts are to be suitable for the compartments and ducts are to be fitted suitably to the ventilation fans.

4 As necessary, joints, such as canvas ducts, are to be used to connect the ventilation fans and ducts, while preventing noise and vibration.

5 In the important spaces, accommodation spaces and service spaces, etc. with the targets of low noise level, the design of the distribution system is to be such as to minimize noise generation.

10.2.2 Mechanical Ventilation

1 The mechanical ventilation system is to be provided, in general, for following compartments specified in **10.1.1-2** above and usages.

(1) Compartments which are not to be air conditioned but are to be mechanically ventilated for the purposes of ventilation and room temperature control.

(2) Compartments which are to be air conditioned and are to be mechanical ventilated for the purpose of fresh air replenishment.

(3) Compartments which are to be partially air conditioned, such as toilets, bath rooms and lavatories, etc., and are to be mechanically ventilated for the purposes of ventilation.

2 The ventilation systems within the airtight or watertight compartments are to be balanced only with the mechanical ventilation without considering ventilation through windows or access openings.

3 In general, the ventilation systems in the compartments of hazardous areas where flammable, explosive or toxic gasses or liquids are stored or generated are to be independent of the ventilation systems of other compartments.

4 As required, the following equipment is to be fitted to the ventilation systems in the galleys.

(1) Simple removable and cleanable grease filters at the overhead ventilation system above the fryers and grills

(2) CO_2 or other fire-fighting appliances

5 The ventilation systems in the galleys of ships equipped with collective protection systems are to be the recirculation systems with odor removable filters in a part of ventilating ducts in order to remove odor from cocked food.

6 The ventilation fans in the systems whose wind volume greatly varies depending on the operational conditions are to be the variable type.

7 The ventilation fans in the ventilation system used in the compartments specified in **-3** above are to be spark-free type machinery, otherwise its motor is to be separately installed in an airtight compartment.

8 The amount of ventilation in each room is to be determined so as to satisfy the rate of ventilation or the room temperature to meet the purposes of each room.

(1) In addition to the requirements, etc. specified by the owners, the amount of ventilation in the compartments which are not to be air conditioned, is to be determined appropriately so that the temperature in summer time will be below 45º specified in **3.1.1, Part 1**.

(2) The rate of ventilation is to be sufficient for the use of each compartment due to requirements, etc. specified by the owners, however, the standard rate of ventilation at each compartment is as followings:

(a) Hazardous areas : supply 10 to 15 *times/h* exhaust 10 to 15 *times/h*

(b) Oil filling stations (pumps, etc.), refrigerating machinery room, ventilation machine room, air conditioning machinery room, etc. : supply 10 *times/h* exhaust 10 *times/h*

(c) Storerooms : supply 5 *times/h* exhaust 5 *times/h*

10.2.3 Recirculation System

1 As a rule, the recirculation systems are to be provided to each watertight transverse bulkhead subdivisions respectively, and the systems in important spaces and other spaces are to be separated.

2 As a rule, the recirculation ventilation is to be the low pressure ventilation system, however, when it is deemed particularly advantageous in terms of duct installation or a wind volume adjustment, the medium pressure ventilation system may be used, while preventing noise.

3 The recirculation system is to be designed appropriately to be the optimal system, considering the type of cooling/heating, capacity of air conditioners and subject spaces.

4 When replenishing fresh air to the air conditioned compartments from the recirculation system, the ducts are to be branched from the mechanical ventilation system to the intake side of the air conditioning coil. The standard amount of fresh air is to be as follow:

(1) 0.3 m^3/min. per person or more. However, in the public spaces where many people gather temporarily, it is to be 0.25 m^3/min per person or more.

(2) For the systems in important spaces, not less than 20 % of the total wind volume of recirculation system.

(3) For the systems in accommodation spaces, not less than 30 % of the total wind volume of recirculation system.

5 As a rule, the medical spaces are to be provided with dedicated air conditioning systems with ducted distribution, fresh air, recirculation system and with as required exhaust system.

6 For the exhaust of air in the subject spaces with the recirculation ventilation system, the ventilation system which is most suitable for the purposes of spaces is to be selected from the following systems except for the recirculation ventilation system.

(1) Recirculation using the recirculation returning system. In the case of compartments which are the aggregate of small rooms, it is acceptable to recirculate through the recirculation returning system of other compartments.

(2) Exhaust of air outboard from the mechanical ventilation system. It is also acceptable to exhaust outboard by the mechanical ventilation system specified in **10.2.2-1(3)** above from other compartments where is exhausted from subject compartments by natural ventilation using vent holes fitted to the doors, etc. of rooms.

7 For the ships, which may be operated temporarily under influence of chemical, biological or exposure to nuclear radiation without collective protection systems, the recirculation ventilation systems in the spaces including important spaces are to be designed to have closed recirculation system without replenishment of fresh air, as required.

8 The closed recirculation systems are to be provided with the circulation returning ventilating ducts.

9 When the air in the room equipped with the recirculation system may be contaminated or there is precision equipment vulnerable to dust in the room, air purification systems are to be installed, as required.

10.2.4 Natural Ventilation System

The natural ventilation systems are to be installed in the compartments where forced ventilation is not required. However, the mechanical ventilation system may be used in part.

10.2.5 Collective Protection System (*CPS*)

In the case of ships equipped with collective protection systems, the design specifications of this system are to be determined in accordance with the requirements, etc. specified by the owners, provided that the specifications are to comply with the following requirements in general:

(1) As a rule, the collective protection system is to be installed in each zone.
(2) It is designed to be over-pressured to atmosphere, so that the air inboard will flow outboard.
(3) Inboard pressure is to be adjusted by the pressure regulating valves.
(4) Specified filters are to be fitted to the fresh air intake ports.
(5) The access inboard/outboard is to be through cleansing stations in which crews are decontaminated.
(6) Access to each zone is to be possible through the air lock compartment.
(7) The necessary amount of fresh air is to be determined in each zone.
(8) To maintain pressurization in the ships, pipes for outboard discharge are to be provided with water sealing, including water-sealing traps.

10.2.6 Ventilating Ducts

1 The ventilating ducts are to be installed under the following requirements:

(1) The ducts are not to be run through watertight transverse bulkheads below the deck immediately below the bulkhead deck, such as a damage control deck.
(2) As a rule, the ducts are not to be run through the bulkheads other than those specified in **(1)** above. When it is unavoidable for the ducts to run through the bulkheads, valves are to be fitted to the duct. When there are any intake or outtake openings in the way of ducts, the valves at the decks immediately below the bulkhead decks, such as a damage control deck, may be eliminated by adopting watertight ducts which are to be located below the worst draft line at the time of damage, provided that valves are to be installed at the penetrated locations of the subject deck.
(3) As a rule, in the ducts which run through the watertight decks, valves are to be installed at the penetrated locations.
(4) Even when at the bulkheads or the penetrated locations of the deck valves are not required, fire-safety dampers are to be installed at the locations where fire spread through the ducts may be anticipated. The fire-safe dampers are to fulfill the following requirements:
    (a) Closing automatically upon detecting an abnormal increase of temperature within the inboard ventilation ducts resulting from fire, etc.
    (b) As required, the important spaces, etc. are to have functions of remote closing and to indicate closing state.
(5) Pipes at the surrounding walls of superstructure or the head of ventilation openings at the decks are to be equipped with valves.

2 The position of equipment of the heads of ventilation ducts opened into the exposed areas is to be determined to fulfill the following requirements:

(1) The positions where tend not to receive ocean waves or blast from the installed equipment.
(2) The height of ventilator coamings above the upper surface of the deck is to be at least 900 *mm* at the position I as and at least 760 *mm* at position II as specified in **20.1.2, Part C of the Rules for the Survey and Construction of Steel Ships.** In application of **20.1.2, Part C of the Rules for the Survey and Construction of Steel Ships**, "Freeboard deck," is read as

"Bulkhead deck". However, when the ships are with particularly large freeboards, the height of ventilator coamings connected to the unenclosed superstructures may be reduced the height appropriately.

(3) As to prevent short circuit of airflow, the intake openings and the outtake openings are to be installed on the hull on the opposite sides. When they are to be installed in the vicinity on the same side, measures are to be provided with preventing the intake openings suctioning exhausted air.

(4) The ventilation openings are to be installed in the positions distant from the doors and hatches as much as possible.

3 In the hazardous areas where explosive gasses or toxic gasses heavier than air are produced, the exhaust ports are to be lowered to the position near the floor face in the compartments.

4 In general, the ventilation ducts for air conditioning by recirculation are to be installed with heat insulation materials with sufficient thickness around the ducts so as to prevent heat loss.

5 Installation of the ventilating ducts is to be fulfilled with the following requirements:

(1) The ducts are to be minimum route as possible without curving.

(2) Stagnation of drain is to be prevented.

6 When the noise is caused by ventilation in the important spaces and accommodation spaces and the noise level may be equivalent or higher than that of other noise, noise prevention treatments are to be applied to the ventilating duct.

7 The type of supply or exhaust ports are to have functions appropriate for the purposes of ventilation of each room. In particular, the supply ports are to be sufficient type to prevent noise.

8 In addition to the requirements in **10.2.6**, the ventilation ducts are to satisfy the requirements stipulated in **6.1.2, Part 9**.

10.3 Air Conditioning System

10.3.1 General

1 The scope of air conditioning is to be optimal, considering the operation, etc., of ships.

2 The air conditioning systems are to be optimal for types of compartments and capacities of the equipment, etc.

3 Air conditioning is to be provided to all compartments which require temperature and humidity control.

4 In general, air conditioning in the important spaces and accommodation space is to be provided through the recirculation ventilation. However, unit coolers, heaters, gravity coils, thermo-tanks radiators or electric heaters, etc., are to be used for the air conditioning of particular compartments for special purposes.

10.3.2 Air Conditioning System

1 Types of air conditioning system

(1) As a rule, types of the air conditioning systems are to be either one or a combination of the followings:

  (a) Direct dilation system using the chilled water type air conditioner
  (b) Unit cooler (package type)
  (c) Chilled water cooling system using the chilled water type air conditioner and the chilled water circulation
  (d) Unit cooler (chilled water type)
  (e) Gravity coil (chilled water type)

(2) As a rule, the air conditioning systems for cooling using recirculation system (cooling system for important spaces and accommodation space) are to be the chilled water cooling system for

ships with larger number of recirculation ventilation systems and are to be the direct dilation system for ships with relatively smaller number of recirculation ventilation systems.

(3) The following standards of use for unit coolers and gravity coils are to be in accordance with the followings.

(a) Unit cooler (package type) : The general compartments in the ships, which are installed with the direct dilation system, or compartments different from the general air conditioned compartments, and the modified ships, etc.

(b) Unit cooler (chilled water type) : The compartments, etc., in which installation of recirculation system is disadvantageous or which have different conditions, in the air conditioned compartments in the important spaces in the ships employing chilled water cooling system using chilled water circulation where the heat loads are high due to electronic equipment.

(c) Gravity coil (chilled water type) : The compartments where installation of electrical equipment is prohibited, the compartments with low loads where weight and space need to be saved, and hazardous areas where cooling with low ventilation rate are required in the ships employing chilled water cooling system using the chilled water circulation.

2 Arrangements, etc., of chilled water type air conditioners

(1) In general, the cooling systems using the chilled water type air conditioners and the chilled water circulation are to be in accordance with the followings requirements:

(a) Provided prevent operational failures of other air conditioning systems resulting from damage to one compartment or a zone, the number of chilled water type air conditioner is to be not less than two, and they are to be installed respectively in separate compartments or zones.

(b) One chilled water circulation pump is to be provided for one chilled water type air conditioner. They are to be installed separately in separate compartments or zones. It may install them in the same compartment or zone as specified in **(a)** above.

(c) However, for the ships not intended to navigate in the threat sea areas specified in **2.2.2, Part 1**, the number of chilled water type air conditioner to be provided may be one.

(2) As a rule, sea water is to be used for cooling of condensers of chilled water type air conditioners. In order to have a capacity to supply cooling sea water even when one compartment or zone is damaged or machine failures occur, not less than two cooling seawater pumps are to be installed in separate compartments or zones. However, in the case of **(1) (c)** above, it may be one unit only.

(3) In general, unit coolers and gravity coils are to be installed within their compartments, and they are to be provided in their positions to enable the most efficient air conditioning.

3 Air conditioner

(1) Scope

The requirements in this section apply to air conditioner using the primary refrigerants listed below and those forming refrigerating cycles used for air conditioner. However, any air conditioner with compressors of 7.5 *kW* or less and any air conditioner using primary refrigerants other than those listed below are to be as deemed appropriate by the Society.

*R*134*a* : *CH*2*FCF*3
*R*404*A* : *R*125/*R*143*a*/*R*134*a* (44/52/4 *wt*%) *CHF*2*CF*3 / *CH*3*CF*3 / *CH*2*FCF*3
*R*407*C* : *R*32/*R*125/*R*134*a* (23/25/52 *wt*%) *CH*2*F*2 / *CHF*2*CF*3 / *CH*2*FCF*3
*R*410*A* : *R*32/*R*125 (50/50 *wt*%) *CH*2*F*2 / *CHF*2*CF*3
*R*507*A* : *R*125/*R*143*a* (50/50 *wt*%) *CHF*2*CF*3 / *CH*3*CF*3

(2) Drawings and Data

Drawings and data to be submitted for approval are generally as follows:

(a) Drawings (with materials, scantlings, type, design pressure, design temperature, etc. of pipes, valves, etc.)

i) Piping diagrams of refrigerating machinery for air conditioning installations

ii) Drawings of pressure vessels exposed to primary refrigerant pressure

iii) Other drawings considered necessary by the Society

(b) Data

i) Particulars of air conditioner

ii) Other drawings considered necessary by the Society

(3) General of design

The design pressure of pressure vessels and piping systems and the class of pipes used for air conditioner are to be as follows:

(a) The design pressure of the pressure vessels and piping systems used for the air conditioner and exposed to the pressure of the refrigerant is not to be less than the pressure in **Table 6.10.1** depending on the kind of refrigerant.

(b) Pipes for the refrigerants specified in **Table 6.10.1** are to be classified into Group III.

Table 6.10.1 Design Pressure of Pressure Vessels and Piping Systems for Refrigerating Machinery

Refrigerants	High Pressure Side(1) (*MPa*)	Low Pressure Side(2) (*MPa*)
*R*134*a*	1.4	1.1
*R*404*A*	2.5	2.0
*R*407*C*	2.4	1.9
*R*410*A*	3.3	2.6
*R*507*A*	2.5	2.0

Notes:

(1) High Pressure side: The pressure part from the compressor delivery side to the expansion valve.

(2) Low Pressure side: The pressure part from the expansion valve to the compressor suction valve. In cases where a multistage compression system is adopted, the pressure part from the lower-stage delivery side to the higher-stage suction side is to be included.

(4) Materials

(a) Materials used for air conditioner are to be suitable for the refrigerant used, with respect to design pressure, minimum working temperature, etc.

(b) Materials used for primary refrigerant pipes, valves and their fittings are to comply with the requirements in **12.1.3** to **12.1.6, Part D of the Rules for the Survey and Construction of Steel Ships** according to the classes of pipes specified in **(3)(b)** above.

(c) Materials used for pressure vessels exposed to refrigerant pressure (condensers, receivers and other pressure vessels) are to comply with the requirements in **2.2, Part 3** according to their respective pressure vessel classifications as specified in **10.1.3, Part 7**.

(d) The following materials are not to be used for any parts of refrigerating machinery.

i) Aluminum alloys containing over 2 % magnesium for any parts coming in contact with primary refrigerants.

ii) Pure aluminum less than 99.7 % for any parts that usually come in contact with water and are without any corrosion protection.

iii) The service limitations of valves made of iron castings are shown in **Table 6.10.2**. Although the utilization of iron castings is permitted by the Table, they are not to be used for valves in piping that has a design temperature below 0 °C or exceeding 220 °C, provided however that *GNS-C* ships and *GNS-D* ships which are not subject to the impact resistant requirements, the valves made of iron casting may be used in accordance with the use restrictions specified in **Table 6.10.2**. However, in cases where the normal working pressure of the piping does not exceeding 1/2.5 times the design pressure, the temperature limitations may be lowered to -50 °C.

Table 6.10.2 Service Limitation of Valves Made of Iron Castings

Kind of valves	Materials	Application
Stop valves	Gray iron castings with specified tensile strength not exceeding 200 N/mm^2 or the equivalent thereto	Not to be used
	Gray iron castings other than those specified above, spheroidal graphite iron castings, malleable iron castings or the equivalent thereto	(1) May be used for design pressures not exceeding 1.6 *MPa* (2) May be used for design pressures exceeding 1.6 *MPa*, but not exceeding 2.6 *MPa*, provided that the nominal diameter does not exceed 100 *mm* and the design temperature is 150 °C or below.
Relief valves	*JIS G* 5501, *G* 5502, *G* 5705 or equivalent	Not to be used
Automatic control valves	Gray iron castings with a specified tensile strength not exceeding 200 N/mm^2 or the equivalent thereto	Not to be used
	Gray iron castings other than those specified above or the equivalent thereto	(1) May be used for design pressures not exceeding 1.6 *MPa* (2) May be used for design pressures exceeding 1.6 *MPa* , but not exceeding 2.6 *MPa*, provided that the nominal diameter does not exceed 100 *mm* and the design temperature is 150 °C or below.
	Spheroidal graphite iron castings, malleable iron castings or the equivalent thereto	Not to be used for design pressures exceeding 3.2 *MPa*

(5) Pressure Relief Devices

(a) Relief valves are to be provided between compressor cylinders and gas delivery stop valves with any discharge being led to suction side of the compressor. However, compressors of 11 *kW* or less for refrigerating installations may be provided with pressure control switches in lieu of the above safety device.

(b) Relief valves are to be fitted to pressure vessels which may be isolated and store primary refrigerants in a liquid condition. Any discharged gases from relief valves are to be released into the atmosphere at a safe place above the weather deck or to the low pressure parts of the equipment.

(c) In cases where any discharged gases from relief valves on the high pressure parts of primary refrigerants are led to low pressure parts before being released into the atmosphere, the operation of relief valves is not to be interrupted by any back pressure accumulation.

(d) Relief valves are to be provided for the cooling liquid side of condensers and the brine side of evaporators except in cases where the connected pump is so constructed that the pressure does not exceed design pressure.

(6) Shop Tests

Air conditioner is to be tested as follows:

(a) Pressure vessels exposed to the pressure of primary refrigerants are to be subjected to a hydrostatic test at a pressure of 1.5 times the design pressure and a tightness test at a pressure equal to the design pressure.

(b) Cylinders and crank cases of the compressors of refrigerators are to be subjected to a hydrostatic test at a pressure of 1.5 times the design pressure and a tightness test at a pressure equal to the design pressure.

10.3.3 Heating System

1 In general, types of the heating systems are to be either one or a combination of the followings:

(1) Direct-heating system with steam
(2) Indirect-heating system with hot water circulation
(3) Radiator
(4) Electric heater
(5) System of preheating using a preheater
(6) System of adjustment using a reheater

2 As a rule, the direct-heating system with steam is to be used only in case of the chilled water cooling system or heating of a specific compartment and heating only. However, the direct-heating system with steam may be used for heating in the ships which provide direct-cooling systems. The indirect-heating system with hot water circulation is to be used when the chilled water-cooling system is used as cooling equipment.

3 As a rule, the use of radiators and electric heaters are to be as follows:

(1) Radiator (steam-operated type) : Emergency generator room, drying room, etc.
(2) Electric heater : Navigation bridge, specific important spaces with no heating ventilation

4 As a rule, preheaters are to be the steam-operated type and they are to be installed to the air intake port for ships which operate in extremely cold areas.

5 As a rule, reheaters are to be the steam-operated type and they are installed on the exhaust side of cooling coils to lower relative humidity or in the rooms where the temperature becomes extremely low in case of only one ventilation line.

6 The steam to be used for hot water coils, heating coils, thermo-tanks, radiators, preheaters and reheaters, is to be provided from the miscellaneous steam pipes.

10.3.4 Adjustment of Temperature and Humidity

1 In general, the temperature and humidity of rooms are to be adjusted automatically to correspond to fluctuation of heat loads, including ship operational conditions, external temperature, solar radiation and ratio of use of respective exothermic equipment.

2 As a rule, in the case of chilled water cooling system, the amount of cold and hot water is to be controlled automatically in proportion to loads. On the other hand, the direct-dilation cooling system, heating coils, thermo-tanks, preheaters and reheaters (heating) are to have automatic ON-OFF control systems. However, the thermo-tanks may be controlled solely with the manual control system and the direct-dilation cooling system may be controlled solely by the unloader mechanism of refrigerating machinery. In the case of automatic control, manual control is to be also possible as spare equipment.

3 As a rule, the air conditioner is to have unloader mechanism. However, this rule may be not applied to the package type.

4 Temperature adjustment corresponding to the fluctuation of heat loads may be conducted by increasing or decreasing the air flow volume. However, in general, the air flow volume adjustment except for fine adjustments using throttle valve of supply port is not be conducted in use of low-pressure ventilation system. When the medium pressure ventilation system is used to air condition the large compartments in the same recirculation line, the way to prevent imbalanced temperature among rooms that air flow adjustments of suction and exhaust ports are possible are to be planned.

5 As a rule, **Table 6.10.3** is to be referred to for external air conditions. However, when they are specified in the requirements specified by the owners due to certain navigation areas, an approval of the Society is to be obtained.

Table 6.10.3 External Temperature Conditions

Item		Summer	Winter	Remarks
External	*DB*	30 °C	-5 °C	
	RH	80 %	60 %	
Sea water temperature		32 °C	0 °C	

6 Designed room temperature and humidity conditions are to be based on the use of compartments and the target fluctuation from design point of dry-bulb temperature is to be within ±2 ºC.

7 The humidity adjustments are to be conducted, at the time of heating, by humidifying within the heating coils or unit cooler/heater using steam, while are to be conducted by cooling air in the cooling coils, at the time of cooling. In the compartments which particularly require humidity controls humidity is adjusted using the reheaters.

10.3.5 Capacity of Air conditioning System

1 The capacities of air conditioning systems are to be determined by calculating the air conditioning loads, for both cooling and heating, according to the operation condition of ships.

2 Calculation of the air conditioning loads is to be in accordance with, the following requirements:

(1) Temperature and humidity plan of the rooms in each compartment at the time of air conditioning is to be agreed upon by the owner.

(2) The external air conditions in **Table 6.10.3** are to be used.

(3) The conditions presented by the owners or the standard conditions of shipyards are to be used for temperatures in adjoining compartments

(4) The heat dissipation of installed equipment and personnel, etc., in positions is also to be considered as heat loads in each compartment. Moreover, the loads of replenished fresh air are also to be considered.

3 Heat values penetrating from outside or adjoining compartments and heat loss, considering conditions of boundary walls and heat insulating materials are to be calculated. When there is a great difference in designed temperature conditions between the target components and adjoining compartments, heat insulation materials are to be fitted to minimize the heat penetrating from outside or heat loss, in general.

Chapter 11 PIPING SYSTEMS

11.1 General

11.1.1 Application

The requirements in this Chapter apply to the piping systems in the compartments other than the machinery spaces of category *A*, such as inboard and on weather decks, etc.

11.1.2 Terminology

The terms used in this Chapter are defined as follows:

(1) "Prewetting pipes" are the pipes used to spray water to exposed part of ships, which are operated under influence of chemical, biological or exposure to nuclear radiation, in order to prevent adhesion of or remove radiation, etc.

(2) "Sea water pipes for *IR* reduction measures" means the piping equipment used to spray sea water to diminish infrared radiation. This is used simultaneously with spraying prewetting.

(3) "Main line" means the pipes which are the major lines running through the ship in order to serve fluids for each area.

(4) "Branch line" means the pipe which is branched from the main line led to each equipment, etc.

(5) "Riser" means the pipe which is connected to the pipe in a vertical direction.

(6) "Connecting line" is the pipe which connects two main pipes, branching pipes or riser pipes.

(7) "Ring main" means the main line installed within the hull in a form of ring.

11.1.3 General

1 Piping

(1) The piping is to be laid in an appropriate way to meet respective purposes without disturbing operations and full functions of related equipment and devices.

(2) For attaching position, vibrations and impacts are necessary to be sufficiently considered to reduce noise from pumps, and the following countermeasures to be taken as required:
   (a) Pump : Anti-vibration device
   (b) Piping : Anti-vibration joints and supports

(3) The piping is to be separated so that the failure or damage of a part of the piping does not cause disturbance of continuous operation in other piping.

(4) In general, the piping is not to be routed above electric equipment, electronic devices and beds, etc. When it is not avoidable to route above these articles, piping is not to be provided with joints as much as possible, and is to be given with countermeasures to prevent dew drops and be provided with drain pans as required.

(5) In general, the piping is not to be laid inside of the lining. When it is not avoidable to route the piping inside of the lining, maintenance doors are to be installed and pipe joints are not to be used.

(6) When installing pipes, sufficient attention to prevent electric erosion, etc. using zinc protectors or sacrifice pipes is to be paid.

(7) Expansion and contraction of pipes are to be sufficiently considered, and bends or expansion joints are to be used, as needed.

(8) The piping used under the temperature other than ambient conditions, such as pipes for steam, hot water, cold/hot water and refrigerant, is to be insulated.

(9) In general, the piping laid in the compartments where steam is produced, such as galleys and bath rooms, is to be with dew-proofing materials.

(10) In general, the piping which are deemed unnecessary is not to be laid in the compartments of

provision chambers, etc. When it is not avoidable, the piping is to be routed inside of the thermal isolation layers.

(11) The fresh water and sea water pipes laid on the open decks are to be equipped with a means of anti-freeze, as required.

(12) The pumps which are used for sea water are to be equipped with a means of anti-corrosion on the pump bodies.

(13) The overboard discharge ports are to be located in the position away from areas for boats loading/unloading, mooring and departing/arriving, as much as possible. Moreover, when it is unavoidable to do so, appropriate countermeasures to be taken at the outboard drain ports to prevent influx of drain water to boats.

(14) The sea water suction ports are to be located around the ship bottom as much as possible, and to avoid the vicinity of sewage discharge port or the area where air are to be in taken easily, etc.

(15) Gratings are to be fitted at the sea water suction ports. The area of grating openings is not to be less than twice the total inlet sea water suction valves opening area. Air pipes or steam pipes for cleaning are to be installed to the sea water suction ports.

(16) Valves for the sea water intake pipes are to be mounted in the positions in the vicinity of shell plates.

(17) The pipes to be attached to the shell plates in the area below the waterline or near the waterline are to be with countermeasures for electric erosion with the bottom valve.

(18) The sea water suction ports which have a risk of air mixing by installing the masker systems are to be protected by means against air mixing.

(19) In addition to the requirements from **(1)** to **(18)** above, requirements stipulated in **13.2, Part 7** are to be referred to.

2 Valves and Joints, etc.

(1) In general, valve operation equipment necessary for damage control is to be installed on the deck below the bulkhead deck, such as the damage control deck. The valves necessary for damage control are to be with effective remote controllers.

(2) For the locations where backflow of fluids in the pipes may damage the functions of equipment or devices, check valves are to be mounted.

(3) In general, for joints of pipes whose nominal pressure is different, pressure reducing valves or throttle valves, etc. are to be mounted together with strainers and safety valves. As required, pressure gauges and ancillary equipment for depressurizing are to be used.

(4) In general, valves are to be installed at the joints where equipment, pressure reducing valve, etc. and pipes are connected.

(5) In general, the type of pipe joints is to be flange joints. However, depending on the positions, appropriate joints, such as sleeves, etc., may be used.

(6) In general, the valves for pipes necessary for damage control onboard are to be installed on the penetration position of the watertight transverse bulkheads.

(7) In piping, necessary valves and cocks are to be installed for handling and maintenance of equipment and devices, as well as for emergency operations.

(8) In addition to the requirements from **(1)** to **(7)** above, requirements stipulated in **13.2, Part 7** are to be referred to.

3 Materials

(1) The materials are to be selected from among those which most meet the purposes in accordance with **Part K of the Rules for the Survey and Construction of Steel Ships**, *ISO* standard or *JIS*, etc.

(2) In general, considering the impact resistance, the brittle materials, including cast iron, etc., are not to be used.

(3) The steel pipes which come in contact with sea water, bilge, hot and cool water and fresh water, etc., are to be zinc plated.

11.2 Fire-fighting Piping

11.2.1 General

1 The requirements in this Section apply to the sea water pipes installed mainly for the purpose of fire-fighting. The fire-fighting pipes are also used for the following usages:

(1) Prewetting
(2) Eductor driving water for bilge and ballast water discharge
(3) Emergency cooling water for auxiliary systems and equipment

2 All ships are to have sea water pumps for fire-fighting, fire main, fire hydrant and fire hoses which meet relevant requirements in this Section.

11.2.2 Fire Mains and Fire Hydrants

1 The fire mains and fire hydrants are to have sufficient strength for the service pressure, and they are to be made of heat-resistive materials, unless they are protected sufficiently.

2 All ships are to be provided with appropriate means of water discharge.

3 In general, the fire mains are to be installed on the deck immediately below the bulkhead decks, such as damage control deck, and riser for sea water fire pumps (hereinafter referred to as "pump riser"), riser leading to the destination of use (hereinafter referred to as "feed riser") and branch lines are to be branched from fire mains.

4 As a rule, according to the full load displacement, laid as follows the fire mains for ships *GNS-A* and *GNS-B* is to be:

(1) Full load displacement is less than 6,000 *t*: 1 line extending fore and aft on the damage control deck
(2) Full load displacement is 6,000 *t* or more : ring main on the damage control deck

5 As a rule, the water main of the ships *GNS-C* is to be one line extending fore and aft on the deck immediately below the bulkhead decks, such as a damage control deck, however for those ships with greater full load displacement, it may be able to have ring main on the deck immediately below the bulkhead decks, such as a damage control deck. However, when the *GNS-C* ship does not have decks stretching along with the longitudinal direction immediately below the bulkhead deck, the fire main may be arranged in an appropriate way for the fire-fighting hoses to be connected easily.

6 The fire main for *GNS-D* ships is to be arranged in an appropriate way that the fire-fighting hoses to be connected easily. However, when damage control decks are installed, 1 fire main extending fore and aft on the deck may be acceptable.

7 When the fire main is the ring main type, connecting lines are to be mounted in the essential parts. Then, the pump risers are to be connected to the fire mains or the connecting lines and the feed riser or the branch lines are to be connected to the fire mains.

8 Consider the damage to more than one compartment in the ship and failures of equipment, devices and pipes, etc., the fire mains are to be separated as follows:

(1) When one fire main is extending fore and aft, it is to be divided into two or more lines in the fore and aft direction
(2) When the ring main is to be applied to the fire mains, it is to be divided into two or more sections in the fore and aft directions and two or more lines in the transverse directions. In total, four or more lines.

9 The shutoff valves are to be mounted in the following positions in the fire-fighting piping, so that the fire-fighting pipes may be separated. In general, the shutoff valves are to be mounted on the

decks immediately below the bulkhead decks, such as a damage control deck.
(1) On both sides of the fire main and the connecting lines and on the pump riser side at the joints where the pump riser is connected to the fire main and connecting line.
(2) On both sides of the fire main at the joint where the fire main is connected to connecting lines.
(3) At the joint where the fire main or the connecting lines are connected to the feed risers or the branch lines on the decks immediately below the bulkhead deck, such as a damage control deck.
(4) As a rule, the shutoff valves are generally to be mounted at the midship side on one side of penetrated parts of the watertight transverse bulkheads of the fire main. However, the shutoff valves may be omitted when they are redundant with other shutoff valves required in **(1)** and **(2)** above.
(5) Other positions where necessary for separate operation
10 With a periodically unattended machinery space or when only one person is required on watch, there is to be immediate water delivery from the fire mains at a suitable pressure, either by remote starting of one of the sea water fire pumps with remote starting from the control stations such as the navigation bridge and fire control station, etc., if any, or permanent pressurization of the fire main by one of the sea water fire pumps
11 As for the ships which have a function to remote-operate the sea water fire pumps in the place of fire control as specified in **-10** above, monitoring is to be enabled, in addition to have a function to control on the machine side.
12 When there is another stations in which damage control is commanded, in addition to the control stations such as a fire control station, etc., a function to monitor the pressure of fire mains is to be available in addition to monitoring of operation condition of the sea water fire pumps.
13 The valves on the suction and discharge sides of the sea water fire pumps are to be operated in the compartment in which the pump is installed. In this case, the valves on the discharge side of the pump are to be check valves.
14 When the fire-fighting pipes are separated, the means for outboard discharge is to be installed to prevent over-heating of the pumps.
15 For those ships which are not provided with overboard discharge equipment as specified in **-14** above, safety valves are to be installed for the sea water fire pumps whose pressure may exceed the design pressure of fire mains, fire hydrants or fire hoses. These safety valves are to be arranged and adjusted appropriately so as to prevent over-pressure which may occur in any place within the piping system of the fire mains.
16 The fire-fighting pipes is to be equipped with fire hydrants within various places inboard and on the open decks and the fire hydrants are to be arranged in the places that fire hoses are to be connected easily.
17 The valves are to be mounted to each fire hydrant so that any fire hose may be removed while the sea water fire pumps are in operation.
18 As for the ships not intended to navigate in the threat sea areas specified in **2.2.2, Part 1,** the number of fire hydrants and their positions are to be in accordance with the requirements of **10.2.1-5, Part R of the Rules for the Survey and Construction of Steel Ships**.
19 As for the ships intended to navigate in the threat sea areas specified in **2.2.2, Part 1**, the fire hydrants are to be arranged appropriately so that cooling water from the fire hydrants, in addition to those specified in **-18** above, is to be able to be sprayed on the boundary walls neighboring the fire compartment.
20 In general, the pressure of the fire hydrants of ships to which **-19** above apply is to be sufficient to maintain the pressure of not less than 0.7 *MPa* at the fire-fighting pipes.
21 The pressure of fire hydrants of the ships to which **-18** above apply is to be in accordance with the requirements of **10.2.1-6, Part R of the Rules for the Survey and Construction of Steel Ships**.

When applying **10.2.1-6, Part R of the Rules for the Survey and Construction of Steel Ships**, "Gross Tonnage," is read as "Estimated Gross Tonnage".

22 As a rule, the size of fire hydrants is to be specified by two nominal diameters: 40 *mm* and 65*mm*. Their arrangements are to be:

(1) In general, nominal diameter of those on the weather deck is 65 *mm*

(2) In general, nominal diameter of those on the helideck is 65 *mm*

(3) In general, the nominal diameter of those on the damage control deck and other inboard decks or compartments inboard is 40 *mm*

(4) The fire hydrants with the nominal diameter of 65 *mm* are to be with Y-shaped fittings for 40*mm* canvas hoses, except for those on the helideck.

23 As a rule, sprinkler systems are to be installed in the hazardous areas and in general their valves are to be as follows:

(1) The operation of the main valves for the sprinklers is to be possible on the fitted position of valves, in addition to remote-operation.

(2) The position of remote-operation is to be on the damage control deck.

(3) An alarm switch of water leakage from the main valve of the sprinkler is to be installed between the main valve of the sprinkler and the sprinkler valves. The sprinkler valves, which have two hazardous areas in common, are to be check valves.

In accordance with the types of substances stowed in the hazardous areas, automatic sprinkler systems may be installed.

24 International Shore connections

(1) Ships are to be provided with at least one international shore connection complying with the requirements of **Chapter 22, Part R, of the Rules for the Survey and Construction of Steel Ships**.

(2) Facilities are to be available enabling such a connection to be used on either side of the ship.

11.2.3 Sea Water Fire Pump

1 The pumps deemed appropriate for sea water fire pumps

As a rule, the sea water fire pumps are to be the dedicated pump. Its discharge pressure is to meet the pressure specified in **11.2.2-20** or **11.2.2-21**. However, the hygiene pumps, ballast pumps, bilge pumps and general service pumps which have specified discharge pressure are not normally used for oil suctioning or delivery may be accepted as sea water fire pumps, provided that they are not normally used for pumping oil and if they are subject to occasional duty for the transfer or pumping of oil fuel, suitable change-over arrangements are fitted.

2 The Number of Fire Pumps

All ships are to have following number of sea water pumps for fire-fighting as shown below:

(1) For the ships with *estimated gross tonnage* of 1,000 *tons* or more, not less than two independent power-operated pumps

(2) For the ships with *estimated gross tonnage* less than 1,000 *tons*, not less than two power-operated pumps (one of them is to be independently operated)

3 Capacity of Sea Water Fire Pump

(1) The total capacity of sea water fire pumps of the ships which are intended to navigate in the threat sea area specified in **2.2.2, Part 1** are to comply with the requirements of maximum capacity specified either in the following **(a)** or **(b)**.

(a) Total capacity for prewetting

(b) The maximum total capacity for fire in one compartment specified in **11.2.2-19** above, plus volume of necessary sprayed water for one hazardous area, hangers, etc.

However, the capacity of each sea water fire pump is to be more than the volume required by **11.3.4-3(5)**.

(2) The total capacity of sea water fire pumps of the ships not intended to navigate in the threat

sea areas specified in **2.2.2, Part1** is to be in accordance with the requirements of **10.2.2-4, Part R of the Rules for the Survey and Construction of Steel Ships**.

4 In order to ensure that damage to one compartment or failures of equipment does not disable other pumps, at least two sea water fire pumps are to be installed separately while maintaining distance from one another as far as possible, so that pumps are to fit to the separation of fire main specified in **11.2.2-8**.

5 In the case of ships which are unable to arrange the pumps as mentioned above due to arrangement restriction, alternative equipment composed of fixed emergency fire pumps which meet the requirements of **Chapter 32, Part R of the Rules for the Survey and Construction of Steel Ships** is to be installed. When applying **Chapter 32, Part R of the Rules for the Survey and Construction of Steel Ships**, "*Gross Tonnage*" is read as "*Estimated Gross Tonnage*" The power source and joint to sea water of the pumps concerned are to be installed in the area outside of the area where the sea water fire pumps or power source are arranged.

6 When automatic sprinkler systems specified in **11.2.2-23(3)** are installed, the sea water fire pumps are to be started automatically, as necessary.

11.2.4 Fire Hose and Nozzle

1 Fire hoses and nozzles of the ships intended to navigate in the threat sea areas specified in **2.2.2, Part 1** are to be determined in accordance with the requirements, etc. specified by the owner. However, in general, the following requirements in **(1)** to **(4)** are to be followed:

(1) The fire hoses are to be made of the materials which have strength sufficient to withstand the pressure specified in **11.2.2-20** and not susceptible to corrosion as approved by the Society, with sufficient length for spraying to any places where they may be used.

(2) As a rule, the length of fire hose is to be 15 *m* each, and not more than two hoses may be connected when in use.

(3) As a rule, the nozzles are to be all purpose nozzles for naval ships and have sufficient strength to withstand the pressure specified in **11.2.2-20**. This all purpose nozzles are to be capable of switching water jet type nozzle and water fog type nozzle freely.

(4) 15 *m* or 30 *m* (two 15 *m* fire hoses) fire hoses are to be used for the fire hydrants with nominal diameter of 40 *mm* specified by the requirements of **11.2.2-22**. Fire hoses dedicated to the fire hydrants dedicated to the fire hoses with nominal diameter of 65 *mm* are to be capable of spraying by connecting two 15 *m* fire hoses.

(5) In general, two 15 *m* fire hoses and one all purpose nozzle for the fire hydrant with nominal diameter of 40 *mm* and two sets of two 15 *m* fire hoses and one all purpose nozzle for the fire hydrant with nominal diameter of 65 *mm* are to be installed in the vicinity of each fire hydrant.

2 The fire hoses and nozzles of the ships not intended to navigate in the threat sea areas specified in **2.2.2, Part** are to be in accordance with the requirements of **10.2.3, Part R of the Rules for the Survey and Construction of Steel Ships**. When applying **10.2.3-6, Part R of the Rules for the Survey and Construction of Steel Ships**, "*Gross Tonnage* " is read as "*Estimated Gross Tonnage*".

11.3 Ballasting and De-ballasting Piping

11.3.1 General

1 Ballasting and de-ballasting piping is to be installed for ballasting and de-ballasting from the compartments, including the tanks, and bilge drainage.

2 Ballasting and de-ballasting piping of the ships applied with the Ballast Water Management Installations is to be in accordance with the requirements of **Part 11.**

11.3.2 Terminology

1 A Main Suction Line is the part of a suction line which forms the main of suction line connected to independently powered pumps and to which all branch suction pipes of sea water or bilge are connected.

2 A Branch Suction Pipe is a pipe connected to the main line from the water suction of each compartment.

3 A Direct Suction Pipe is a suction pipe which is connected directly to an independently powered pump and arranged entirely separately from other pipes.

11.3.3 Ballasting Piping

1 Piping, etc.

(1) As a rule, the ballasting piping of the ships, except for those which always adjust ballast, are to be branched from the fire main and the piping is routed to the tanks, such as ballast tanks. When the tanks are arranged in a group, a group of tanks is to be branched from the fire main as a whole.

(2) Dedicated ballast pumps are to be used for ballasting of ships which always adjust ballast. The ballast systems are to have capabilities for simultaneous operation of ballasting to one ballast tank and de-ballasting from the other ballast tank.

(3) The tanks which necessitate ballasting, such as stabilizing tanks, trimming tanks and healing tanks are to have suitable ballasting systems.

(4) 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 7.13.4(1)** and **7.13.4(2), Part 7** and all of their joints are to be welded.

(5) 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 sea water into the ballast tanks or of any ballast water passing from one ballast tank to another.

(6) In cases where a tank is intended to be used for both fuel oil and ballast water, adequate provisions, such as blank flanges or spool pieces, are to be made to prevent any mixing of fuel oil and ballast water in the ballast pipe when carrying fuel oil and in the fuel oil pipe when carrying ballast water.

For those ships to which the **Rules for Marine Pollution Prevention Systems** applies, **Part 11** also applies

2 Ballasting capability, etc.

(1) The target of ballasting capability of ballast tank specified in **-1(1)** above is to fill up the ballast tanks of ships within 1.5 hours.

(2) In general, the ballasting capability of the ships specified in **-1(2)** above is to be the capacity suitable for the sizes and duties of the ships, and the detailed ballasting capability is to be determined upon requirements, etc. specified by the owners.

11.3.4 De-ballasting Piping

1 Piping, etc.

(1) The de-ballasting piping system is to be provided in the ballast tanks, the tanks which are commonly used for fuel tanks and ballast tanks, and required compartments below the maximum load line.

(2) De-ballasting from the compartments other than those specified in **(1)** above may be conducted using hoses by connecting them to the de-ballasting piping, otherwise moving

eductors, electrical submersible pump and fire pump may be used.

(3) 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 maximum load line.

(4) As a rule, the number of de-ballasting ports in one de-ballasting system for several tanks or compartments is to be one or two, and one or two de-ballasting device is to have a sufficient capability to de-ballast.

(5) In general, de-ballasting piping is not to penetrate through the watertight transverse bulkhead. When it is not avoidable to do so, the piping is not to penetrate through two watertight transverse bulkheads or more than.

(6) De-ballasting piping of a ballast tank, the tanks which are also used as a ballast tank, a fuel tank and chain lockers, etc., may also be used for ballasting piping.

(7) Suitable measures are to be taken so that bilge drainage systems prevent the possibility of any ingress of sea water into any watertight compartments and to prevent any bilge from inadvertently passing from one compartment to another.

(8) Screw-down check valves are to be provided to the suction ports between the suction port and the power means, such as an eductor.

(9) Valves necessary for de-ballasting operation are to be installed appropriately so that operate at a position in the vicinity of power means, such as an eductor is possible.

(10) The valves necessary for de-ballasting for damage control resulting from damage to compartments are to be easily operated from the decks immediately below the bulkhead decks, such as damage control decks.

(11) In cases where a suction line passes through a collision bulkhead, it is to comply with the requirements in **11.1.3-2(9)**.

2 Size of Suction Pipes

The internal diameters of a main suction line, a direct suction pipe and a branch suction pipe in each watertight compartment are to comply with the requirements in **13.6.3, part7**.

3 De-ballasting devices and capacity, etc.

(1) As a rule, the de-ballasting devices of the ships, except for those which always adjust the ballast are to be provided with eductors, as to address a large amount of sea water influx resulting from damage to the compartments.

(2) The pipes for eductor driving water are to be branched from the fire main.

(3) Moving eductors, submersible electrical pumps or fire pumps, etc. may be used as emergency de-ballasting devices.

(4) Dedicated ballast pumps are to be used for ballasting of ships which always conduct ballasting and de-ballasting, and not less than two ballast pumps are to be provided for simultaneous ballasting and de-ballasting operation.

(5) Each eductors specified in **(1)** above is to be capable of discharging bilge, through the main suction line specified in **-2** above, of an amount not less than that obtained from the following formula:

$$Q=5.66\, d^2 \times 10^{-3}$$

where

Q : Required suction quantity (m^3/hr).

d : Internal diameter of the main suction line in **-2** above (mm).

In cases where one of these eductors is of a capacity slightly less than what is required, the deficiency may be made good by any excess capacity of the other eductors.

(6) In general the amount of de-ballasting suctioning specified in **(5)** above is to be greater than 15 m^3/h. However, in case of branch suction pipe in a small compartment which have been confirmed and recognized by the Society, this does not apply.

(7) In cases where, an eductor is used exclusively for bilge drainage in a hold, the eductor is to be so arranged as to be driven by two or more pumps. The capacity of the sea water pump for sending water to drive the eductor, the suction capacity of the eductor and the internal diameter of the suction pipe are to all be considered appropriate by the Society.

4 Bilge Wells, etc.

For Bilge well and rose box, **13.6.8, and 13.6.9, Part 7** are to be referred to.

11.4 Multi-purpose Sea Water Piping

11.4.1 General

1 The requirements of this section applies to sea water piping, other than fire-fighting piping and prewetting piping, etc., used for sea water for machine cooling of equipment, such as hydraulic power unit and refrigerator condenser, and condenser for air conditioners.

2 In general, the sea water piping for cooling of equipment and air conditioners are to be installed independently.

3 As a rule, the system for cooling sea water piping for equipment is to be also used for sea water for general use, such as cleansing, etc.

11.4.2 Cooling Sea Water Piping for Equipment

1 Piping, etc.

(1) The system of cooling sea water piping for equipment is to be an independent system with the pump for their cooling of equipment or a system branched from the fire main through pressure reducing valves.

(2) In general, the main piping of cooling sea water piping is to be installed on the deck immediately below the bulkhead deck, such as the damage control deck.

(3) The piping is to have a system which enables separation of failure piping so as to prevent the entire system of cooling sea water piping from being inoperative by the partial piping failure.

(4) When providing an independent pump for cooling sea water piping, the following backup piping is to be required so as to maintain water supply from the fire main.

  (a) A backup piping which is connected to the main piping for cooling sea water from the fire main through pressure reducing valve.

  (b) A backup piping with pump riser pipe and pipe with orifice in vicinity of cooling equipment.

(5) As a rule, in the case the piping is to be branched from the fire main, the branch piping is to be connected at least at two locations. Each branch pipe is to be cross-connected.

(6) In general the piping branched from the fire main are to have pressure reducing valves or use orifice for depressurization. In addition, safety valves are to be installed on their secondary side.

2 Cooling Sea Water Pump for equipment

(1) In order to maintain a capacity to supply sea water for cooling even when one compartment or zone is damaged or equipment failures occur, not less than two sea water pumps for cooling are to be provided in separate compartments or zones. However, for the ships which are not intended to navigate in the threat sea areas specified in **2.2.2, Part 1**, the number of pump to be provided, may be one.

(2) When providing an independent cooling sea water pump, the performance of the pump, such as its capacity is determined as follows:

  (a) Capacity : The total amount of required cooling sea water for all equipment to be cooled.

  (b) Pressure : The maximum pressure from among the pressure required at the inlet side of all equipment to be cooled. However, the pressure at the outlet side of the equipment is to be the pressure allowed to discharge outboard.

11.4.3 Cooling Sea Water Piping for Air conditioner

1 Piping, etc.

(1) The cooling sea water piping for air conditioner is to be an independent system with dedicated cooling sea water pumps for air conditioner.

(2) The cooling sea water piping for air conditioner is to be provided with backup piping with orifice in vicinity of condensers for air conditioner to enable sea water supply from the fire main.

(3) The cooling sea water piping for air conditioner is to have a function for flow rate adjustment, as required, using flow regulation valves, etc. in vicinity of condensers for air conditioner.

2 Cooling Sea Water Pump for air conditioner

In order to maintain a capacity to supply sea water for cooling even when one compartment or zone is damaged or equipment failures occur, not less than two sea water pumps for cooling are to be provided in separate compartments or zones. However, for the ships which are not intended to navigate in the threat sea areas specified in **2.2.2, Part 1**, the number of pump to be provided, may be one.

(1) Capacity : Refer to the following formula.

Required amount of cooling sea water = (Cooling load + Compressor load) ／ (Specific heat of water × Differnce in temp at intake/outlet)

where,

Cooling load : Maximum cooling load

Compressor load : 3,600 kJ/kW × Output of compressor [kW]

Specific heat of water : 4,186 J/m^3°C

Difference in temperature at intake/outlet : Difference in temperature at inlet/outlet of condenser:

The pump capacity is the result of above formula plus some margin. As a rule, the margin is to be 15 % of the cooling load.

(2) Pressure : Considering pressure loss at the condensers of air conditioner and the pipe line, the pressure is to be sufficient to deliver required amount of sea water.

11.5 Fresh Water Piping

11.5.1 General

The requirements in this Section applies to piping system for fresh water and hot water used for drinking, cooking, bathing, feeding to auxiliary boiler, cooling water for air conditioning and washing of windows of navigation bridge, etc.

11.5.2 Piping, etc.

1 In general, the main piping of fresh water and hot water piping are to be installed on the deck immediately below the bulkhead deck, such as the damage control deck.

2 The feeding system of fresh water inboard is to be pressurized water feeding system and to feed fresh water from the fresh water tank (including temporary fresh water tanks. Same applies hereinafter) to each place of use through the valve box, the fresh water pump and fresh water pressure tank.

3 The hot water piping is to be laid in each place from the fresh water piping through general service boiler.

4 Hot water is to be fed to each use place by the pressure from the fresh water piping. The system of the main piping for the hot water is to be a circulation system so that hot water is always to be supplied using the hot water circulation pump.

5 As a rule, the fresh water piping for drinking and cooking is to be laid independently from the piping for general services such as for bath rooms.
6 The fresh water piping is not to be laid within the tanks which may contaminate the fresh water. The piping which may contaminate the fresh water is not to be laid within the fresh water tanks.
7 Valves are to be fitted to necessary places in order to prevent the entire system from non-service in case of failure in certain locations in service.
8 Not less than three hose couplings for cleaning equipment are to be installed in the positions of fore, middle and after on the weather Deck. Moreover, for washing propulsion machinery and helicopters with fresh water, the place of installation and required amount of the fresh water are to be determined upon the requirements, etc. specified by the owner.
9 In general, the air release valves and drain valves are to be fitted into the uppermost and lowermost positions within the fresh water piping.
10 The fresh water intake to the fresh water tank from the onshore facilities is to be fitted to the position above the draught line.

11.5.3 Fresh Water Pump and Pressurized Tank

1 In general, not less than two fresh water pumps are to be installed, each with a sufficient capacity for supplying all required amount of use respectively, in addition to meeting the pressure requirements for delivery to the uppermost and furthest destinations.
2 The fresh water pumps are to start or stop by the pressure switches on the fresh water pressurized tank. The start and stop pressure of the pressure switches are to be adjustable, and their pressure to start or stop each pump is to be different with each other, as assistance in case of the water supply increase, providing sufficient pressure for feeding water to each user.
3 The fresh water pumps are to be provided in the way that simultaneous or individual operation is possible.
4 As a rule, the fresh water pressurized tanks are to be installed between the fresh water pump and the fresh water main pipe.
5 The fresh water pressurized tanks are to be equipped with pressure sensors, pressure gauges, safety valves and level gauges.
6 The fresh water pressurized tanks are to be pneumatic method and check valves are to be installed at the joints so as to prevent the fresh water flowing back to the miscellaneous compressed air piping.

11.5.4 Hot Water Circulation Pump and General Service Hot Water Boiler

1 The hot water circulation pumps are to be electrically powered with an ability to lift hot water for circulation.
2 The capacity of general service hot water boiler is to be based on the number of crews, while the capacity is to be sufficient to maintain the minimum hot water temperature at 60ºC within the ship.

11.6 Chilled Water Piping

11.6.1 General

1 The requirements in this Section apply to the piping system used fresh water or a mixture of fresh water and ethylene glycol for use specified hereinafter:
(1) For cooling (cooling coil, unit cooler (chilled water type), gravity coil (chilled water type), etc.)
(2) For cooling of electronic equipment and devices in the important spaces
2 As a rule, the fresh water used in the cooling pipe is to be desalinated water.

11.6.2 Piping, etc.

1 The cooling water is operated with a circular system using chilled water circulation pumps, and piping is to be laid in an appropriate way so that chilled water is supplied to each cooling coil and unit coolers, etc.

2 The chilled water piping is to be with expansion tanks.

3 As a rule, in accordance with the full load displacement of ships *GNS-A* and *GNS-B*, the chilled water piping is to be installed as follows:

(1) Full load displacement is 6,000 *t* less : 1 line extending fore and aft on the damage control deck

(2) Full load displacement is 6,000 *t* or more : ring main system on the damage control deck

However, for ships equipped with *CBR* system each zone is to be provided with the chilled water system. As a rule, for ships other than *GNS-A* or *GNS-B*, chilled water piping is to be one line extending fore and aft on the deck immediately below the bulkhead decks, such as a damage control deck, however for those ships with larger full load displacement, it may be able to have a ring main system on the bulkhead decks, such as a damage control deck. However, the ships with only one air conditioner are not necessarily to be provided with piping specified in this requirement.

4 The chilled water piping is to have the air vent systems at optimal place.

5 In general, the method of cooling water feeding to the chilled coil is to be the proportional control system operated by automatic three-way valves.

6 The chilled water piping is to have a system which enables separation of failure piping so as to prevent the entire system from non-service in case of failure in certain locations in service.

11.6.3 Chilled Water Circulation Pump and Expansion Tank

1 In general, the chilled water circulation pumps are to be electrically powered.

2 One chilled water circulation pump is to be provided to each air conditioner. They are to be provided in separate compartments or zones. It may provide them in the same compartment or zone as specified herein.

3 As a rule, the capacity of chilled water circulation pump is to be calculated at 3 ℃ of a temperature difference at the inlet/outlet of the water cooler. The discharge pressure is to be sufficient to supply chilled water at all users. As a rule, the standard margin for the capacity is 15 %.

4 The expansion tanks are to be provided to absorb the expansion amount resulting from fluctuation of chilled water temperature. The expansion amount is to be determined by the amount of water within the piping and the maximum temperature differences.

5 The expansion tank is to be provided with a fresh water pipe so that replenishment and water supply are possible. However, in order to prevent backflow of the water in the tank, an appropriate means of prevention such as installation of check valves is required.

11.7 Scuppers and Sewage Piping

11.7.1 General

1 The requirements in this Section applies to scupper piping which sea water and rain water, etc. on the deck, etc. due to gravity, as well as sewage in general is discharged.

2 When the ships have a function to treat human sewage and sewage from medical treatment, **Part 11** applies.

11.7.2 Piping, etc.

1 Scupper pipes, sufficient in number and size, to provide effective drainage are to be provided for all decks. However, the Society may permit this means of drainage to be dispensed with in any particular compartment on bulkhead deck of any ship or class of ship, if it is satisfied that, due to the size or internal subdivision of those spaces, the safety of the ship is not thereby impaired.

2 Scupper pipes, draining weather decks and spaces within superstructures and deckhouses, which are not provided with access openings equipped with closing means in accordance with the requirements in **18.3.1, Part C of the Rules for the Survey and Construction of Steel Ships**, are to be led overboard.

3 Scupper pipes, originating from within enclosed superstructures or enclosed deckhouses on bulkhead decks, are to be led directly into inboard bilge wells. Alternatively, they may be led overboard in cases where they are provided with valves in accordance with the following requirements:

(1) Each separate discharge is to have one automatic non-return valve with a positive means of closing it from a position above the bulkhead deck, or one automatic non-return valve having no positive closing means and one stop valve controlled from above the bulkhead deck. However, where the scuppers are led overboard through the shell plating in way of a manned engine room, fitting a locally operated positive closing valve, together with a non-return valve inboard to the shell plating will also be accepted. The means for operating the positive action valve from above the bulkhead deck are to be readily accessible and provided with an indicator showing whether the valve is open or closed.

(2) However, in cases where the vertical distance from the design maximum load line to the inboard end of the scupper pipe exceeds $0.01L_f$, the scupper pipe may have two automatic non-return valves without any positive means of closing in lieu of valves prescribed in **(1)** above. In this case, the inboard valve is to be located above the level of the design maximum load line and is to be always accessible for inspection under service conditions. When it is not practicable to fit an inboard valve above the specified waterline then it can be accepted below provided that a locally controlled stop valve is fitted between the two automatic non-return valves.

(3) In cases where the vertical distance prescribed in **(2)** above exceeds $0.02L_f$, a single automatic non-return valve, without any positive means of closing, may be accepted in lieu of valves prescribed in **(1)** and **(2)** above subject to Society approval.

4 Scupper pipes from spaces below the bulkhead deck are to be led directly into inboard bilge wells. Alternatively, they may be led to overboard in cases where they are provided with valves in accordance with the following requirements:

(1) Each separate discharge is to have one automatic non-return valve with a positive means of closing it from a position above the bulkhead deck, or one automatic non-return valve having no positive closing means and one stop valve controlled from above the freeboard deck. The means for operating the positive action valve from above the freeboard deck are to be readily accessible and provided with an indicator showing whether the valve is open or closed.

(2) However, in cases where the vertical distance from the load line to the inboard end of the scupper pipe exceeds $0.01L_f$, the scupper pipe may have two automatic non-return valves without any positive means of closing in lieu of valves prescribed in **(1)** above. In this case, the inboard valve is to be located above the design maximum load draught.

5 Notwithstanding the requirements in **-3** above, scupper pipes from enclosed cargo spaces on the bulkhead deck are to be in accordance with the following requirements:

(1) In cases where the bulkhead deck is such that the deck is immersed when the ship heels more than 5 *degrees*, scupper pipes are to be led directly overboard and fitted in accordance with the requirement specified in **-3(1)** through **(3)**. Provided the requirements specified in **(2)(a)** thorough **(c)** are fulfilled, scupper pipes may be led directly into inboard bilge wells.

(2) In cases where the bulkhead deck is such that the deck is immersed when the ship heels 5 *degrees* or less, scupper pipes are to be in accordance with the following requirements:

   (a) Scupper pipes are to be led directly into inboard bilge wells.

(b) High water level alarms are to be provided in the bilge wells that are fed into by scupper pipes.
(c) In cases where enclosed cargo spaces are protected by a carbon dioxide fire-extinguishing system, deck scuppers are to be fitted with means to prevent any escape of fire-extinguishing gas.

6 Notwithstanding the requirements in **-3** and **-4** above, only one stop valve may be arranged for overboard discharge pipes which are always closed, except when discharging, during navigation. However, this stop valve is to be capable of being closed from an easily accessible position during navigation by closing devices with indicators.

7 Scuppers originating at any level and penetrating the shell plating at either more than 450 *mm* below the bulkhead deck or below 600 *mm* above the load line are to be provided with non-return valves at the shell plating. These valves, unless specifically required by **-3** and **-4** above, may be omitted provided that the thickness of the scupper pipes complies with the requirements in **Table 6.11.1** and **Table 7.13.4(2), Part 7**.

8 In cases where fixed pressure water-spraying systems are fitted in closed vehicle and Ro-ro spaces and special category spaces, drainage systems are to comply with **9.4.1-4** and **9.4.1-5, Part 9** in addition to those requirements specified in **-1** to **-7** above.

9 When the treatment of human sewage or sewage resulting from medical treatment are treated within the ships, the sewage after treatment may be directly discharged outboard or led to a storage facility onboard due to switching valves, etc.

10 For the purpose of watertightness within the compartments, the means of watertight is to be provided. For equipment and hardwares, install water sealing as required.

11 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.

Table 6.11.1 Minimum Thickness of Steel Pipes

Services of pipes	Location of pipes		Minimum thickness of the encircled alphabets corresponds to those in **Table 7.13.4(2)**
Scupper pipes Sanitary pipes (Note 1)	Penetrating shell plating except for cargo oil tanks and cargo holds and automatic non-return valves being required		Ⓖ
	Penetrating shell plating except for cargo oil tanks and cargo holds and automatic non-return valves being omitted		Ⓓ
	Led form exposed deck and passing through cargo oil tanks		Ⓐ, but 16 *mm* when $D \geqq 150 A$
	Passing through cargo holds	Not protected	Ⓐ (Note 2)
		protected	Ⓒ (Note 2)
	Passing through ballast tanks		Ⓖ
	Not passing through tanks		Ⓖ

Notes:

1 This is not applied for scupper pipes and sanitary pipes for ships not engaged in international voyages and ships of less than 24 *m* in length.

2 The thickness of the pipe need not exceed the thickness of the shell plating in way of the pipe penetration.

11.7.3 Sewage Piping

1 General

(1) The requirements in this Section apply to sewage pipes through which toilet wastes are discharged.

(2) The sewage treatment plant is to be appropriate approved by the Society.

2 Piping, etc.

(1) In general, the sewage piping is not to be penetrated through the watertight transverse bulkheads.

(2) The sewage piping within the same compartment is to be gathered as much as possible.

(3) The sewage piping is not to be laid in any rooms in which their first priority is sanitation, including galleys, medical spaces, etc.

(4) The sewage piping in the medical spaces is to be individual piping.

(5) For the ships which are designed to have sewage treatment plants, the sewage is to be directly discharged outboard or led to the sewage treatment plant by switching the valves, etc.

(6) As a standard, the position of discharge port is to be 300 *mm* above the designed maximum load line, considering taint on the shell plate. However, the discharge port for the medical sewage is to be 300 *mm* below the designed maximum load line as a standard and storm valves are to be mounted to the discharge port on the shell plate.

(7) In general, valves for the sewage piping are to be a ball valve.

11.8 Helicopter Fuel Oil (*JP*-5) Piping

11.8.1 General

1 The requirements of this Section apply to the piping system used to refuel or defuel helicopter fuel oil (hereinafter called, "*JP*-5").

2 In general, *JP*-5 piping system is composed of refueling, defueling and supply pipes, *JP*-5 transfer and supply pump, *JP*-5 storage tank and service tank, filter separator, etc.

11.8.2 Piping, etc.

1 *JP*-5 loading pipe is provided from the refueling position to *JP*-5 storage tank, in addition, *JP*-5 defueling using the *JP*-5 transfer pump is also possible.

2 Between the *JP*-5 storage tank and the service tank, the transfer piping equipped with *JP*-5 transfer pump is to be provided.

3 Between the service tank and refueling position of the helicopter, etc. supply pipe with a supply pump for *JP*-5 is to be provided. Moreover, without going through the service tank or supply pump from the *JP*-5 transfer piping, direct refueling of fuel to the helicopter is to be possible and defueling from helicopters is also necessary.

4 *JP*-5 storage tank, service tank and filter separator are to be equipped with piping which leads remaining oil to the remaining oil tank via residual oil pump and for separation water of filter separator a drain pipe which lead water into the *JP*-5 drain tank is to be installed.

5 Supplying pipes for tanks are to be through closed piping systems with outlet ends configured to reduce turbulence and foaming of the fuel.

6 In general, the transfer and supply pumps are to be equipped with safety valves.

7 At the positions which be deemed to cause undesired impact to other equipment within the system due to refueling interruption at both sides of each pump or the refueling positions, and at the other necessary positions, check valves are to be provided.

8 The supply piping is to be equipped with valves, which adjusts pressure of the piping, so as to maintain the supply pressure.

9 The drain piping is to be provided with the sight glass at optimal place.

11.8.3 Pump and Service Tank

1 Transfer pumps and supply pumps are to be electrically powered and provided with a means to prevent over-heating of pump in case of pump shut off. Two pumps of transfer and supply pump may be omitted one pump by using in common.
2 It is also acceptable to use alternatively the transfer pump and supply pump, therefore, it is necessary to install access pipes on the suction side of the pump for alternative use.
3 As a rule, the residual oil pump is to be either manual type or pneumatic-driven type.
4 Bubble dispersion prevention means is to be considered for the transfer pipe in the service tank as specified in **11.8.2-5**, in addition to installing bubble prevention means on the bottom of tank.
5 The suction port at the supply pipe in the service tank is to be installed above the transfer pipe.
6 The service tank is to be provided with overflow pipe, air vent pipe and automatic-closing oil gauge.
7 Filter separators, which has a function to remove dust and moisture, are to be provided with the discharge side of the transfer pump and supply pump.

11.9 Overflow Piping

11.9.1 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 vent pipes does not comply with the requirements in **11.10.3**;
(2) In cases where there is any opening below the open ends of air vent 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 **11.9**, overflow pipes for tanks for fuel oil, lubricating oil and other flammable oil are 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 vent 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 vapor and are not to lead into service spaces, accommodation spaces nor into closed ro-ro 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 It is desirous to install the overflow pipes at the height appropriate for the ships *GNS-A* and *GNS-B* so that fuel oil in the fuel oil tank will not flow out from the overflow pipes even provided the ship is heeled to 45°. The maximum height of the overflow pipes is to be sufficient to prevent fuel oils from overflowing in case of heel angle 45°.

11.9.2 Piping, etc.

1 In general, the overflow pipes are not to be penetrated through the watertight transverse bulkheads.
2 The aggregated sectional area of overflow pipes which come under **11.9.1-1** is to be not less than 1.25 times the aggregated sectional area of the filling pipes.
3 The internal diameter for overflow pipes is not to be less than 50 *mm*.
4 Overflow pipes to fuel oil, lubricating oil and other flammable oil tanks are to be in

accordance with the following requirements **(1)** and **(2)**:

(1) Overflow pipes are to be fed into an overflow tank of adequate capacity or into other storage tanks 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.

5 In cases where overflow pipes to deep tanks which are used alternately to carry fuel oil, cargo oil, ballast water, general cargo, etc. are connected to an overflow main common to other tanks, arrangements are to be made to prevent any liquid, gases, etc. from other tanks from leaking into the deep tank carrying general cargo, and to prevent any liquid of different quality from leaking into those other tanks from the deep tank carrying the liquid.

6 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 sea through the overflow pipes.

7 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 bulkhead deck, additional effective means are to be provided to prevent the sea water from passing inboard.

8 The overflow pipes of loading tanks for fuel replenishment at sea are to be laid to the overflow tanks.

11.10 Air Vent Piping

11.10.1 General and Piping

1 All tanks cofferdams, hazardous areas where spraying takes place and other compartments which may be pressurized are to be provided with air vent pipes having sufficient cross-sectional areas to permit easy venting from any part of the tank and cofferdam.

2 In general, the air vent pipes are not to be penetrated through the watertight traverse bulkheads.

3 Tanks having top plates not less than 7 *m* 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 vent pipe located at the highest part of the top plate. Two or more air vent pipes installed to one identical tank may be converged into one pipe at their upmost parts.

4 For tanks requiring more than one air vent pipe, overflow pipes which comply with requirement **10.9.2-2** may be used in lieu of air pipes as long as proper air flow from the tank to the atmosphere is ensured; all tanks, however, are to be provided with at least one air vent pipe.

5 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 vent pipes.

6 Air vent pipes are to be arranged to be self-draining.

7 Air vent pipes for fuel oil service, settling and lubrication oil tanks are to be located and arranged so that, in cases where such pipes break, there is no direct risk of any ingress of seawater or rainwater.

11.10.2 Open Ends of Air Vent Pipes

1 The position of the open ends of air vent pipes is to be in accordance with the following requirements **(1)** to **(5)** depending on the type and purpose of tanks.

(1) Air vent 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 sea water

(d) Cofferdams

(2) Air vent pipes to the following tanks and cofferdams are to be led to the weather part.

(a) Fuel oil tanks and thermal oil tanks

(b) Cargo oil tanks

(c) Heated lubricating oil tanks and hydraulic oil tanks

(d) Tanks which hold liquids and are filled by pumps, (only for tanks which are situated outside machinery spaces and not provided with overflow pipes)

(e) Cofferdams adjacent to fuel oil tanks and cargo oil tanks.

However, the openings of air vent pipes of lubricating oil tanks in the machine and boiler rooms, drain tanks and fresh water tanks may be led to the machine and boiler rooms.

(3) Air vent 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 vent 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. However, the openings of air vent pipes in the hazardous areas may be led inboard.

(5) In general, the openings of the air vent pipes of the fresh water tank are to be led inboard with insect screens at their heads. Provided it is unavoidable to have openings in the exposed area, cocks are to be mounted.

2 All openings of air vent pipes leading above the weather deck are to be provided with automatic closing devices.

3 The open ends of air vent pipes to fuel oil and cargo 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 vent pipe.

11.10.3 Internal Diameter of Air Vent Pipes

Sizes of air vent pipes are to be as follows:

(1) The total sectional area of air vent 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 **11.9**, the internal diameter is to be not less than 1/10 of the sectional areas of the filling pipes. The internal diameter of the air vent pipes is not to be less than 50 *mm*.

(2) Provisions are to be made for relieving vacuum when the tanks are being pumped out.

(3) The internal diameter of air vent pipes to cofferdams or tanks which form part of ship's structure is not to be less than 50 *mm*.

11.10.4 Height of Air Vent Pipes

1 The opening to be made on the exposed deck is to have a shape which prevents waves from splashing and be at the height as much as possible along with neighboring structure. As required, it is to have a closing means.

2 The height of opening on the deck is to be as follows, considering the motion of the ship:

(1) The height of opening is to be 600 *mm* or more

(2) For the ships "*GNS-A*" and "*GNS-B*", the height of opening is to be determined considering the means of prevention of out-flow of fluids in the tank or sea water inflow when the heel angle is up to 45°.

(3) In order to prevent sea water inflow at the time of wave splash, the air vent pipe to be opened on the exposed deck is to be no lower than 1,500 *mm* from the surface of the deck.

However, for the ships "*GNS-C*" and "*GNS-D*", in cases where air vent pipes extend above the bulkhead deck or the superstructure deck, all exposed parts of the pipes are to be of substantial construction; the height from the upper surface of the deck to the point where water may have access below is to be at least. In cases where these heights may interfere with the working of the ship, the height may be reduced to values approved by the Society, provided that the Society is satisfied that the closing arrangement and other circumstances justify this lower height.

760 *mm* on the bulkhead deck, and

450 *mm* on the superstructure deck

11.11 Sounding Piping

11.11.1 General and Piping

1 All tanks, cofferdams, the void spaces under the design maximum load line and the compartments under design maximum load line which are all times difficult to access are to be provided with a sounding pipe or a liquid level indicator.

2 In general, the sounding pipes are not to be penetrated through the watertight transverse bulkhead.

3 Name plates are to be affixed to the upper ends of all sounding pipes.

4 In addition to **11.11**, sounding pipes for tanks for fuel oil, lubricating oil and other flammable oils are to comply with the requirements in **2.2.2(3)(e)**, **Part 9**.

11.11.2 Upper Ends of Sounding Pipes

Sounding pipes are to be led to positions above the damage control deck or the highest point of the sounding compartments, whichever is the highest and 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 **2.2.2(3)(e)**, **2.2.2(9)** and **2.2.3(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.

11.11.3 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. In general, the curved pipes are to have a radius of larger than 3 *m*.

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 As a rule, the internal diameter of sounding pipes is to be 40 *mm*. However, those which passing through a refrigerated chamber that has been cooled down to 0 ℃ or below is not to be less than 65 *mm* and is not to be less than 32 *mm* for all other sounding pipes.

4 The sounding rods of the fuel oil tanks and fresh water tanks are to be dedicated rods for each tank. The rods are to be stored within the upper end fittings of the sounding pipes.

11.11.4 Construction of Liquid Level Indicators

A liquid level indicator which is specified in **11.11.1** 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 **2.2, Part 9**.

11.12 Miscellaneous Steam Piping

11.12.1 General

The requirements in this Section apply to piping system for steam used for cooking, bathing and heating.

11.12.2 Piping, etc.

1 In general the main pipe of miscellaneous steam pipes (including drain pipe) are to be installed on the deck immediately below the bulkhead deck, such as the damage control deck.
2 The miscellaneous steam pipes are to be installed from the auxiliary boiler specified in **Part 7** through pressure reducing valve and to each destination of use.
3 Drain pipes are to be installed at each steam equipment to exhaust air, except for bathrooms and kitchen sink. Drain pipes are also installed to return the steam to the piping of machinery installations in **Part 7**.
4 As a rule, the valves in the bathrooms and kitchen sinks where no drain pipes are installed are to provide with check valves.
5 Steam for heating and miscellaneous steam is to have different lines.
6 Valves are to be installed on the exhaust port side of equipment using steam.
7 Expansion of pipes due to heat is to be sufficiently considered, and expansion joints are to be installed in the miscellaneous steam pipes, as necessary.

11.13 Miscellaneous Compressed Air Piping

11.13.1 General

1 The requirements in this Section apply to the piping system for compressed air used for airtight tests and cleaning.
2 The pressure of miscellaneous compressed air is to be 0.7 *MPa* or less.

11.13.2 Piping, etc.

1 In general, the main pipe of miscellaneous compressed air piping is to be installed on the deck immediately below the bulkhead deck, such as the damage control deck.
2 Provided compressed air piping tends to cause stagnant of drain within there, drain discharge equipment is to be provided.
3 The miscellaneous compressed air pipes are to be installed from the air reservoir specified in **Part 7** through pressure reducing valve and to the destination of use.
4 The pipes led to the pressurized tank are to be provided with check valves.
5 Provided the pressurized tanks exceed the design pressure during operation, relief valves are to be provided so as to control the pressure inside of the tank while preventing its pressure from exceeding 1.1 times the designed value. In addition, effective means of drain discharge and pressure gauge are to be installed.

11.14 Masker Air Piping

11.14.1 General

1 Terminology
(1) "Masker system" means the equipment which has a purpose to reduce the underwater radiation noise which may be produced from the propulsion machinery and/or auxiliary system by covering the hull with bubbles.
(2) "Air compression type system" means the system which supplies air compressed with a dedicated air compressor to the emitter belt.

(3) "Air extraction system" means the system which supplies air the emitter belt after compressing it with gas turbine engine and extracting part of the combustion air.
(4) "Emitter" means the belt-shaped piping installed outside the shell plate in order to release air from the ship.
(5) "Emitter hole" means a hole made on the emitter for releasing air.

2 General

(1) As a rule, the masker system is to be provided with the ships which require reducing the underwater radiation noise produced by propulsion machinery and auxiliary system in the machinery spaces of category *A*.
(2) The source of air is to be selected appropriately by considering the performance of ship propulsion plant.
(3) The emitters are to be installed appropriately so that the machinery spaces of category *A* will be covered with bubbles.
(4) The emitters are to be provided with means to reduce the propulsion resistance and in general it is to be installed outside the shell plate approximately 1 *m* below the draft line so as to reduce wave making resistance.
(5) The emitter hole is to have a hole diameter and pitch appropriately so that the density of bubbles will be equal at any depth.
(6) The amount of air is to be sufficient so that the bubble is able to cover the target compartment.

11.14.2 Piping, etc.

1 The piping is to be laid appropriately to meet respective purposes of pipes so as to exert their full performance of related systems.

2 The piping is to be as simple as possible and without disturbing handling of equipment or overhaul inspection. It also needs to be installed to facilitate maintenance of each part.

3 The piping is to have pipe resistance as less as possible. Their weight also needs to be reduced.

4 The air pipes are to be connected to the emitter at both ends of hull at the lower position at the ship bottom area.

5 The piping is not to have stagnating drain. Provided it is not avoidable to have drain, means for drainage, etc. are to be installed.

6 The pipes to be opened to the shell plate are to have a valve in the position nearest to the shell plate.

7 Expansion and contraction of pipes are to be sufficiently considered, and expansion joints are to be installed, as necessary.

8 The pipes to be connected to the shell plates in the area below the waterline or near the waterline are to be with countermeasures for electric erosion to the bottom of a ship bottom.

9 The discharge pipes for the safety valves are to be exhausted outboard.

10 When there is risk of air coming into the sea-chest opening for pump, etc. from the emitter countermeasures are to be taken by the means, etc. to prevent air from mixing.

11 When deciding the mount positions of pipes, vibrations and impacts are to be sufficiently considered.

12 As a rule, the flow rate in the pipe is to be in accordance with the *ISO* standard or *JIS* standard.

13 The pipes laid and equipment installed are to have sufficient means for heat prevention, as necessary.

14 Emitters are to have a cleaning system as a part of maintenance.

15 In general, when the service pressure of pipes are different, pressure reducing valves are to be installed, as well as safety valve, pressure gages and accessory equipment used to reduce the pressure, as required, are to be installed.

16 When backflow of fluids in the pipes may damage the functions of equipment or these systems, check valves are to be installed in such positions.
17 In addition to flow meter, the air pipes are to have needle valves for the quantity adjustment.
18 In general, the type of pipe joint is to be a flange type. However, depending on the positions, appropriate joints, such as sleeves type, etc., may be used.
19 As a rule, the air pipes and emitter pipes are to be stainless steel.

11.14.3 Air Supply Device

1 Air compression system

(1) Air compressor

- (a) As a rule, the air compressor is to be electric type and several numbers of them are to be installed.
- (b) The air compressors are to be equipped with required safety devices in addition to automatic control systems, including constant controllers.
- (c) The air compressors are to be designed based on the intake air parameters specified in **Table 6.11.2**.
- (d) Air compressors are to be equipped with antivibration and noise prevention measures.

Table 6.11.2 Condition Of Intake Air

Item	Standard	Minimum	Maximum
Pressure (*atg*)	-0.015（constant）		
Temperature（℃）	30	-15	30
Humidity（%）	87.5	35	95

(2) Piping

- (a) As a rule each air compressor is to be connected through connecting pipes, so that even when any one compressor has failed, air are to be provided to any emitter.
- (b) Required anti-icing and anti-dust means to be taken such as filters and bypass doors, etc., at the head of the feed port.

2 Air extraction system

(1) Air cooler

- (a) In general, several number of air coolers are to be installed.
- (b) Air coolers are to have a capacity of cooling certain amount of air down to the service temperature of masker system. When the discharge side of temperature of air cooler becomes abnormally high, there is a safety device installed to shut down extraction emergently.
- (c) The cooling sea water pipe for air cooler is to be provided with safety device, such as a low pressure alarm, etc.
- (d) Air cooler is to be provided with a drain release mean as required during heat exchanging.

(2) Piping

As a rule, each air cooler is to be connected with through connecting pipes, so that even when any one cooler has failed, air can be provided to any emitter.

Chapter 12 REFRIGERATING MACHINERY AND REFRIGERATED PROVISION CHAMBER

12.1 General

12.1.1 General

1 The capacities of refrigerated provision chamber and refrigerating machinery are to be sufficient for storage of specified amount of provision to be refrigerated at required temperature conditions.

2 The refrigerating machinery is to be operated in an expeditious way while maintaining safety without being disturbed by impact, vibration or angle of inclinations.

12.1.2 Terminology

The terms used in this Chapter are defined as follows:

(1) "Refrigerated provision chamber" means the generic name of compartment which stores frozen food, fresh food, etc. at low temperature conditions so as to maintain food quality.

(2) "Refrigerating machinery" means the generic name of equipment, including compressors for refrigeration, motors, condenser, cooling equipment and other necessary accessories.

(3) "Freezer chamber" means the compartment within the refrigerated provision chamber where goods and provisions are stored at temperature of -14 °C or lower.

(4) "Cool chamber" means the compartment within the refrigerated provision chamber where goods and provisions are stored at temperature between 1 °C and 5 °C.

12.2 Refrigerated Provision Chamber Outfitting

12.2.1 General

1 The standard arrangement of refrigerated provision chamber is to be divided into freezer chamber and cool chamber by cooling temperature in each chamber, and is to be designed to access the freezer chamber through the cool chamber.

2 Each refrigerated provision chamber is to have escape and alarm systems which can be operated from the refrigerated provision chamber. The alarm system is to have external indications which are to be located in the frequently accessing area in the vicinity of the refrigerated provision chamber.

3 Ceilings, floors and peripheral walls in the refrigerated provision chamber are to be equipped with heat insulation materials sufficient for cooling.

4 Linings are to be provided within the refrigerated provision chamber. Floors and lower part of the peripheral walls are to be of watertight structure and other areas are to be of airtight structure.

5 The floors within the refrigerated provision chamber, including below both the racks and passages, are to have removable gratings.

6 In general, pipes and wires are to be laid within the refrigerated provision chamber only when necessary. When pipes and wires are laid by necessity, they are to be laid in the way and places where they do not disturb one another as much as possible.

7 Each refrigerated provision chamber is to have effective drainage systems within the chambers.

12.2.2 Refrigerated Provision Chamber Temperature Requirement

1 Initial refrigeration requirements

Stored provisions are to be refrigerated in the following conditions:

(1) Frozen food : Frozen food, -14 °C to -18 °C, to be loaded

(2) Fresh food products of meat food and fish : 0 °C to -18 °C within 30 hours
(3) Fresh vegetables and fruits : +15 °C to ＋1 °C within 30 hours

2 Chamber refrigeration temperature requirements
(1) Freezer chamber : -14 ℃ to -18 ℃
(2) Freezer chamber : -18 ℃ to -20 ℃
(3) Cool chamber : +1 ℃ to +5 ℃
(4) Lobby :+1 ℃ to +5 ℃

3 Refrigeration operational requirements
(1) Refrigeration to be made possible within 8 to 12 hours/day/set
(2) Ventilation rate of inside air by opening and closing doors for loading and unloading of provisions
   (a) Freezing chamber : 8 times/day
   (b) Cooling chamber : 10 times/day
   (c) Lobby : 10 times/day

12.3 Refrigerating Machinery

12.3.1 General

1 The requirements in this chapter apply to refrigerating machinery using the primary refrigerants listed below, used for refrigeration, air conditioning, etc., as well as any controlled atmosphere systems for cargo holds, which it is to be most suitable for in terms of intended temperature and cooling capacity. However, any refrigerating machinery with compressors of 7.5 *kW* or less and any refrigerating machinery using primary refrigerants other than those listed below are to be as deemed appropriate by the Society.

*R*134*a* : *CH*2*FCF*3
*R*404*A* : *R*125/*R*143*a*/*R*134*a* (44/52/4 *wt* %) *CHF*2*CF*3 / *CH*3*CF*3 / *CH*2*FCF*3
*R*407*C* : *R*32/*R*125/*R*134*a* (23/25/52 *wt* %) *CH*2*F*2 / *CHF*2*CF*3 / *CH*2*FCF*3
*R*410*A* : *R*32/*R*125 (50/50 *wt* %) *CH*2*F*2 / *CHF*2*CF*3
*R*507*A* : *R*125/*R*143*a* (50/50 *wt* %) *CHF*2*CF*3 / *CH*3*CF*3

2 At least two sets of refrigerating machinery are to be installed, taking into consideration that alternating refrigeration operation in each chamber must be possible.

3 Full capacity of refrigerating machinery are to be determined in the maximum value of the following conditions:
(1) Required initial refrigeration is possible.
(2) Required refrigeration temperature can be maintained during alternating operation.

4 The countermeasures are to be taken to prevent such vibration and noise from the refrigerating machinery, as required.

5 Refrigerant gas discharge pipes of the compressors are to have oil separators equipped with oil return piping. In addition, refrigerant gas suction pipes of the compressors or suction parts of the compressors are to have suction filters.

6 In case where refrigerant dehydrators are provided within the refrigerant system, bypass line is to be provided as well so as not to disturb operation during opening.

7 Refrigerant system is to be controlled with an automatic control system, so that the temperature inside the chamber will be able to be controlled automatically. Manual start and stop of the refrigerant system are also to be possible.

12.3.2 Drawings and Data

Drawings and data to be submitted for approval are generally as follows:
(1) Drawings (with materials, scantlings, type, design pressure, design temperature, etc. of pipes,

valves, etc.)
(a) Piping diagrams of refrigerating systems for refrigerating machinery
(b) Drawings of pressure vessels exposed to primary refrigerant pressure
(c) Other drawings considered necessary by the Society
(2) Data
(a) Particulars of refrigerating machinery
(b) Other drawings considered necessary by the Society

12.3.3 General and Design of Refrigerating Machinery

The design pressure of pressure vessels and piping systems and the class of pipes used for refrigerating machinery are to be as follows:
(1) The design pressure of the pressure vessels and piping systems used for the refrigerating machinery and exposed to the pressure of the refrigerant is not to be less than the pressure in **Table 6.12.1** depending on the kind of refrigerant.
(2) Pipes for the refrigerants specified in **Table 6.12.1** are to be classified into Group III.

Table 6.12.1 Design Pressure of Pressure Vessels and Piping Systems for Refrigerating Machinery

Refrigerants	High Pressure Side(1) (*MPa*)	Low Pressure Side(2) (*MPa*)
*R*134*a*	1.4	1.1
*R*404*A*	2.5	2.0
*R*407*C*	2.4	1.9
*R*410*A*	3.3	2.6
*R*507*A*	2.5	2.0

Notes:
(1) High Pressure side: The pressure part from the compressor delivery side to the expansion valve.
(2) Low Pressure side: The pressure part from the expansion valve to the compressor suction valve. In cases where a multistage compression system is adopted, the pressure part from the lower-stage delivery side to the higher-stage suction side is to be included.

12.3.4 Materials

1 Materials used for refrigerating machinery are to be suitable for the refrigerant used, with respect to design pressure, minimum working temperature, etc.
2 Materials used for primary refrigerant pipes, valves and their fittings are to comply with the requirements in **12.1.3** to **12.1.6, Part D of the Rules for the Survey and Construction of Steel Ships** according to the classes of pipes specified in **(3)(b)** above.
3 Materials used for pressure vessels exposed to refrigerant pressure (condensers, receivers and other pressure vessels) are to comply with the requirements in **2.2, Part 3** according to their respective pressure vessel classifications as specified in **10.1.3, Part 7**.
4 The following materials are not to be used for any parts of refrigerating machinery.
(1) Aluminum alloys containing over 2 % magnesium for any parts coming in contact with primary refrigerants.
(2) Pure aluminum less than 99.7 % for any parts that usually come in contact with water and are without any corrosion protection.
(3) The service limitations of valves made of iron castings are shown in **Table 6.10.2**. Although the utilization of iron castings is permitted by the Table, they are not to be used for valves in piping that has a design temperature below 0 °C or exceeding 220 °C, provided however that *GNS-C* ships and *GNS-D* ships which are not subject to the impact resistant requirements, the valves made of iron casting may be used in accordance with the use restrictions specified in

Table 6.10.2. However, in cases where the normal working pressure of the piping does not exceeding 1/2.5 times the design pressure, the temperature limitations may be lowered to -50 ℃.

12.3.5 Pressure Relief Devices

1 Relief valves are to be provided between compressor cylinders and gas delivery stop valves with any discharge being led to suction side of the compressor. However, compressors of 11 kW or less for refrigerating installations may be provided with pressure control switches in lieu of the above safety device.

2 Relief valves are to be fitted to pressure vessels which may be isolated and store primary refrigerants in a liquid condition. Any discharged gases from relief valves are to be released into the atmosphere at a safe place above the weather deck or to the low pressure parts of the equipment.

3 In cases where any discharged gases from relief valves on the high pressure parts of primary refrigerants are led to low pressure parts before being released into the atmosphere, the operation of relief valves is not to be interrupted by any back pressure accumulation.

4 Relief valves are to be provided for the cooling liquid side of condensers and the brine side of evaporators except in cases where the connected pump is so constructed that the pressure does not exceed design pressure.

12.3.6 Shop Tests

Refrigerating machinery is to be tested as follows:

(1) Pressure vessels exposed to the pressure of primary refrigerants are to be subjected to a hydrostatic test at a pressure of 1.5 times the design pressure and a tightness test at a pressure equal to the design pressure.

(2) Cylinders and crank cases of the compressors of refrigerators are to be subjected to a hydrostatic test at a pressure of 1.5 times the design pressure and a tightness test at a pressure equal to the design pressure.

Part 7 MACHINERY INSTALLATIONS

Chapter 1 GENERAL

1.1 General

1.1.1 Scope

1 The requirements in 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 For the vessels with intention of dangerous area specified in **2.2.2, Part 1** of service, the requirements in **3.3, Part 1** are to be applied.

1.1.2 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 maneuvering and safety.
Defined as all auxiliary machinery that is used for ensuring safe maneuvering, 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.

1.1.3 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 General Requirements for Machinery Installations

1.2.1 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 gas turbine ships:
Gas turbine engines (including compressors, combustors), used as the main propulsion machinery, reduction gears and propulsion shafting systems

(3) 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 Means are to be provided whereby normal operations of the main propulsion machinery can be sustained or restored even though one of the essential auxiliaries becomes inoperative. Special consideration is to be given to the malfunctioning of any of the following:

(1) A generating set which serves as a main source of electrical power;
(2) The sources of steam supply;
(3) The boiler feed water systems;
(4) The fuel oil supply systems for boilers or engines;
(5) The sources of lubricating oil pressure;
(6) The sources of water pressure;
(7) A condensate pump and the arrangements to maintain vacuum in condensers;
(8) The mechanical air supply for boilers;
(9) An air compressor and a receiver for starting or control purposes;
(10) The hydraulic, pneumatic or electrical means for control in main propulsion machinery including controllable pitch propellers.

However, having regard to overall safety consideration, a partial reduction in propulsion capability from normal operation may be accepted.

5 For the main propulsion machinery and all machinery installation for starting main propulsion machinery, means are to be provided to ensure that machinery installations can be brought into operation from the dead ship condition without external aids. In addition, the starting systems in conjunction with other machinery are to be so arranged as to restore propulsion from dead ship condition within 30 *minutes* after blackout. This does not apply to this requirements where approved by the Society.

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.

8 The exhaust gas treatment systems specified in the following **(1)** and **(2)** fitted onto machinery installations are to be to the satisfaction of the Society.

(1) Selective catalytic reduction (*SCR*) systems
(2) Exhaust gas cleaning systems (*EGCS*) (excluding those specified in **2.1.1-5**)

1.2.2 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 used solid propellers is to be capable of maintaining in free route astern at least at 70 % of the ahead speed 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.

1.2.3 Limitation in the Use of Fuel Oil

Limitation in the use of fuel oil is to comply with the requirements in **2.2.1**, **Part 9**.

1.2.4 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 **1.2.4**, fire protections are to comply with the requirements in **2.2** and **3.2**, **Part 9**.

1.2.5 Ventilating Systems for Machinery Spaces

1 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.
2 In cases where ventilation louvers are fitted to emergency generator rooms or closing appliances are fitted to ventilators serving emergency generator rooms, such louvers or closing appliances are to comply with the requirements specified in the following **(1)** to **(4)**:
(1) Louvers and closing appliances may either be hand-operated or power-operated (hydraulic, pneumatic or electric) and are to be operable under fire conditions.
(2) Hand-operated louvers and closing appliances are to comply with the following **(a)** and **(b)**:
  (a) Louvers and closing appliances are to be kept open during normal operation of the vessel; and
  (b) Corresponding instruction plates are to be provided at the location where hand-operation is provided.
(3) Power-operated louvers and closing appliances are to comply with the following **(a)** to **(c)**:
  (a) Louvers and closing appliances are to be of a fail-to-open type;
  (b) Closed louvers and closing appliances are acceptable during normal operation of the vessel; and
  (c) Power-operated louvers and closing appliances are to open automatically whenever the emergency generator is starting or in operation.
(4) Ventilation openings, louvers and closing appliances are to comply with the following **(a)** to **(c)**:
  (a) It is to be possible to close ventilation openings by a manual operation from a clearly marked safe position outside the space where the closing operation can be easily confirmed;
  (b) The louver status (open or closed) is to be indicated at the position of the manual operation specified in **(a)** above; and

(c) Closing of the louvers and closing appliances is not to be possible from any other remote position than the position of manual operation specified in **(a)** above.

1.2.6 Machinery Spaces

Machinery spaces are to be sufficiently large enough to ensure the effective operation of any machinery installations installed in that machinery space.

1.2.7 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.

1.2.8 Engineers' Alarm

An engineers' alarm is to be installed at an appropriate location in either the engine control room or manoeuvring platform so that it can be operated properly. Such an alarm is to be clearly audible in the Engineers' accommodation.

1.2.9 Operating and Maintenance Instructions for Ship Machinery and Equipment

Operating and maintenance instructions as well as engineering drawings for all ship machinery and equipment essential to the safe operation of the ship are to be provided and written in a language understandable by her officers and crew members who are required to understand such information in the performance of their duties.

1.3 Tests

1.3.1 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., the records of the tests carried out by the manufacturer are to be submitted to the Society upon request.

1.3.2 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 **1.3.1-1** above.

1.3.3 Omission of Tests

Where machinery installations have test certificates which are deemed appropriate by the Society, a part of or all of the tests for the machinery specified in **1.3.1** may be omitted.

Chapter 2 DIESEL ENGINES

2.1 General

2.1.1 General

1 The requirements in 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 For diesel engines which are used for driving emergency generators, in addition to all of the requirements in this Chapter (excluding **2.2.3**, section **2.3**, **2.4.1-4** and the requirement for "devices to stop the operation of the engine" specified in **2.5.5-1**), the requirements of **15.5.2** (if controlled automatically or by remote) as well as those in **3.3** and **3.4**, **Part 8** also apply.

3 For each type of diesel engines, an approval of use is to be obtained by the engine designer (hereinafter referred to "licensor" in this Chapter) in accordance with the requirements specified in **Chapter 8**, **Part 6 of Guidance for the Approval and Type Approval of Materials and Equipment for Marine Use**.

4 Electronically-controlled diesel engines which are used as the main propulsion machinery are to be in accordance with the requirements specified in **Annex D2.1.1, "GUIDANCE FOR THE ADDITIONAL REQUIREMENTS ON ELECTRONICALLY-CONTROLLED DIESEL ENGINES" of Part D of the Rules for the Survey and Construction of Steel Ships** in addition to those in this Chapter.

5 Diesel engines fitted with exhaust gas recirculation (*EGR*) systems are to be in accordance with requirements specified in **Annex D2.1.1-5, "GUIDANCE FOR THE SURVEY AND CONSTRUCTION OF EXHAUST GAS RECIRCULATION SYSTEMS AND ASSOCIATED EQUIPMENT" of Part D of the Rules for the Survey and Construction of Steel Ships** in addition to those in this Chapter.

6 Gas-fuelled engines are to be in accordance with the requirements specified in the followings in addition to those in this Chapter.

Annex 3, "GUIDANCE FOR HIGH PRESSURE DUAL FUEL DIESEL ENGINES" or **Annex 4, "GUIDANCE FOR LOW PRESSURE DUAL FUEL DIESEL ENGINES" of Part N of the Rules for the Survey and Construction of Steel Ships** for gas-fuelled engines to which **Chapter 16**, **Part N of the Rules for the Survey and Construction of Steel Ships** apply, and **Annex 3, "GUIDANCE FOR HIGH PRESSURE GAS-FUELLED ENGINES"** or **Annex 4, "GUIDANCE FOR LOW PRESSURE GAS-FUELLED ENGINES" of Part GF of the Rules for the Survey and Construction of Steel Ships** for gas-fuelled engines to which **Chapter 16, Part N of the Rules for the Survey and Construction of Steel Ships** does not apply (**Part GF of the Rules for the Survey and Construction of Steel Ships** apply instead).

2.1.2 Terminology

1 In this Chapter, exhaust driven turbochargers are categorised into the following three groups according to the engine power at maximum continuous rating (*MCR*) supplied by a group of cylinders served by the actual turbocharger (*e.g.*, turbocharger size is to be 50 % of total engine power for a V-engine with one turbocharger serving each bank of cylinders).

(1) Category *A* turbochargers
The engine power at *MCR* supplied by a group of cylinders served by the turbocharger is not more than 1000 *kW*.

(2) Category *B* turbochargers
The engine power at *MCR* supplied by a group of cylinders served by the turbocharger is not less than 1000 *kW,* but not more than 2,500 *kW*.

(3) Category *C* turbochargers
The engine power at *MCR* supplied by a group of cylinders served by the turbocharger is not less than 2,500 *kW*.

2 The terminology used in the application of **2.1.3-1(3)** and **-2** of **2.1.3** as well as **2.1.4** is as specified in the following **(1)** to **(36)**:

(1) "Acceptance criteria" mean a set of values or criteria which a design, product, service or process is required to conform with, in order to be considered in compliance.
(2) "Appraisal" means evaluation by a competent body.
(3) "Approval" means the granting of permission for a design, product, service or process to be used for a stated purpose under specific conditions based upon a satisfactory appraisal.
(4) "Assembly" means equipment or a system made up of components or parts.
(5) "Assess" means to determine the degree of conformity of a design, product, service, process, system or organization with identified specifications, rules, standards or other normative documents.
(6) "Certificate" means a formal document attesting to the compliance of a design, product, service or process with acceptance criteria.
(7) "Certification" means a procedure whereby a design, product, service or process is approved in accordance with acceptance criteria.
(8) "Competent body" means an organization recognized as having appropriate knowledge and expertise in a specific area.
(9) "Component" means a part, member of equipment or system.
(10) "Conformity" means that a design, product, process or service demonstrates compliance with its specific requirements.
(11) "Contract" means an agreement between two or more parties relating to the scope of service.
(12) "Customer" means a party who purchases or receives goods or services from another.
(13) "Design" means all relevant plans, documents, calculations described in the performance, installation and manufacturing of a product.
(14) "Design appraisal" means evaluation of all relevant plans, calculations and documents related to the design.
(15) "Equipment" means a part of a system assembled from components.
(16) "Equivalent" means an acceptable, no less effective alternative to specified criteria.
(17) "Evaluation" means systematic examination of the extent to which a design, product, service or process satisfies specific criteria.
(18) "Examination" means assessment by a competent person to determine compliance with requirements.
(19) "Inspection" means examination of a design, product service or process by a Surveyor.
(20) "Installation" means the assembling and final placement of components, equipment and subsystems to permit operation of the system.
(21) "Manufacturer" means a party responsible for the manufacturing and quality of the product.
(22) "Manufacturing process" means systematic series of actions directed towards manufacturing a product.
(23) "Material" means goods supplied by one manufacturer to another manufacturer that will require further forming or manufacturing before becoming a new product.
(24) "Modification" means a limited change that does not affect the current approval.
(25) "Product" means a result of the manufacturing process.
(26) "Quality assurance" means all the planned and systematic activities implemented within the quality system, and demonstrated as needed to provide adequate confidence that an entity will fulfill requirements for quality. Refer to *ISO* 9000 series.
(27) "Regulation" means a rule or order issued by an executive authority or regulatory agency of a

government and having the force of law.
(28) "Repair" means to restore to original or near original condition from the results of wear and tear or damages for a product or system in service.
(29) "Requirement" means specified characteristics used for evaluation purposes.
(30) "Information" means additional technical data or details supplementing the drawings requiring approval.
(31) "Specification" means technical data or particulars which are used to establish the suitability of materials, products, components or systems for their intended use.
(32) "Substantive modifications" mean design modifications, which lead to alterations in the stress levels, operational behavior, fatigue life or an effect on other components or characteristics of importance such as emissions.
(33) "Sub-supplier/subcontractor" means one who contracts to supply material to another supplier.
(34) "Supplier" means one who contracts to furnish materials or design, products, service or components to a customer or user.
(35) "Test" means a technical operation that consists of the determination of one or more characteristics or performance of a given product, material, equipment, organism, physical phenomenon, process or service according to a specified procedure. A technical operation to determine if one or more characteristic(s) or performance of a product, process or service satisfies specific requirements.
(36) "Witness" means an individual physically present at a test and being able to record and give evidence about its outcome.

3 For low pressure gas-fuelled engines, the terminology is in accordance with the requirements specified in **1.4 of Annex 4, Part GF** or **1.4 of Annex 4, Part N of the Rules for the Survey and Construction of Steel Ships**.

2.1.3 Drawings and Data

1 Drawings and data to be submitted are generally as follows:
(1) Drawings and data for approval
 (a) Connecting rod bearings (including bolts details) of 4-stroke cycle engines
 (b) High pressure oil pipes for driving exhaust valves with its shielding
 (c) High pressure fuel oil pipes with its shielding and clamping
 (d) 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)
 (e) The drawings and data as specified in **(3) (d)** to **(f)**
 (f) The drawings and data, etc. as required by the requirements of **2.1.4** (excluding those specified in **2.1.3-1(3)**)
 (g) The following drawings and data for exhaust driven turbochargers:
  i) Sectional assembly
   1) For *A* turbochargers, this drawing is to be contained the principal dimension and parts name. This requirement will be modified where approved by the Society.
   2) For *B* or *C* turbochargers, this drawing is to be contained the principal dimension and the material of housing parts regarding the evaluation for preventing the scatter of fracture parts.
  ii) Particulars (only for category *B* or *C* turbochargers)
   1) Maximum permissible running speed (min^{-1})
   2) Maximum permissible exhaust gas temperature
   3) Lower limit of lubricating oil inlet pressure.
   4) Upper limit of lubricating oil outlet temperature.
   5) Maximum permissible vibration level (self-generated vibration, external

generated vibration, and so on)

iii) Documentation of containment in the event of the disc fracture specified in **2.5.1-4** (only for category *B* or *C* turbochargers with novel design features or no service records)

iv) Drawings of the housing and rotating parts, including details of blade fixing (only for category *C* turbochargers)

v) Material specifications of the parts mentioned in **iv)** above (only for category *C* turbochargers. Mechanical property and chemical composition are to be provided.)

vi) Welding details and welding procedures for the parts mentioned in **iv)** above, if made of welded construction (only for category *C* turbochargers with novel design features or no service records)

(2) Drawings and data for reference

(a) A list containing all drawings and data submitted (with relevant drawing numbers and revision status)

(b) Gudgeon pins

(c) Connecting rod bearings (including bolts details) of 2-stroke cycle engines

(d) Rocker valve gears

(e) Cylinder cover fixing bolts and valve box fixing bolts

(f) Engine control system diagram (including the monitoring, safety and alarm systems)

For diesel engines with *B* or *C* turbochargers, the drawing is to be contained the following items.

i) Set points for over speed protective devices

ii) Set points for temperature protective devices for turbine inlet exhaust gas temperature

iii) Set points for low pressure protective devices for lubricating inlet pressure

iv) Set points for high temperature protective devices for lubricating outlet temperature

(g) Construction and arrangement of dampers, detuners, balancers or compensators, bracings as well as all calculation sheets related to engine balancing and engine vibration prevention

(h) Location of measures preventing oil from spraying out from joints in flammable oil piping (if fitted)

(i) The following drawings and data for exhaust driven turbochargers:

i) Documentation of the safe torque transmission specified in **2.5.1-5** when the disc is connected to the shaft by an interference fit (only for category *C* turbochargers with novel design features or no service records)

ii) Information on expected lifespan (only for category *C* turbochargers with novel design features or no service records)

iii) Operation and service manuals (only for category *C* turbochargers with novel design features or no service records)

(j) Other drawings and data deemed necessary by the Society

(3) Drawings and data for the purpose of inspection and testing of diesel engines

(a) A list containing all drawings and data submitted (including relevant drawing numbers and revision status)

(b) Engine particulars to be in the form designated by the Society

(c) Material specifications of main parts with information on non-destructive testing and pressure testing as applicable to the material

(d) Bedplate and crankcase of welded design, with welding details and welding instructions for approval of materials and weld procedure specifications. The weld procedure specification is to include details of pre and post weld heat treatment, weld consumables and fit-up conditions.

(e) Thrust bearing bedplate of welded design, with welding details and welding instructions for approval of materials and weld procedure specifications. The weld procedure specification is to include details of pre and post weld heat treatment, weld consumables and fit-up conditions.

(f) Frame/framebox/gearbox of welded design, with welding details and instructions for approval of materials and weld procedure specifications. The weld procedure specification is to include details of pre and post weld heat treatment, weld consumables and fit-up conditions.

(g) Crankshaft, assembly and details

(h) Thrust shaft or intermediate shaft (if integral with engine)

(i) Shaft coupling bolts

(j) Bolts and studs for main bearings

(k) Bolts and studs for cylinder heads and exhaust valve (two stroke design)

(l) Bolts and studs for connecting rods

(m) Tie rods

(n) Schematic layout or other equivalent drawings and data on the diesel engine of the following **i)** to **vii)** (Details of the system so far as supplied by the licensee such as: main dimensions, operating media and maximum working pressures).

    i) Starting air system
    ii) Fuel oil system
    iii) Lubricating oil system
    iv) Cooling water system
    v) Hydraulic system
    vi) Hydraulic system (for valve lift)
    vii) Engine control and safety system

(o) Shielding of high pressure fuel pipes, assembly
(All engines)

(p) Construction of accumulators for hydraulic oil and fuel oil

(q) High pressure parts for fuel oil injection system
The documentation to contain specifications for pressures, pipe dimensions and materials.

(r) Arrangement and details of the crankcase explosion relief valve (only for engines of a cylinder diameter of 200 *mm* or more or a crankcase volume of 0.6 m^3 or more)

(s) Oil mist detection and/or alternative alarm arrangements

(t) Cylinder head

(u) Cylinder block, engine block

(v) Cylinder liner

(w) Counterweights (if not integral with crankshaft), including fastening

(x) Connecting rod with cap

(y) Crosshead

(z) Piston rod

(aa) Piston, assembly, including identification (*e.g.* drawing number) of components

(ab) Piston head

(ac) Camshaft drive, assembly, including identification (*e.g.* drawing number) of components

(ad) Flywheel

(ae) Arrangement of foundation (for main engines only)

(af) Fuel oil injection pump

(ag) Shielding and insulation of exhaust pipes and other parts of high temperature which may be impinged as a result of a fuel system failure, assembly

(ah) Construction and arrangement of dampers

(ai) For electronically controlled engines, assembly drawings or arrangements of the following **i)** to **iv)**:

i) Control valves

ii) High-pressure pumps

iii) Drive for high pressure pumps

iv) Valve bodies, if applicable

(aj) Operation and service manuals

Operation and service manuals are to contain maintenance requirements (servicing and repair) including details of any special tools and gauges that are to be used with their fitting/settings together with any test requirements on completion of maintenance.

(ak) Test program resulting from *FMEA* (for engine control system) in cases of engines that rely on hydraulic, pneumatic or electronic control of fuel injection and/or valves

(al) Production specifications for castings and welding (sequence)

(am) Certification of an approval of use for environmental tests, control components

Drawings and data modified for a specific application are to be submitted to the Society for information or approval, as applicable.

(an) Quality requirements for engine production

(ao) Other drawings and data deemed necessary by the Society

2 The drawings and data specified in **-1(3)** above are to be submitted by the engine manufacturer producing engines with the drawings and data whose approval of use has been obtained in accordance with **2.1.1-3** (hereinafter referred to "licensee" in this Chapter) but may be submitted by the licensor in accordance with **2.1.4-2**.

2.1.4 Approval of Diesel Engines

1 Diesel engines are to be approved in accordance with the following **(1)** to **(6)**:

(1) Development of documents and data for engine production

(a) Prior to the start of the diesel engine approval process in accordance with the following **(3)** and subsequent sub-paragraphs of this paragraph, a design approval is to be obtained as specified in **Chapter 8, Part 6 of Guidance for the Approval and Type Approval of Materials and Equipment for Marine Use**.

(b) Each type of diesel engine is to be provided with a certificate of approval of use obtained by the licensor in accordance with **2.1.1-3**. For the first engine of a type or for those with no service records, the process of an approval of use and the approval process for production by the licensee may be performed simultaneously.

(c) The licensor is to review the drawings and data of the diesel engine whose approval of use has been obtained for the application and develop, if necessary, application specific drawings and data for production of diesel engines for the use of the licensee in developing the diesel engine specific production drawings and data listed in **2.1.3-1(3)**.

(d) If substantive modifications to the drawings and data of the diesel engine whose approval of use has been obtained have been made in the drawings and data of diesel engines to be produced, the affected drawings and data are to be resubmitted to the Society as specified in **8.2.2-2, Part 6 of Guidance for the Approval and Type Approval of Materials and Equipment for Marine Use**.

(2) Drawings and data for the purpose of inspection and testing of diesel engines

(a) The licensee is to develop the drawings and data listed in **2.1.3-1(3)** and a comparison list of these drawings and data to the drawings and data of the diesel engine whose approval of use has been obtained by the licensor and submit these drawings and the comparison list to the Society.

(b) In applying **2.1.3-1(3)**, if there are differences in the technical content on the licensee's production drawings and data of the diesel engine compared to the drawings and data of the diesel engine whose approval of use has been obtained by the licensor, the licensee is to submit "Confirmation of the licensor's acceptance of licensee's modifications" approved by the licensor and signed by the licensee and licensor. If the licensor acceptance is not confirmed, the diesel engine manufactured by the licensee is to be regarded as a different engine type and is **2.1.1-3** is to apply to the diesel engine.

(c) In applying **(b)** above, modifications applied by the licensee are to be provided with appropriate quality requirements.

(d) The Society returns the drawings and data specified in **(a)** and **(b)** above to the licensee with confirmation that the design has been approved.

(e) The licensee or its subcontractors are to prepare to be able to provide the drawings and data specified in **(a)** and **(b)** above so that the Surveyor can use the information for inspection purposes during manufacture and testing of the diesel engine and its components.

(3) Additional drawings and data

In addition to the drawings and data listed in **2.1.3-1(3)**, the licensee is to be able to provide to the Surveyor performing the test specified in **2.6.1** upon request the relevant detail drawings, production quality control specifications and acceptance criteria. These drawings and data are for supplemental purposes to the survey only.

(4) Licensee approval

(a) The Society assesses conformity of production with the Society's requirements for production facilities comprising manufacturing facilities and processes, machining tools, quality assurance, testing facilities, etc. as specified in **8.2.2-4, Part 6 of Guidance for the Approval and Type Approval of Materials and Equipment for Marine Use**.

(b) Satisfactory conformance with **(a)** above results in the issue of a document showing the licensee has been approved by the Society.

(5) Engine assembly and testing

The licensee is to assemble and test the diesel engine according to the Society's technical rules each of the diesel engine assembly and testing procedure is to be witnessed by the Surveyor unless the manufacturer of the diesel engine is one approved in accordance with the **Rules for Approval of Manufacturers and Service Suppliers** and use of a mass production system is agreed between the manufacturer and the Society.

(6) Issue of certificates of diesel engines and components

(a) The attending Surveyors, at the licensee/subcontractors, will issue product certificates as necessary for components manufactured upon satisfactory inspections and tests.

(b) An engine certificate is issued by the Surveyor upon satisfactory completion of assembly and tests specified in **(5)** above.

2 In applying **-1** above, for those cases when a licensor - licensee agreement does not apply, a "licensor" is to be understood as the following **(1)** or **(2)**:

(1) The entity that has the design rights for the diesel engine type; or

(2) The entity that is delegated by the entity having the design rights to modify the design.

3 Components of licensor's design which are covered by the certificate of approval of use of the relevant engine type are regarded as approved whether manufactured by the diesel engine manufacturer or sub-supplied.

4 For components of subcontractor's design, necessary approvals are to be obtained by the relevant suppliers (*e.g.* exhaust driven turbochargers, charge air coolers, etc.).

2.2 Construction and Strength

2.2.1 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 **Part 3**.

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

8 The arrangement of main propulsion engine is to be planned to cause the damage as little as possible.

9 The machinery for main propulsion and the auxiliary apparatus associated with main propulsion are to be divided into each propulsion shafting system (for multiple engines vessel, each engine system). Each system is to be able to be use separately.

10 The apparatus and equipment are to be arranged as lower as possible. And the centre of balance of apparatus and equipment is to be approached the centreline of vessel as close as possible.

11 The equipment is to be arranged in consideration of the easy operation, easy maintenance, easy assembly of piping system and un-obstacle to the maintenance for hull structure.

2.2.2 Crankpin Bearings of 4-Stroke Cycle Engines

The crankpin bearings of 4-stroke cycle engines are to be designed and constructed so as to keep a fair contact pressure upon the contact face of the bearing caps as well as not to cause any excessive stress on the crankpin bolts against the alternating load acting on the connecting rod.

2.2.3 Flywheel Shafts and Other Shafts

Where flywheels or eccentric sheaves for pumps are fitted onto crankshafts or additional shaft located between the aftermost journal bearing and the thrust shaft, the shaft diameter in way of the part is not to be less than the required diameter of the crankshaft determined by the formula in **2.3**.

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*)

$M = 10^{-2} A L P_{max}$

$T = 10^{-2} B S P_{mi}$

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 7.2.1** and **Table 7.2.2** 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.

Table 7.2.1 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 7.2.2(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 7.2.2(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

D : Cylinder bore (*mm*)

K_m : Value given by the following **(1)** or **(2)** 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.

(1) 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 760 N/mm^2 for carbon steel forgings and 1,080 N/mm^2 for low alloy steel forgings.

(2) In cases where the specified tensile strength of material is not more than 440 N/mm^2 but not less than 400 N/mm^2;

$K_m = 1.0$

K_s : Value given by the following **(1)**, **(2)**, or **(3)** in accordance with the manufacturing method of crankshafts.

(1) 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;

$$K_s = \sqrt[3]{\frac{1}{1.15}}$$

(2) 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 (%)

(3) In cases other than **(1)** and **(2)** above;

$K_s = 1.0$

K_h **:** Value given by the following **(1)** or **(2)** in accordance with the inside diameter of the crankpins or journals.

(1) 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

(2) In cases where the inside diameter is less than one-third of the outside diameter;

$K_h = 1.0$

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 $(d_c/d_a)^3$.

$$\left\{0.122\left(2.20 - {}^{b}/_{d_a}\right)^2 + 0.337\right\}({}^{d_a}/_{t})^{1.4} \le 1$$

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 ($N \cdot m$)
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:

$$t \geq \frac{C_1 T D^2}{C_2 d_h^2 (1 - 1/r_s^2)}$$

$$t \geq 0.525 d_c$$

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 $(1 - R^2)$

$$\alpha = \frac{\text{Shrinkage allowance } (mm)}{d_h} \times 10^3$$

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*)

$$r_s = \frac{\text{External diameter of web } (mm)}{d_h}$$

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:

$$\frac{1.1Y}{225} \leq \alpha \leq \left(\frac{1.1Y}{225} + 0.8\right) \frac{1}{1 - R^2}$$

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

However, when the specified yield point of the crank web exceeds 390 N/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

$$\frac{S - d_p - d_j}{2 d_p}$$

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 **2.2.3** 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 1,000 N/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 speed 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 speed 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 speed by more than 15 %.

2.4.2 Alarm for Overpressure in the Cylinders

Each cylinder of diesel engines having a bore exceeding 230 *mm* is to be provided with an effective sentinel valve or other means for overpressure.

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 0.6 m^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 7.2.3**.

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 0.6 m^3.

4 The explosion relief valves given in **-1** and **-3** above are to conform to the following requirements **(1)** to **(3)**:

(1) The free area of each explosion relief valve is to be not less than 45 cm^2.

(2) The combined free area of the valves fitted on an engine is to be not less than 115 cm^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 7.2.3 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

1 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 Scavenging spaces in open connection to the cylinders are to be connected to an approved fire extinguishing system completely independent of the system in the engine room.

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 low speed diesel engines (a rated speed of less than 300 min^{-1}), 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 medium speed diesel engines (a rated speed of 300 min^{-1} and above, but less than 1,400 min^{-1}) and high speed diesel engines (a rated speed of 1,400 min^{-1} and above), 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 Turbochargers

1 For main propulsion engine equipped with exhaust driven turbochargers, 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 turbochargers.

2 Where the main propulsion engine cannot be operable only with the exhaust driven turbochargers 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 turbochargers show their function.

3 The air inlets of exhaust driven turbochargers with novel design features or no service records are to be fitted with filters.

4 Exhaust driven turbochargers with novel design features or no service records are to be capable of containment in the event of a rotor burst. This means that no parts are to penetrate the casing of exhaust driven turbochargers or escape through the air intake in the case of a rotor burst. It is to be assumed that the discs disintegrate in the worst possible way.

5 In the case of category *C* turbochargers with novel design features or no service records where the disc is connected to the shaft by an interference fit, calculations are to substantiate safe torque transmission during all relevant operating conditions such as maximum speed, maximum torque and maximum temperature gradient combined with minimum shrinkage amount.

6 For categories *B* and *C* turbochargers with novel design features or no service records, the indications and alarms listed in the **Table 7.2.4** are to be provided. Indications may be provided at local locations, monitoring stations or control stations. Alarm levels may be equal to permissible limits, but are not to be reached when operating the engine at 110 % power, or at any approved intermittent overload beyond 110 % in cases where the turbochargers are fitted to engines for which intermittent overload power is approved.

7 Turbochargers are to have compressor characteristics that allow the engines, for which they are intended, to operate without any audible high pitch vibrations or explosion-like noises from the scavenger area of the engine (hereinafter referred to as "surging" in this Part) during all operating conditions and also after extended periods of operation. For abnormal, but permissible, operation conditions such as misfiring and sudden load reduction, repeated surging (hereinafter referred to as "continuous surging") is not to occur.

Table 7.2.4 Alarms and Indications of Turbochargers

Monitoring Item	Category *B* Turbochargers		Category *C* Turbochargers		Remarks
	Alarm	Indication	Alarm	Indication	
Speed	H(1)	○(1)	H(1)	○(1)	Alarm level is to be based upon an air inlet temperature of 45 °C.
Exhaust gas temperature at each turbocharger inlet	H(2)	○(2)	H	○	High temperature alarms for each cylinder at engine are acceptable.(3)
Lubrication oil temperature at turbocharger outlet	—	—	H	○	If not forced lubrication system, oil temperature near bearings is to be monitored.
Lubrication oil pressure at turbocharger inlet	L	○	L	○	Only for forced lubrication systems.(4)

Notes:

(1) For turbocharging systems where turbochargers are activated sequentially, speed monitoring is not required for the turbocharger(s) being activated last in sequence, provided all turbochargers share the same intake air filter and are not fitted with waste gates.

(2) Exhaust gas temperature may be alternatively monitored at the turbocharger outlet, provided that the alarm level is set to a safe level for the turbine and that correlation between inlet and outlet temperatures is substantiated.

(3) Alarms and indications for exhaust gas temperatures at turbocharger inlets may be omitted if the alarms and indications for individual exhaust gas temperatures are provided for each cylinder and the alarm level is set to a value safe for the turbocharger.

(4) Separate sensors are to be provided when the lubrication oil system of the turbocharger is not integrated with the lubrication oil system of the diesel engine, or when it is separated from the diesel engine lubrication oil system by a throttle or pressure reduction valve.

(5) "H" and "L" mean "high" and "low", respectively.

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 **13.14** 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)** through **(5)**:

(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*.

(3) An adequate rupture disc device is to be fitted at an appropriate position on the starting air manifold as an emergency means of relieving a pressure caused by explosion for direct reversing engines fitted with flame arresters in accordance with **(2)** above.

(4) For rupture disc devices of which ruptured discs cannot be easily replaced, a mechanism of blocking up the exhaust way is to be provided for the purpose of quick restart of the engine. This blocking mechanism is to be fitted with a means of indicating whether it is blocking or not.

(5) An effective arrangement to prevent the accumulation of combustibles (fuel oil, lubrication oil, system oil, etc.) in the starting air manifold or to prevent the excessive temperature rise in the starting air manifold is to be provided for direct reversing engines.

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)**, **(2)** and **(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 **13.11**.

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 **13.7** and **2.2.2, 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 The lubricating oil arrangements are to be provided with lubricating oil sampling connections at proper locations.
3 Lubricating oil arrangements for rotor shafts of exhaust driven turbochargers are to be designed so that the lubricating oil may not be drawn into charging air.
4 Lubricating oil drain pipes from the engine crankcase sump to the sump tank are to be submerged at their outlet ends.
5 The lubricating oil drain pipes shown in **-4**, above of two or more engine units are not to be interconnected.
6 Arrangements for lubricating oil system are additionally to comply with the requirements in **13.8** and **2.2.3, Part 9**.

2.5.6 Cooling Arrangements

Cooling arrangements are to comply with the requirements in **13.10** 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.

2.5.7 Engine Driven Chargers

Engine driven chargers are, in principle, to be in accordance with the requirements of exhaust driven turbochargers specified in this Chapter.

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 on the water or oil side of the component at the pressures shown in the Table. In cases deemed necessary by the Society, tests may also be required for any components not specified in **Table 7.2.5**.
2 For diesel engines, shop trials are to be carried out according to the test procedure deemed appropriate by the Society.
3 For diesel engines with novel design features or for those with no service records, tests are to

be carried out to verify their durability according to the procedure deemed appropriate by the Society.

4 For rotating assemblies of exhaust driven turbochargers, dynamic balancing tests are to be carried out.

5 For the impellers and inducers of exhaust driven turbochargers, overspeed tests are to be carried out according to test procedures deemed appropriate by the Society.

6 For categories *B* and *C* turbochargers with novel design features or for those with no service records, tests are to be carried out to verify durability according to procedures deemed appropriate by the Society.

Table 7.2.5 Hydrostatic Test Pressure

Part		Cylinder bore D (mm) $D \le 300$	Cylinder bore D (mm) $300 < D$	Test Pressure[1](MPa)
Cylinder block (gray cast iron or spheroidal graphite cast iron) [2] [3] [10]		○	○	1.5 P
Engine block (gray cast iron or spheroidal graphite cast iron) [3] [4] [10]		○	○	1.5 P
Cylinder liner [3]			○	1.5 P
Cylinder head (gray cast iron, spheroidal graphite cast iron, cast steel or forged steel) [10]			○	1.5 P
High pressure fuel line	Fuel injection pump body fuel injection valves [5]	*TR*[6]	○	1.5 P or P +30, whichever is smaller
	fuel injection pipes including common fuel rail [5]	*TR*[6]	○	
High pressure common servo oil system		*TR*[6]	○	1.5 P
Turbocharger, cooling space [7]		○	○	0.4 or 1.5 P, whichever is greater
Heat exchanger, both sides			○	1.5 P
Exhaust gas valve cage [2]		○	○	1.5 P
Accumulator of common rail fuel or servo oil system [8]		○	○	1.5 P
Piping, pumps, actuators, etc. for hydraulic drive of valves [9]		○	○	1.5 P
Engine driven pumps (oil, water, fuel, bilge) [9]		○	○	1.5 P
Piping system other than those listed in this Table		○	○	Apply the requirements in **13.15**

Notes:

(1) P is the maximum working pressure (MPa).

(2) Only for crosshead diesel engines.

(3) Hydrostatic tests are also required for those parts filled with cooling water that have the ability to contain water which is in contact with the cylinder or cylinder liner.

(4) Only when engine power exceeds 400 *kW/cyl*.

(5) Only when not autofretted.

(6) For items marked by *TR*, submission of a test report signed by the manufacturer which compiles test results in an acceptance protocol issued by the manufacturer may be accepted. Tests or inspections may be carried out on samples from the current production.

(7) In cases where the manufacturer has a quality system deemed appropriate by the Society, hydrostatic tests for categories *A* and *B* turbochargers may be substituted for by manufacturer tests. In such cases, the submission or presentation of test records may be required by the Society.

(8) Only when capacity exceeds 0.5 *l*.

(9) Only when engine power exceeds 800 *kW/cyl*.

(10) Gray cast iron is to be used only for *GNS-D* and the position which is free from influence of thermal, impact and so on.

Chapter 3 GAS TURBINES

3.1 General

3.1.1 Scope

1 The requirements in this Chapter apply to open cycle gas turbines (*i.e.*, thermodynamic cycle in which the working fluid enters the gas turbine from the atmosphere and is discharged into the atmosphere) used as 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.). The requirements of this Chapter apply mutatis mutandis to other cycle types gas turbines.

2 Gas turbines for driving emergency generators are to comply with the requirements in **3.3** and **3.4, Part 8**, in addition to the requirements (excluding **3.3.1-1**, **3.3.2** and **3.3.3**) in this Chapter.

3.1.2 Terminology

The terminology used in this Chapter is as specified in the following **(1)** to **(5)**:

(1) "Gas generator" is an assembly of gas turbine components that produces heated pressurized gas to a process or to a power turbine.

(2) "Power turbine" is a turbine which is driven by the gases from a gas generator, producing power output from the gas turbine through an independent shaft.

(3) "Combustion chamber" is a component of a gas turbine in which fuel (heat source) reacts with the working fluid to increase its temperature.

(4) "Enclosure" is barriers, used to protect personnel, protect equipment from the environment, contain fires and possibly provide sound attenuation.

(5) "Principal components" of gas turbines are those listed in the following **(a)** to **(h)**:

- (a) Discs (or rotors), stationary blades and moving blades of the turbine
- (b) Discs, stationary blades and moving blades of the compressor
- (c) Turbine and compressor casings
- (d) Combustion chambers
- (e) Turbine output shafts
- (f) Connecting bolts for main turbine components
- (g) Shaft couplings and bolts
- (h) Pipes, valves and fittings attached to a gas turbine classified in **Part 3** as either Group I or II

3.1.3 Drawings and Data

Drawings and data to be submitted are as follows:

(1) Drawings and data for approval

- (a) Discs (and/or rotors) of the turbine and compressor
- (b) Combustion chambers
- (c) Details of the fixing of moving and stationary blades
- (d) Shaft couplings and bolts
- (e) Piping arrangements fitted to the turbine (including fuel, lubricating oil, cooling water, pneumatic and hydraulic systems and information on materials, sizes and working pressures of pipes)
- (f) Pressure vessels and heat exchangers (classified as Group I and Group II as defined in **10.1.3**) attached to the turbine
- (g) Details of turbine installation
- (h) Particulars (type and product number of the turbine, power and speed of the turbine and compressors at maximum continuous rating, temperatures and pressure at turbine inlet

and outlet, pressure losses in inlet air and exhaust gas arrangements, ambient condition intended for operation, fuel oil and lubricating oil to be used)

(i) Material specifications of principal components

(j) Critical speeds of turbine rotors and compressors

(k) Number of moving blades in each stage

(l) Number and arrangements of stationary blades

(m) Lists of safety devices, including those specified in **3.3.5**

(n) In the case of a gas turbine without service records for Society-classed ships or the modification of specifications of a gas turbine with such service records, the following **i)** and **ii)**:

i) Welding details of principal components

ii) Maintenance instructions

(2) Drawings and data for reference

(a) A list containing all drawings and data submitted (with relevant drawing numbers and revision status)

(b) Sectional assembly

(c) Moving blades and stationary blades

(d) General arrangement

(e) Starting arrangement

(f) Inlet air and exhaust gas arrangements

(g) Diagram of engine control systems

(h) Documents containing strength considerations made for principal components

(i) Calculation sheets for vibration of turbine blades

(j) Documentation on the failure mode and effect analysis

(k) In the case of a gas turbine without service records for Society-classed ships or modification specifications of a gas turbine with such service records, the following **i)** and **ii)**:

i) Operation instructions for fuel oil control systems

ii) Illustrative drawing of cooling method for each part of turbine

(l) Other drawings and data deemed necessary by the Society

3.2 Materials, Construction and Strength

3.2.1 Construction and Installations

1 Gas turbines are to be so designed that no excessive vibration and surging, etc. are induced within the operating speed range.

2 Each part of gas turbines is to be so constructed that no detrimental deformations are caused by its thermal expansions.

3 Where the principal components of gas turbines are of welded construction, they are to comply with the requirements in **Part 3**.

4 Gas turbines used as main propulsion machinery are to be so designed that they can restart immediately when the electrical power supply is resumed after any stoppage resulting from a temporary failure of the main source of electrical power.

5 Gas turbines are to be installed so that no excessive structural constraints are caused by thermal expansion.

6 Gas turbines are to be installed so that any turbine or compressor blade loss or any failure of other principal components does not endanger persons and machinery in the vicinity of the gas turbine. In addition, gas turbines are to be constructed to contain, as far as possible, turbine or compressor blades and any blade debris in the event of blade loss.

7 The arrangement of main propulsion engine is to be planned to cause the damage as little as possible.
8 The machinery for main propulsion and the auxiliary apparatus associated with main propulsion are to be divided into each propulsion shafting system (for multiple engines vessel, each engine system). Each system is to be able to be use separately.
9 The apparatus and equipment are to be arranged as lower as possible. And the centre of balance of apparatus and equipment is to be approached the centreline of vessel as close as possible.
10 The equipment is to be arranged in consideration of the easy operation, easy maintenance, easy assembly of piping system and un-obstacle to the maintenance for hull structure.

3.3 Safety Devices

3.3.1 Governors and Overspeed Protective Devices

1 Gas turbines are to be provided with an overspeed protective device. This device is to be so adjusted that the output shaft speed may not exceed the maximum continuous speed by more than 15 % and is to have the functions specified in **3.3.2-2**.
2 Gas turbines are to be provided with a speed governor independent of the overspeed protective device specified in **-1** above. The speed governor is to be capable of controlling the speed of the unloaded gas turbine without bringing the overspeed protective device into action.
3 The governors of gas turbines used to drive generators are to comply with the requirements in **2.4.2-1** and **-2, Part 8**. However, when gas turbines used as main propulsion machinery in electric propulsion ships are used to drive generators to supply electric power exclusively to propulsion motors, the requirements in **5.1.2-2, Part 8** are to be applied.

3.3.2 Shut-down Devices

1 Gas turbines are to be provided with hand trip gear for shutting off the fuel in an emergency which is to be provided at the control station.
2 Gas turbines are to be provided with a quick closing device (shut-down device) which automatically shuts off the fuel supply to the turbines at least in the cases of the following **(1)** to **(7)**. In addition, means are to be provided so that alarms are operated at the control station by the activation of these shut-down devices.
(1) Over speed
(2) Unacceptable lubricating oil pressure drop (for gas turbines other than the main gas turbines, only in the case where forced lubrication is adopted.)
(3) Failure of the lubricating oil system
(4) Failure in automatic starting
(5) Loss of flame during operation
(6) Excessive vibrations
(7) Excessive high temperature of gas at the turbine inlet or outlet
3 In addition to the requirements specified in **-2** above, gas turbines used as main propulsion machinery are to be provided with a quick closing device (shut-down device) which automatically shuts off the fuel supply to the turbines in at least the following **(1)** to **(3)** cases. In addition, means are to be provided so that alarms are operated at the control station by the activation of these shut-down devices.
(1) Excessive axial displacement of each rotor (except for gas turbines with roller bearings)
(2) Unacceptable lubricating oil pressure drop of reduction gear
(3) Excessive high vacuum pressure at the compressor inlet

3.3.3 Alarms

Gas turbines are to be provided with alarm devices as required by **Table 7.3.1**.

Table 7.3.1 Emergency Shutdown and Alarm Settings(1)

Monitoring parameter	Alarm	Emergency Shutdown	
		Gas turbines used as main propulsion machinery	Gas turbines other than those used as main propulsion machinery
Turbine speed	H	X	X
Lubricating oil pressure	L(2)	X	X(3)
Failure of the lubricating oil system	○(4)	X	X
Lubricating oil pressure of reduction gear	L(2)	X	
Differential pressure across lubricating oil filter	H		
Lubricating oil temperature	H		
Oil fuel supply pressure	L		
Oil fuel temperature	H		
Cooling medium temperature	H		
Bearing temperature	H		
Flame and ignition failure	○	X	X
Automatic starting failure	○	X	X
Vibration	H(2)	X	X
Axial displacement of rotor	H	X	
Exhaust gas temperature at the turbine inlet	H(2)	X	X
Exhaust gas temperature at the turbine outlet	H(2)	X	X
Vacuum pressure at the compressor inlet	H(2)	X	
Loss of control system	○		

Notes:

(1) "H" and "L" mean "high" and "low". "○" means abnormal condition occurred.

(2) Alarms are to be activated at the suitable setting points prior to arriving the critical condition for the activation of shut-down devices in the case where such shutdown is required.

(3) Only in the case where forced lubrication is adopted.

(4) Alarms are to be audible and visual.

3.3.4 Fire Detection and Extinction Systems in Enclosures

Where gas generators and the high pressure oil pipes of gas turbines are surrounded by an enclosure, the enclosure is to be provided with fire detection systems and a fire extinguishing system which complies with the requirements of **Part 9**.

3.3.5 Additional Safety Devices

Gas turbines may be required to be provided with additional safety devices as required in order to safeguard against hazardous conditions arising in the event of malfunctions in the gas turbine installation. Such hazardous conditions are to be verified by the manufacturer in accordance with the failure mode and effects analysis.

3.4 Associated Installations

3.4.1 Air Inlet Systems

Air inlet systems are to be so constructed and arranged that any intrusion of harmful particles and water into compressors can be minimized. In addition, means are to be provided to minimize the detrimental effects caused by any salt deposits in the suction air, and if necessary, by any icing of the air intake.

3.4.2 Exhaust Gas Arrangement, etc.

1 The open ends of exhaust gas pipes are to be located so as to prevent exhaust gas from entering into the air inlet system.

2 Boilers and heat exchangers utilizing the exhaust heat of gas turbines are also to comply with the requirements specified in **Chapter 9** and **Chapter 10**.

3 Exhaust gas arrangements and other hot surfaces are to be water-cooled or sufficiently covered with thermal insulation so that surface temperature does not exceed 220 ℃. However, in cases where no fire is likely to occur, this requirement may be dispensed with.

4 Exhaust gas arrangements are also to comply with the requirements specified in **13.14**.

3.4.3 Starting Arrangements

1 Starting devices are to be so arranged that the firing operation is discontinued and the main fuel valve is closed within a pre-determined time in cases where ignition fails. In addition, gas turbines are to be provided with automatic or interlocked means for the following **(1)** or **(2)** before ignition commences (on starting) or recommences so as to prevent abnormal combustion or ignition trouble.

(1) Clearing all parts of the main gas turbine of the accumulation of liquid fuel; or

(2) Purging gaseous fuel

2 Where compressed air is used for starting, the starting arrangement is to comply with the requirements specified in **13.11**, in addition to the following **(1)** to **(5)**:

(1) In order to protect starting air mains against the effects of backfiring and internal explosion in the starting air pipes (including explosion arising from improper functioning of starting valves), means are to be provided in accordance with the following **(a)** to **(e)**:
   - (a) An isolation non-return valve or equivalent is to be fitted at the starting air supply connection to each gas turbine.
   - (b) A rupture disc or flame arrester is to be fitted in way of the supply inlet to the starting air manifold.
   - (c) In cases where an flame arrester is provided in accordance with **(b)** above, a rupture disc is to be fitted at an appropriate position on the starting air manifold as an emergency means for pressure relief.
   - (d) For rupture discs which cannot be readily replaced, a mechanism of blocking up the exhaust way is to be provided for the purpose of quick restart of the gas turbine. This blocking mechanism is to be fitted with a means of indicating whether it is blocking or not.
   - (e) An effective arrangement to prevent the accumulation of oils in the starting air manifold or to prevent the excessive temperature rise in the starting air manifold is to be provided.

(2) The arrangement for the air starting of main propulsion machinery is to be provided with at least two starting air reservoirs which may be used independently. The total capacity of the air reservoirs is to be sufficient to provide, without their being replenished, the number of consecutive starts of main propulsion machinery under cold and ready-to-start conditions not less than the following **(a)** and **(b)**. Where the arrangements of the main propulsion machinery and shafting systems are other than those shown below, the required number of starts is to be as deemed appropriate by the Society. In any case, an additional number of starts may be required when the gas turbine is in the warm-running condition. When other consumers such as auxiliary machinery starting systems, control systems, whistles, etc., are to be connected to the starting air reservoirs, their air consumption is also to be taken into account.
   - (a) Ships other than electric propulsion ships

     $Z = 6C$

     where

     Z : Total number of starts of gas turbines

C : Constant determined by the arrangement of gas turbines and shafting systems, where the following values are to be referred to as the standard

C = 1.0: Single screw ships, where one gas turbine is either coupled with the shaft directly or through reduction gears.

C = 1.5: Twin screw ships, where two gas turbines are either coupled with the shafts directly or through reduction gear, and for single screw ships, where two gas turbines are coupled with the shaft through declutchable coupling provided between gas turbines and reduction gear.

C = 2.0: Single screw ships, where two gas turbines are coupled with one shaft without any declutchable coupling between gas turbines and reduction gear.

(b) Electric propulsion ships

$Z = 6 + 3\,(k\text{-}1)$

where

Z : Total number of starts of gas turbines

K : Number of engines (In the case of more than three gas turbines, the value of k to be used need not exceed three.)

(3) The capacity of the reservoirs specified in **(2)** above is to be about equal. However, the requirements may be waived when deemed acceptable by the Society.

(4) The compressor to which **13.11.3-2** applies is to have a capacity not less than 50 % of the total capacity specified in **13.11.3-3**.

(5) The capacity of starting air compressors fitted for main propulsion machinery (excluding an emergency compressor which is installed to satisfy **1.2.1-5**) is to be approximately equally divided between the number of said compressors.

3 Gas turbines which are arranged for starting by battery are to comply with the requirements specified in **Part 8**, in addition to the following **(1)** to **(3)**:

(1) Two separate batteries are to be fitted to the starting arrangement for main propulsion machinery. The arrangement is to be such that the batteries cannot be connected in parallel, and each battery is to be capable of starting the main propulsion machinery under cold and ready-to-start conditions. The capacity of each battery is to be sufficient (without recharging) to provide the number of consecutive starts specified in **-2** above within 30 *minutes*.

(2) Electric starting arrangements for gas turbines driving generators and auxiliary machinery are to have two separate batteries, but may be supplied by separate circuits from the batteries for main propulsion machinery. In the case of a single gas turbine, only one battery need be fitted. The capacity of each set of batteries is to be sufficient for at least three starts for each gas turbine.

(3) The starting batteries are to be used for starting and the gas turbine's own monitoring purposes only. Provisions are to be made to continuously maintain the stored energy at all times.

4 Gas turbines which are arranged for hydraulic starting are to comply with the requirements specified in **13.8**, in addition to the following **(1)** and **(2)**:

(1) Starting arrangements for main propulsion machinery are to be provided with two sets of hydraulic systems.

(2) The capacity of the hydraulic power pack is to be sufficient (without recharging) to provide the number of consecutive starts specified in **-2** above within 30 *minutes*.

3.4.4 Ignition Arrangements

1 Each ignition arrangement is to consist of two or more systems independent of each other.

2 Cables of an electric ignition device are to be arranged so that satisfactory electrical insulation is ensured and the cables are not likely to be damaged.

3 Ignition distributors are to be of an explosion-proof construction or are to be provided with proper shielding. No coils for any ignition device are to be situated in areas where explosive gases may accumulate.

3.4.5 Fuel Oil Arrangements

1 Sufficient consideration is to be given to the prevention of any clogging of fuel manifolds and fuel nozzles due to solids contained in the fuel and to the prevention of any corrosion of turbine blades and other parts due to corrosive substances such as salts.

2 The fuel control system is to comply with the following requirements:

(1) The fuel control system is to be capable of adjusting the fuel supply to the burners so as to maintain the exhaust gas temperature within the pre-determined range throughout the normal operation.

(2) The fuel control system is to be capable of ensuring stable combustion throughout the operation range where the fuel supply is adjustable.

(3) The fuel control system is to be capable of maintaining the minimum speed of the turbines without stopping the gas generator in the case of sudden load fluctuations.

(4) In dual-fuel applications, provision is to be made for automatic isolation of both primary and standby fuel supplies in the event of a fire.

3 The fuel oil arrangements are also to comply with the requirements in **13.7** and **2.2.2**, **Part 9**.

3.4.6 Lubricating Oil Arrangements

1 Gas turbines used as main propulsion machinery are to be provided with an effective emergency supply of lubricating oil which comes into service automatically and has sufficient amount to ensure adequate lubrication until the turbine is brought to rest after a shutdown of the fuel oil supply in the event of a failure of the lubricating oil supplying system. For this purpose, a gravity tank or from an auxiliary lubricating oil pump driven by the turbine may be used.

2 An oil sampling valve is to be provided at a proper location.

3 Lubricating oil arrangements are also to comply with the requirements in **13.8** and **2.2.3**, **Part 9**.

3.4.7 Automatic Temperature Controls

The gas turbine services specified in the following **(1)** to **(3)** are to be fitted with automatic temperature controls so as to maintain steady state conditions throughout the normal operating range of the main gas turbine.

(1) Lubricating oil supply

(2) Oil fuel supply (or automatic control of oil fuel viscosity as alternative)

(3) Exhaust gas

3.4.8 Cooling Arrangements

Gas turbines are to be provided with cooling arrangements as required, and arrangements are to be provided so that the design temperature is not exceeded.

3.5 Tests

3.5.1 Shop Tests

1 For gas turbines and their accessories hydrostatic tests are to be carried out at pressures specified below.

(1) Casing: 1.5 times the maximum design pressure. The non-destructive test may be carried out instead of this hydrostatic test when deemed acceptable by the Society.

(2) Piping system: Pressures specified in section **13.6**.

2 For rotating assemblies of turbines and compressors, dynamic balancing tests are to be carried out after their assembly.

3 For turbine rotors, excess speed tests are to be carried out at 115 % or greater of the maximum continuous speed for at least 2 *minutes* after completion of manufacture. When the Society recognizes that the speed does not exceed 115 % of the maximum continuous speed, tests may be carried out at 115 %.

4 For gas turbines, shop trials are to be carried out, including the test of safety devices specified in **3.3** above, by procedures deemed appropriate by the Society. In this case, the Society may request tests regarding the starting characteristics and critical speeds of rotor shafts.

Chapter 4 POWER TRANSMISSION SYSTEMS

4.1 General

4.1.1 Scope

The requirements in 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.).

4.1.2 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 speed 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.

4.2 Construction

4.2.1 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 preformed 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.

4.2.2 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 Where the clutch of power transmission systems for main propulsion is operated by a hydraulic or pneumatic system, a stand-by pump or compressor that is connected and ready for use at anytime or some other appropriate unit is to be provided in order to ensure that a ship can maintain its normal service condition.
4 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 preformed as easily as possible.

4.2.3 Lubricating Oil Arrangements

1 Lubricating oil arrangement is to comply with the requirements in **13.8**. 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.

4.3 Strength of Gears

4.3.1 Application

The requirements in **4.3** apply to external tooth cylindrical gears having an involute tooth profile. All other gears are to be as deemed appropriate by the Society.

4.3.2 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.

4.3.3 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:

$$P_{MCR} = \frac{1.91H}{N_0 D_1 b} \times 10^{-6} \quad (N/cm)$$

- H : Output which the pinion shares at maximum continuous output (*kW*)
- N_0 : Speed of the pinion at maximum continuous output (min^{-1})
- 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:

$$K_1 = \frac{1.10P_{MCR}}{P_{MAX}}$$

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 7.4.1** may be used.

Table 7.4.1 Values of K_1 (3)(4)

Driving unit	Construction	Use	
	Kind of coupling	Gear for main propulsion	Gear for auxiliaries
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.

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. 7.4.1**.

$$K_2 = k_2(Dn)^{0.8}$$

D : Pitch circle diameter of gears (*cm*)

n : Speed per minute of gears divided by 1,000.

k_2 : Value given in **Table 7.4.2**. 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

Table 7.4.2 Values of k_2

Expected accuracy	ε_{SP}≥1.25	ε_{SP}<1.25
Those correspond to finishing shaved or ground	0.044	0.088
Those correspond to finishing hobbed	0.11	0.22

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. 7.4.2**.

$$K_3 = 1 - k_3\left(\frac{b_t}{D_1}\right)^3$$

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 7.4.3**

Table 7.4.3 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

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.

(1) In the case of gears, including bottom land, to which a surface hardening process was applied:

$$S_b = 0.83\sqrt{T}$$

(2) In the case of other gears:

$$S_b = \frac{(T+Y)/49}{1+(0.0096T-2.4)\left(\frac{0.04}{r_0}+0.02\right)(0.023m_n+0.75)}$$

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

Fig. 7.4.1 Values of K_2

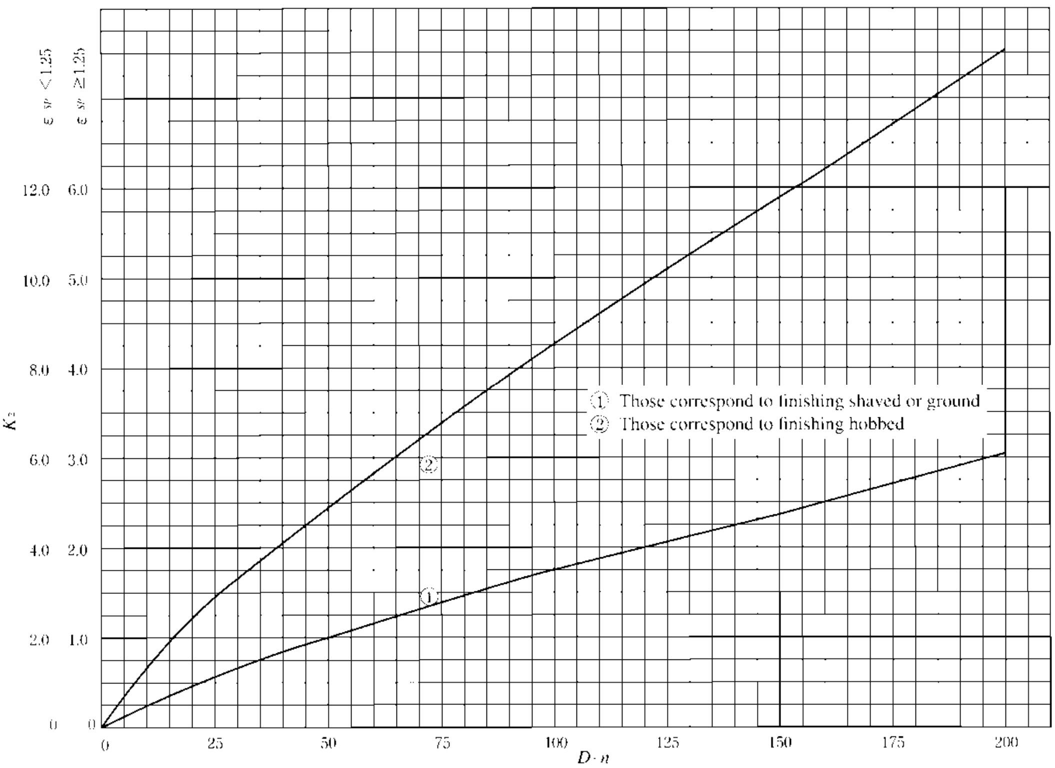
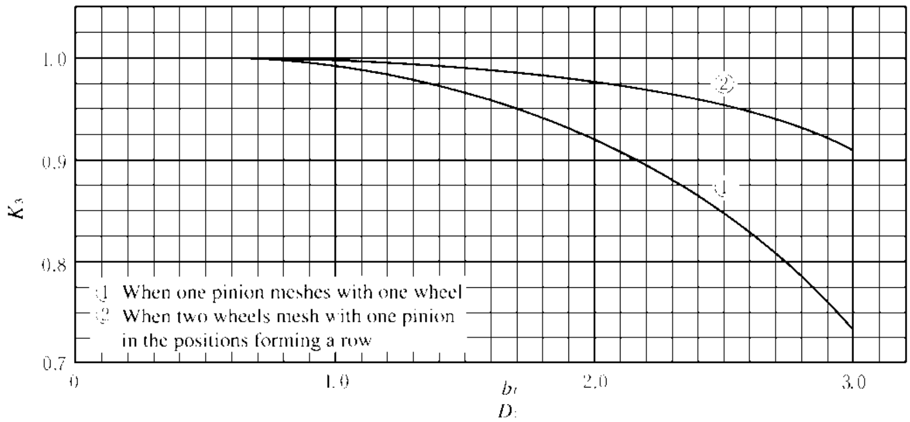


Fig. 7.4.2 Values of K_3



4.3.4 Tangential Loads for Surface Strength

The tangential loads on gear-teeth are to satisfy the following condition for limiting tooth surface stress, 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:

(1) Combination of hardened gear

$$S_s = 2.23\sqrt{T_W}$$

(2) Combination of other gears

$$S_s \left(0.005 \frac{H_{BP}}{H_{BW}} + 0.007\right) T_W + 7.5$$

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 speed and is given either by the following formula or by **Fig. 7.4.3**. However, in the case of a combination of hardened gears, $K_4 = 0.53$

$$K_4 = 0.3(Dn)^{\frac{1}{6}}$$

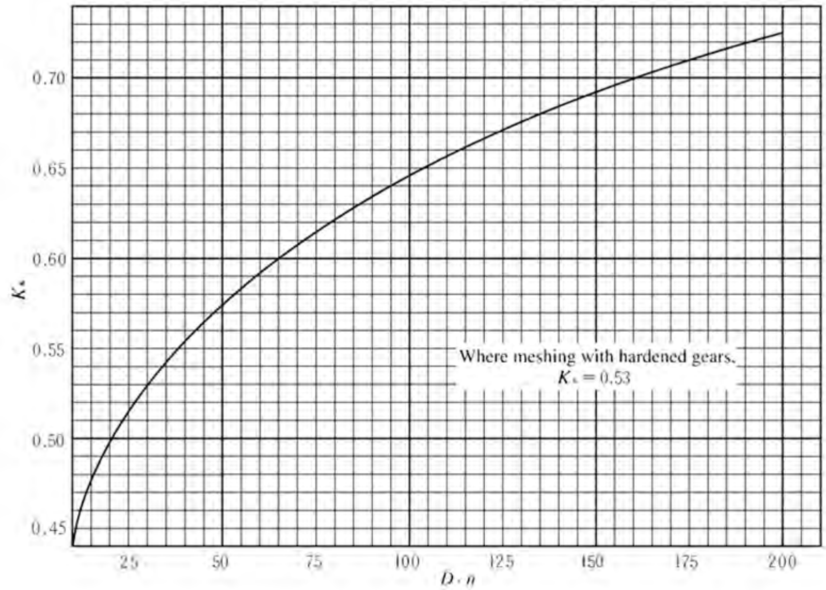
i : Gear ratio (the number of teeth of the wheel divided by the number of teeth of the pinion)

Other symbols are same as in **4.3.3**.

4.3.5 Detailed Evaluation for Strength

Special consideration will be given to the gearing devices, notwithstanding the requirements in **4.3.3** and **4.3.4**, provided that detailed data and calculations on their strength are submitted to the Society and considered appropriate.

Fig. 7.4.3 Values of K_4



4.4 Gear Shafts and Flexible Shafts

4.4.1 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 **5.2.2**. In this case, H and R in the formula represent respectively the output and the speed 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 degrees 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 degrees, 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.

4.4.2 Flexible Shafts

The diameter of a flexible shaft is not to be less than the value given by the following formula:

$$d = 93\sqrt[3]{\frac{H}{N_0}\frac{560}{(T+160)}}$$

where

d : Diameter of the flexible shaft (mm)

H : Output which the flexible shaft shares at maximum continuous output (kW)

N_0 : Speed of the flexible shaft at maximum continuous output (min^{-1})

T : Specified tensile strength of the shaft material (N/mm^2)

4.4.3 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 **5.2.12-1** 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.

4.5 Tests

4.5.1 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 : Speed of gear (min^{-1})

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 5 SHAFTINGS

5.1 General

5.1.1 Scope

The requirements in 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 8** are to be complied with.

5.1.2 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

5.2 Construction, Strength and General

5.2.1 General

1 For two or more shafts, the shaft fixing device is to be provided for each propeller shaft in principle.

2 The shafting system is to be arranged as lower as possible. And the incline of shaft is to be arranged as little as possible.

5.2.2 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 : Speed of intermediate shaft at maximum continuous output (min^{-1})

F_1 : Factor given in **Table 7.5.1**

k_1 : Factor given in **Table 7.5.2**

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. The upper limit of the value of T_s used for the calculation may be increased to 950 N/mm^2 where deemed appropriate by the Society.

K : Factor for hollow shaft and given by the following formula. In cases where $d_i \leq 0.4d_a$, 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 7.5.1 Values of F_1

For 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 7.5.2 Values of k_1

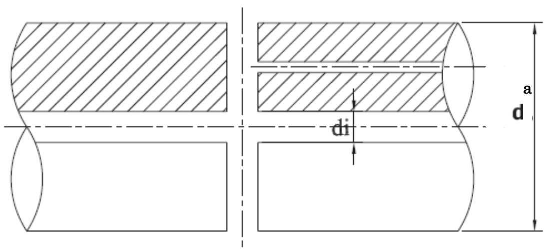
Shaft with integral flange coupling	Shaft with flange coupling either shrink fit, push fit or cold fit [(1)]	Shaft with keyway [(2)]	Shaft with transverse hole [(3)]	Shaft with longitudinal slot [(4)]	Shaft with splines [(5)]
1.0	1.0	1.1	1.1	1.2	1.15

Notes:

(1) In cases where shafts, during continuous operation, experience torsional vibration stress exceeding 85 % of τ_1 given in **8.2.2-1(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) $d_i < 0.7d_a$

(c) $0.15d_a < e \leqq 0.2d_a$

(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 *ISO, JIS*, etc. deemed appropriate by the Society.

5.2.3 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 **5.2.2-1**.

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.

5.2.4 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 7.5.3**

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 **5.2.2-1**

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:

$$d_s = 100k_3 \sqrt[3]{\frac{H}{N_0}}$$

k_3 : Factor concerning the shaft material and shaft portion, which is given in **Table 7.5.4**. 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 **5.2.2-1**.

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 7.5.3 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 **5.2.2**.

Table 7.5.4 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 **5.2.2-1** considering T_s=400.

5.2.5 Other Shafts

The diameter of shafts transmitting power to generators or essential auxiliary machinery is, in principle, to conform to the requirements in **5.2.2**.

5.2.6 Detailed Evaluation for Strength

Special consideration will be given to the shaft diameters, notwithstanding the requirements in **5.2.2**, **5.2.3**, **5.2.4** and **5.2.5**, provided that the detailed data and calculations are submitted to the Society and considered appropriate.

5.2.7 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_(sea water, outboard freshwater and inboard freshwater. The same is referred to hereinafter in this Chapter) with the means specified in the following **(1)** to **(3)**, as applicable.

(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 3** for shafts with diameter not exceeding 200 *mm*

(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.

5.2.8 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:

$$t_1 = 0.03d_s + 7.5$$

$$t_2 = \frac{3}{4}t_1$$

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 **5.2.4** (*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.

5.2.9 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 **5.2.2**.

5.2.10 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)** and **(2)**:

(1) In the case of oil lubricated bearings of white metal.

(a) The length of the bearing is not to be less than twice the required diameter of the propeller shaft given by the formulae in either **5.2.4-1** 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 load water 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 load water 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.

(2) In cases where bearing materials other than **(1)** 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 twice the required diameter of the propeller shaft given by the formulae in either **5.2.4-1** 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 **5.2.4-1** 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.

5.2.11 Additional Requirements for Propeller Shaft Kind 1C

Means are to be provided to sufficiently ensure the integrity of the stern tube bearings in accordance with the requirements specified otherwise by the Society where the propeller shaft is intended to be a propeller shaft Kind 1*C*.

5.2.12 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 **5.2.2**

n : Number of bolts

D : Pitch circle diameter (*mm*)

T_s : Specified tensile strength of intermediate shaft material taken for the calculation in **5.2.2**

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 (*Nm*)

Q_m : Nominal rated torque given by the following formula (Nm)

$$Q_m = 9549 \frac{H}{N_0}$$

H : Maximum continuous output of engine (kW)

N_0 : Rate of speed of intermediate shaft at the maximum continuous output (min^{-1})

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.

5.2.13 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.

5.3 Tests

5.3.1 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)

Chapter 6 PROPELLERS

6.1 General

6.1.1 Scope

The requirements in this Chapter apply to screw propellers and azimuth thrusters intended for main propulsion (hereinafter referred to as "thrusters").

6.1.2 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 maximum continuous speed 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)

6.1.3 Design Requirements

The propeller is to be so designed as to avoid the occurrence of harmful vibration, howling and cavitation as much as possible in addition to the high reliability, the satisfaction of designated performance and the sufficient strength within the operational range.

6.2 Construction and Strength

6.2.1 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.

$$t = \sqrt{\frac{K_1}{K_2}\left(\frac{H}{ZN_0 l}\right)SW}$$

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 speed per minute divided by 100 (min^{-1}/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 7.6.1**

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 7.6.1**

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 7.6.2**

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* **2.3.9, Part 1**)

d_s : Load draught (*See* **2.3.11, Part 1**)

W : Coefficient concerning alternate stress, given by the following formula or to be taken as 2.80, whichever is greater.

$$W = 1 + 1.724\left(\frac{A_2 A_3 + A_4 A_1 P'/D}{A_3 + A_4 P'/D}\right)$$

$$A_1 = \frac{\Delta w}{w + C_1}$$

$$A_2 = \frac{\Delta w}{w + C_2}$$

$$A_3 = \frac{(C_1 + 1)(C_2 + w)}{C_3(C_2 + 1)(C_1 + w)}$$

$$A_4 = \begin{cases} 3.52(0.25R) \\ 2.41(0.35R) \\ 1.26(0.6R) \end{cases}$$

$$C_1 = \frac{D}{0.95P}\left\{\frac{P}{D}\left(1.3 - \frac{2a_e}{Z}\right) + 0.22\right\} - 1$$

$$C_2 = \frac{D}{0.95P}\left(1.1\frac{P}{D} - \frac{1.19a_e}{Z} + 0.2\right) - 1$$

$$C_3 = 0.122\frac{P}{D} + 0.0236$$

a_e : Expanded area ratio of propeller

w : Nominal mean wake in the propeller disc

Δw : Peak to peak value of wake fluctuation in the propeller disk at a radius of 0.7 R. The values of w and Δw are to be calculated by using the following formulae, except in the case of multi-screw ships or when expressly approved by the Society.

$$\Delta w = 7.32\left\{1.56 - 0.04\left(\frac{B}{D} + 4\right)\sqrt{\frac{B}{d_s} - C_b}\right\} w$$

$$w = 0.625\left\{0.04\left(\frac{B}{D}+4\right)\sqrt{\frac{B}{d_s}}+C_b\right\}-0.527$$

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 7.6.1 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
0.25R	1.62	0.386	0.239	1.92	1.71
0.35R	0.827	0.308	0.131	1.79	1.56
0.6R	0.281	0.113	0.022	1.24	1.09

Table 7.6.2 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 $2.0 \geq D$

6.2.2 Controllable Pitch Propellers

1 The thickness of the controllable pitch propeller blade is to be in accordance with the requirements specified in **6.2.1**.

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. 7.6.1**)

A : Value given by the following formula, where H, N_0 and Z are the same as those specified in **6.2.1-1**:

$$A = 3.0 \times 10^4 \frac{H}{N_0 Z}$$

K_3 : Value given by the following formula:

$$K_3 = \left\{ \left(\frac{D}{P}\right)^2 (0.622 - 0.9x_0)^2 + (0.318 - 0.499x_0)^2 \right\}^{\frac{1}{2}}$$

x_0 : Ratio of the radius at the boundary between blade flange and pitch control gear to the propeller radius (*See* **Fig. 7.6.1**). 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. 7.6.2**)

F_C : Centrifugal force (*N*) of propeller blade given by the following formula:

$$F_C = 1.10 m R' N_0^2$$

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):

$$\sigma_a = 34.7 \left(\frac{\sigma_B + 160}{600}\right)$$

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 **6.2.1-1**.

3 For blade fixing bolts, corrosion-resistant materials are to be used, or special means precluding their direct contact with sea 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. 7.6.1**)

d : required 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 **6.2.1** 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 pump, a stand-by oil pump that is connected and ready for use at anytime or some other suitable device is to be provided in order to ensure that the ship can maintain its normal service condition in the event of a failure of the oil pump.

9 The operating oil piping arrangement is to comply with the requirements in **13.8**.

Fig. 7.6.1 Measuring Method of Blade Fixing Bolt Dimensions

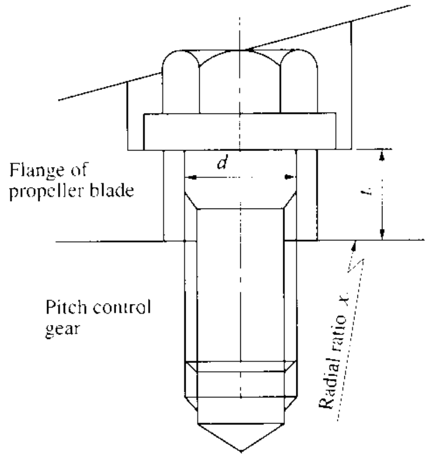
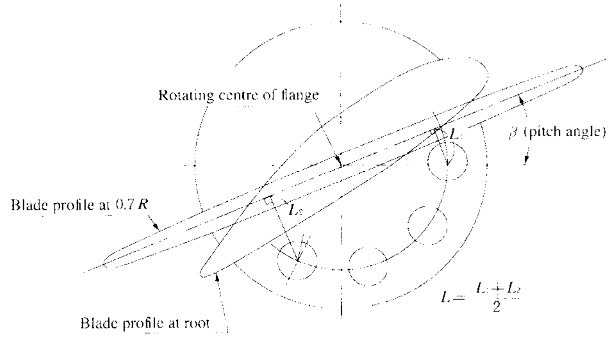


Fig. 7.6.2 Determination of L



6.2.3 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 **6.2.2**. However, in cases where the position of fixing bolts is other than those specified in **Fig. 7.6.2**, the requirements are to be deemed appropriate by the Society.

6.2.4 Air Supply Duct for Prairie Device

In cases where the prairie device is provided, air supply ducts are to be arranged for shafting system, propeller boss, propeller boss cap, propeller blade and so on. In addition, air supply ducts are to be provided with effective means for counterflow.

6.3 Force Fitting of Propellers

6.3.1 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 7.6.3**. In cases where the material of propeller boss is other than those specified in **Table 7.6.3**, 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):

$$P = \frac{2.8T}{SB}\left\{-2.8tan\alpha + \sqrt{0.0169 + B\left(\frac{F_V}{T}\right)^2}\right\}$$

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*):

$$F_V = \frac{9.55cH}{N_0R_0} \times 10^4$$

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.

$$(0.194\ln D + 0.255)\left\{\left(\frac{Nc}{N_0}\right)^2 + 1.047\frac{Q_vN_0}{H} \times 10^{-2}\right\}$$

Q_V : Torsional vibratory torque acting on the fitted portion of the propeller at a speed of resonant critical within the range of above 25 % of the maximum continuous speed (*N-m*)

H, N_0, D : Same as those specified in **6.2.1-1**, 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 : Speed (min^{-1}) 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 7.6.3**, the value is to be determined by the Society as considered appropriate.

K_4 and K_5 : Values given in **Table 7.6.3**

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 7.6.3**, 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 7.6.3**

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.

Table 7.6.3 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

6.3.2 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.

6.4 Azimuth Thrusters

6.4.1 General

1 Application

(1) The prime movers for driving thrusters are to comply with the following requirements:

(a) Diesel engines : **Chapter 2**

(b) Gas turbines : **Chapter 3**

(c) Electric motors : **Chapter 2** and **5**, **Part 8**

(2) Special consideration will be given to those thrusters of unconventional designs to which the requirements in this Chapter are not applicable.

2 Number of Thrusters

(1) In general, a minimum of two thrusters is to be provided for ships. Thrusters are to be designed so that the failure of one thruster does not result in the failure of any other thrusters. As a result, the requirements for auxiliary steering gear as specified in **Chapter 3**, **Part 6** do not apply to thrusters.

(2) In special cases, a single thruster installation may be subject to consideration and deemed acceptable, notwithstanding the requirements specified in **(1)**. In such cases, the functions of propulsion and steering are to be designed with redundancy as in the following arrangements:

(a) A minimum of two prime movers is to be provided.

(b) A minimum of two independent azimuth steering gears is to be provided. However, such azimuth steering gears may have only one gear wheel.

(c) Electric supplies are to be maintained or restored immediately in the case of loss of any main generator in service so that the functions of at least one of thrusters, including its prime movers, are maintained by the arrangements specified in **6.4.5-2(1)** and **(2)**.

3 Terminology

The terms used in this **6.4** are defined as follows:

(a) Thrusters are propulsion units with steering functions enabled by their own capability of azimuthing. Thrusters include the following components:
  i) Propellers
  ii) Propeller shafts
  iii) Gears, clutches and gear shafts for transmission of propulsion torque (when integrated in thrusters)
  iv) Azimuth thruster casings
  v) Azimuth steering gears
  vi) Control systems

(b) Azimuth thruster casings are watertight structures that include steering columns (or struts), propeller pods, propeller nozzles and nozzle supports.

(c) Azimuth steering gears are devices for applying steering torque to thrusters, and include electric motors, hydraulic pumps, hydraulic systems, hydraulic motors and gear assemblies for azimuth steering gears.

6.4.2 Drawings and Data to be Submitted

Plans and documents to be submitted are generally as follows:

(1) Particulars
(2) Specifications
(3) Material specifications
(4) Details of welding procedures for principal components
(5) General arrangements and sectional assembly drawings
(6) Shafting arrangements (details of propeller shafts, gears, clutches, gear shafts, shaft couplings, bearings and sealing devices and propellers, specifications and service life calculations of roller bearings, torsional vibration calculations and propeller pull-up length calculation sheets)
(7) Details of azimuth thruster casings
(8) Drawings of azimuth steering gears (details of actuating systems, gear assemblies, bearings and sealing devices for azimuth steering gears)
(9) Piping diagrams (hydraulic systems, lubricating systems, cooling water systems and etc.)
(10) Arrangements of control systems and diagram of hydraulic and electrical systems (including safety devices, alarm devices and automatic steering)
(11) Arrangements and diagrams of an alternative source of power
(12) Diagrams of indication devices for azimuth angles
(13) Strength calculations
(14) Sea trial records
(15) When a vibration measurement system for power transmission system in the azimuth thrusters is being used, the following documents **a)** and **b)**:
  (a) Function description for vibration measurement system
  (b) Management manual including the following **i)** through **iii)**
    i) List of the bearings for vibration measurement and measurement points.
    ii) Guidance for the measurement (including the way for taking signals from the casing)
    iii) Guidance for the analysis and the evaluation of the measurement result
(16) When a Fe-density measurement system for lubricating oil in the azimuth thrusters is being used, the following documents **a)** and **b)**:
  (a) Function description for the Fe-density measurement system
  (b) Management manual including the following **i)** through **iii)**
    i) Guidance for the lubricating oil sampling

ii) Guidance for the Fe-density measurement
iii) Guidance for the analysis and the evaluation of the measurement result
(17) Other plans and documents considered necessary by the Society

6.4.3 Construction and Strength

1 General

(1) The installation and construction of thrusters are to be such that ship stability is not adversely affected even when sea water enters azimuth thruster casings and floods compartments where they are installed.

(2) Sealing devices are to be provided in cases where thrusters penetrate hull structures to prevent any sea water from entering ships.

2 Gears, Clutches, Gear Shafts and etc.

The construction and strength of gears, clutches, gear shafts and etc. for propulsion are to comply with the requirements specified in **Chapter 4**. The construction and strength of bevel gears and gears for azimuth steering gears are to comply with recognised standards.

3 Propeller Shafts, Bearings and Sealing Devices of Propeller Shafts

The construction and strength of propeller shafts, bearings and sealing devices of propeller shafts are to comply with the requirements specified in **Chapter 5**.

4 Propellers

The construction and strength of propellers are to comply with the requirements specified in **Chapter 6**.

5 Torsional Vibration of Shaftings

Calculations for torsional vibration of shaftings are to comply with the requirements specified in **Chapter 8**.

6 Strengthening for Navigation in Ice

Thrusters in ships intended to be registered with the ice-strengthened class notation are to comply with the requirements specified in **Chapter 8**, **Part I of the Rules for the Survey and Construction of Steel Ships**.

6.4.4 Azimuth Steering Gears

1 Capability of Azimuth Steering Gears

(1) The steering arrangements of thruster are to be capable of changing direction of the ship's directional control system from one side to the other at declared steering angle limits at an average speed of not less than 2.3 °/*s* with the ship running ahead at speeds specified in **2.3.16**, **Part 1**. The wording "declared steering angle limits" refers to the operational limits in terms of maximum steering angle according to manufacturer guidelines for safe operation.

(2) In addition to the requirements specified in **(1)**, the rate of turning for azimuth steering gears is to be not less than 1.0 min^{-1} in static conditions of ships if astern power is obtained by turning thrusters.

2 Construction of Azimuth Steering Gear

(1) Design pressures for calculations to determine the scantlings of piping and other components of hydraulic power systems of azimuth steering gears subject to internal hydraulic pressure are to be at least 125 % of the maximum working pressure expected under the worst permissible operation conditions after taking into account any pressure which may exist in low pressure sides of such systems. Design pressures are not to be less than relief valve setting pressures.

(2) The construction and strength of the hydraulic pumps and hydraulic systems are to comply with the requirements in **10.4**, **13.3.1**, **13.4**, **13.5.2** through **13.5.4** and **11.2.1**.

(3) The installation of piping and arrangements of relief valves as well as measuring devices for hydraulic systems and the construction of liquid level indicators are to comply with the

requirements in **13.2.1** and **11.11.4**, **Part 6**

3 Hydraulic Systems

Hydraulic power-actuated azimuth steering gears are to be provided with the following arrangements:

(1) Suitable arrangements to maintain the cleanliness of hydraulic fluids are to be provided after taking into consideration the types and designs of such hydraulic systems.

(2) Arrangements for bleeding air from hydraulic systems are to be provided where necessary.

(3) Relief valves are to be fitted to any part of hydraulic systems which can be isolated and in which pressure can be generated from power sources or from external forces. Setting pressures of such relief valves are not to be less than 125 % of the maximum working pressure expected in such protected parts. Minimum discharge capacities of relief valves are not to be less than 110 % of the total capacity of pumps which provide power for hydraulic motors. Under such conditions, any rise in pressure is not to exceed 10 % of the setting pressure. In this regard, due consideration is to be given to any extreme foreseen ambient conditions in respect to oil viscosity.

(4) Low level alarms are to be provided for hydraulic fluid tanks in order to give the earliest practicable indication of any hydraulic fluid leakage. These alarms are to be audible and visual and to be given on navigation bridges and at positions from which main engines are normally controlled.

(5) In cases where flexible hoses are used for hydraulic systems, the construction and strength of such flexible hoses are to comply with the requirements specified in **3.4.4**, **Part 6**.

4 Sealing Devices

Sealing devices for steering parts of azimuth steering gears are to be approved by the Society in their materials, construction and arrangement.

6.4.5 Electric Installations

1 General

(1) Each thruster is to be served separately by exclusive circuits fed directly from main switchboards. In cases where three or more thrusters are provided, at least two those exclusive circuits are required. One of these circuits, however, may be supplied through the emergency switchboard.

(2) Cables used in those exclusive circuits required in **(1)** are to be separated, as far as practicable, throughout their length.

(3) Audible and visual alarms are to be given on navigation bridges and at positions from which main engines are normally controlled in the event of any power failure to electric motors for propulsion and steering.

(4) For items not specified in this section **(1)**, those requirements specified in **Part 8** are to apply.

2 Maintenance of Electric Supplies

(1) In cases where any generators in service are lost, main sources of electric power are to be so arranged that electric supplies to any relevant equipment are maintained or restored immediately in order to ensure the functions of propulsion and steering of at least one thruster, its associated control systems and indication devices for azimuth angles by the following arrangements:

(a) In cases where electrical power is normally supplied by one generator, adequate provisions are to be made for the automatic starting and the connecting to main switchboards of standby generators of sufficient capacities to maintain the functions of the above with automatic restarting of important auxiliaries, including sequential operations, in cases of loss of electrical power to generators in operation.

(b) If electrical power is normally supplied by more than one generator simultaneously in parallel operations, provisions are to be made to ensure that, in cases of loss of electrical power to one of such generating sets, the remaining ones are kept in operation to maintain the functions of those above. (See **2.3.6**, **Part 8**)

(2) In cases where propulsion power exceeds 2,500 *kW* per thruster unit, an alternative source of power is to be provided in accordance with the following:

(a) The alternative source of power is to be either:

i) An emergency source of electric power; or

ii) An independent source of power located in the steering gear compartment and used only for this purpose.

(b) Any alternative source of power is to be capable of automatically supplying alternative power within 45 *seconds* to the steering arrangement and its associated control system and its indication devices for azimuth angles. In this case, the alternative source of power is to be capable of changing direction of the ship's directional control system from one side to the other at declared steering angle limits at an average speed of not less than 0.5 °*/s* with the ship running ahead at one half of the speeds specified in **2.3.16**, **Part 1** or 7 *knots*, whichever is greater. Alternative sources of power are to have enough capacity for the continuous operation of such systems for at least 30 *minutes* in every ship of 10,000 *gross tonnage* or more, and for at least 10 *minutes* in every other ship. However, for the gas turbine as the alternative source of power approved by the Society, the requirements may be waived.

(c) Automatic starting arrangements for generators or prime movers of pumps used as the independent source of power specified in **(a)ii)** are to comply with the requirements for starting devices and performance in **3.4.1, Part 8**.

3 Electrical Installations for Azimuth Steering Gears

Electrical installations for azimuth steering gears are to comply with the following requirements in **(1)** through **(4)**:

(1) Means for indicating that electric motors for steering are running are to be installed on navigation bridges and those positions from which main engines are normally controlled.

(2) Short circuit protections and overload alarms are to be provided for such circuits and motors respectively. Overload alarms are to be both audible and visible and are to be situated in conspicuous positions in those places from which main engines are normally controlled.

(3) Any protection against excess current, including starting currents, if provided, is to be for not less than twice the full load current of motors or circuits so protected, and is to be arranged to permit passage of appropriate starting currents.

(4) In cases where three-phase supplies are used, alarms are to be provided that will indicate the failure of any one of the supply phases. Such alarms are to be both audible and visible and are to be situated in conspicuous positions in those places from which main engines are normally controlled.

6.4.6 Controls

1 Thrusters are to be capable of being brought into operation and being controlled from navigation bridges or appropriate control stations.

2 Azimuth steering gears are to be controlled from azimuth thruster compartments. Means are to be provided in azimuth thruster compartments for disconnecting any control system operable from navigation bridges from the steering system it serves.

3 Independent control devices are to be provided for thrusters. In cases where multiple thrusters are designed to operate simultaneously, they may be controlled by a single device such as a joystick.

4 Those control devices specified in **-3** are to be so designed that a failure of any one control device does not result in the failure of the others.

5 Cables and pipes of control systems are to be separated, as far as practicable, throughout their length.

6 In cases where control systems are electric, they are to be served by their own separate circuits supplied from power circuits for thrusters from points in azimuth thruster compartments, or directly from switchboard busbars supplying such power circuits for thrusters at points on those switchboards adjacent to such supplies to power circuits for thrusters.
7 Short circuit protections are only to be provided for control supply circuits.
8 Audible and visual alarms are to be given on navigation bridges and at positions from which main engines are normally controlled, in the event of any failure of control systems or of electrical power supplies to such control systems.
9 The following instruments are to be provided on navigation bridges and at all control stations of thrusters
(1) Indication devices for propeller speeds and direction of rotation in the cases of solid propellers
(2) Indication devices for propeller speeds and pitch positions in the case of controllable pitch propellers
(3) Indication devices for azimuth angles
10 Indication devices for those azimuth angles specified in **-9(3)** are to be independent of control systems.
11 Means of communication are to be provided between navigation bridges and all control stations for thrusters.
12 Thrusters of those ships provided with automatic steering are to be capable of immediate change-overs from automatic to manual steering.
13 For those items concerned with any safety, alarm and control devices for thrusters not specified in this paragraph **6.4.6**, those requirements specified in **15.1** through **15.3** and **15.7** are to apply.

6.4.7 Piping System

1 Lubricating Oil Systems
(1) Lubricating oil systems for thrusters are to comply with the relevant requirements specified in **13.8** (in this case the term "main propulsion machinery, propulsion shaftings and power transmission systems" is to be read as "thrusters"). Additionally, it is recommended to use strainers with magnets for thrusters.
(2) Lubricating oil arrangements of thrusters are to be provided with alarm devices which give visible and audible alarms on navigation bridges and at positions from which main engines are normally controlled in the event of any failure of the supply of lubricating oil or any appreciable reduction of lubricating oil pressure.
2 Cooling Systems
Cooling systems of thrusters are to comply with the requirements specified in **13.10** (in this case the term "main propulsion machinery" is to be read as "thrusters").

6.4.8 Position of Thrusters

1 Thrusters are to be installed in readily accessible enclosed compartments and be separated, as far as possible, from any machinery spaces.
2 Azimuth thruster compartments are to be of sufficient space as to permit thrusters to be operated effectively.
3 Azimuth thruster compartments are to be provided with suitable arrangements to ensure working access to azimuth steering gear machinery and controls. These arrangements are to include handrails and gratings or other non-slip surfaces to ensure suitable working conditions in the event of any hydraulic fluid leakage.
4 The locations where the following equipment are provided and which comply with the requirements specified in **6.4.6-2** may be deemed as azimuth thruster compartments.

(1) Instruments specified in **6.4.6-9**
(2) Communication means specified in **6.4.6-11**
(3) Gyro repeaters required in Regulation 19.2.5.2, Chapter V, *SOLAS*

6.4.9 Additional Requirements for Thrusters which Incorporate Electric Motors in Propeller Pods

1 Means to detect any ingress of sea water into propeller pods are to be provided, and audible and visual alarms are to be given on navigation bridges and at positions from which main engines are normally controlled. Means for discharging sea water from propeller pods are to be provided.
2 Fire detection and alarm systems are to be provided in propeller pods if propeller pods can be accessed.
3 In cases where cooling fans are provided for propulsion motors, main cooling fans with sufficient capacities at maximum output of propulsion motors as well as auxiliary cooling fans with sufficient capacities at normal output of propulsion motors are to be provided. These cooling fans are to be arranged so that they can be easily changed over. However, such auxiliary fans may be omitted provided that exclusive cooling fans are provided for thrusters.
4 In cases where cooling fans are provided for propulsion motors, control means for stopping such fans and closing any inlets and outlets of air for such fans from safe positions in the case of fire, are to be provided.

6.4.10 Instructions, etc.

1 Display of Operating Instructions, etc.
Simple operating instructions with block diagrams showing change-over procedures for thrusters and control systems are to be permanently displayed on navigation bridges and in azimuth thruster compartments.
2 Operating and Maintenance Instructions for Thrusters
Operating and maintenance instructions and engineering drawings for thrusters are to be provided and written in a language understandable by officers and crew members who are required to understand such information in the performance of their duties.

6.5 Tests

6.5.1 Shop Tests

1 Propellers are to be subjected to static balancing tests.
2 The following tests and inspections are to be carried out at the manufacturing plants of thrusters.
(1) Gears
Tests specified in **4.5.1**
(2) Propeller shaft sleeves
Tests specified in **5.3.1(2)**
(3) Propellers
Tests specified in **6.5.1**
(4) Azimuth steering gears
a) Tests specified in **3.5.1**, **Part 6**
b) Tests specified in **4.5.1** for gears
(5) Azimuth thruster casings
After assembly, pressure tests at the larger of 0.2 *MPa* and the following pressure of a water head equivalent to 1.5D or 2d, whichever is smaller
where
D : The depth of ship (m)

d : The design maximum load draught (m)

However, airtight tests at pressures of 0.05 MPa for propeller nozzles may be acceptable.

(6) Performance tests of control, safety and alarm devices

Chapter 7 WATERJET PROPULSION SYSTEMS

7.1 General

7.1.1 Application

1 The requirements in this Chapter apply to waterjet propulsion systems (hereinafter referred to as "propulsion systems").

2 The prime movers used for driving propulsion systems are to comply with the following requirements:

(1) Diesel engines: **Chapter 2**

(2) Gas turbines: **Chapter 3**

3 The following requirements need not be applied to those propulsion systems without steering arrangements.

(1) **7.3.2-1**

(2) **7.3.3**

(3) **7.3.4-3**

(4) **7.4.2**

(5) **7.4.3(1)**, **(2)**, **(5)**, **(6)** and **(7)**

(6) **7.5.1-1**, **-5** through **-10**

4 Special consideration will be given to propulsion systems of unconventional designs to which the requirements in this Chapter are not applicable.

7.1.2 Number of Propulsion Systems

1 In general, a minimum of two propulsion systems are to be provided for ships. Propulsion systems are to be designed so that the failure of any one system does not result in the failure of all of the other systems. As a result, the requirements for auxiliary steering gear specified in **Chapter 3**, **Part 6** do not apply to propulsion systems.

2 In certain special cases, a single propulsion system installation may be considered, notwithstanding the requirements specified in **-1**, provided that the ship in question is not engaged in international voyages. In this case, the functions of propulsion, steering and reversing are to be designed with redundancy in the following arrangements:

(1) A minimum of two prime movers are to be provided.

(2) A minimum of two hydraulic power systems for steering and reversing are to be provided.

(3) Electric supply is to be maintained or restored immediately in cases where there is a loss of any one of the main generators in service so that the functioning of at least one of the propulsion systems, including their prime movers, is maintained by the arrangements specified in **7.4.2-1(1)** and **(2)**.

7.1.3 Terminology

The terms used in this Chapter are defined as follows:

(1) Waterjet propulsion systems are systems, including the following components **(a)** through **(d)**, which receives water through inlet ducts and discharges it through nozzles at an increased velocity to produce propulsive thrust.

 (a) Shaftings (main shafts, bearings, shaft couplings, coupling bolts and sealing devices)

 (b) Water intake ducts

 (c) Waterjet pump units

 (d) Steering and reversing systems

(2) Waterjet pump units are made up of impellers, impeller casings, stators, stator casings, nozzles, bearings, bearing housing and sealing devices.

(3) Impellers are a rotating assemblies provided with blades to give energy to the water.

(4) Main shafts are shafts that impellers are connected to.
(5) Water intake ducts are portions that lead water drawn from water intakes to impeller inlets.
(6) Nozzles are portions that inject rectified water from impellers.
(7) Deflectors are devices serving as rudders by leading water injected from nozzles either to port or to starboard.
(8) Reversers are devices to thrust ships to go astern by reversing flow directions of water injected from nozzles.
(9) Stators are assemblies composed of rows of stationary vanes that reduce any swirl added to water by impellers.
(10) Steering and reversing systems are those systems consisting of deflectors, reversers and hydraulic power system driving defectors and/or reversers.
(11) Hydraulic power systems are systems composed of hydraulic pumps and electric motors or engines for driving such pumps, and hydraulic piping systems and hydraulic actuators.
(12) High speed engines are diesel engines complying with the following condition or gas turbines:

$(S \cdot n^2)/(1.8 \times 10^6) \geq 90$

$(\pi \cdot d_j \cdot n)/(6 \times 10^4) \geq 6$

S : Length of stroke (mm)

n : Speed of an engine at maximum continuous output (min^{-1})

d_j : Diameter of journal (mm)

7.1.4 Classification Survey

Plans and documents to be submitted are generally as follows:

(1) Particulars
(2) Specifications
(3) Material specifications
(4) Details of welding procedures
(5) General arrangements and sectional assembly drawings (showing the materials and dimensions of various parts including water intake ducts)
(6) Shafting arrangements (showing arrangements, shapes and construction of main engines, gears, clutches, couplings, main shafts, main shaft bearings and thrust bearings, sealing devices and impellers)
(7) Details of water intake ducts
(8) Construction of impellers (showing detailed blade profiles, the maximum diameter of blades from the centre of main shafts, number of blades, and material specifications)
(9) Details of bearings (including thrust bearings), in the case of roller bearing, together with specifications of such bearings and the calculation sheets for the life times of roller bearings
(10) Details of sealing devices (including waterjet pump unit sealing devices)
(11) Details of deflectors
(12) Details of reversers
(13) Details of hydraulic actuators
(14) Piping diagrams (hydraulic systems, lubricating systems, cooling water systems and etc.)
(15) Arrangements of control systems and diagram of hydraulic and electrical systems (including safety devices, alarm devices and automatic steering)
(16) Arrangements and diagrams of an alternative source of power
(17) Diagram of indication devices for deflector positions
(18) Torsional vibration calculation sheets and calculation sheets for the bending natural frequency when bending vibration due to self-weight is expected
(19) Strength calculation sheets for deflectors and reversers
(20) Sea trail records

(21) Others items considered to be necessary by the Society

7.2 Construction and Strength

7.2.1 Main Shaft

The minimum diameter of main shafts is to be not less than the value determined by the following formula:

$$d_s = k\sqrt[3]{\frac{H}{N_o}}$$

where

d_s : Required diameter of main shaft (*mm*)

H : Maximum continuous output of main engine (*kW*)

N_0 : Speed of main shaft at the maximum continuous output (min^{-1})

k : Values shown in **Table 7.7.1**

Table 7.1.1 Values of k according to Fitting Method

Shaft material		Position				
		Fitting part of shafts with impellers and shaft couplings				
		Fitting method				Other Positions
		with Keyway	with Spline	With Flange Coupling	Force Fitting	
Carbon steel or low alloy steel	Shaft of Kind 2	105	108	102		105
	Shaft of Kind 1	The value in the Note below where a_1=100, or a_2=80	The value in the Note below where a_1=102, or a_2=82	The value in the Note below Where a_1=98, or a_2=78		The value in the Note below where a_1=100, or a_2=80
Austenitic stainless steel						
Martensite precipitation hardened type stainless steel		80	82	78		80

Note:

$200 \leq \sigma_y \leq 400$: $k = a_1 - 0.1(\sigma_y - 200)$

$\sigma_y > 400$: $k = a_2$

where

σ_y : Yield point or 0.2 % of proof stress of main shaft material (N/mm^2)

7.2.2 Shaft Couplings and Coupling Bolts

1 The minimum diameter of shaft coupling bolts at joining faces of couplings is to be not less than the value determined by the following formula:

$$d_b = 15300\sqrt{\frac{H}{N_o}\left(\frac{1}{nDT_b}\right)}$$

where

d_b : Required diameter of shaft coupling bolt (*mm*)

n : Number of bolts

D : Pitch circle diameter (*mm*)

T_b : Specified tensile strength of bolt material (N/mm^2)

Other symbols used here are the same as those used in **7.2.1**.

2 The thickness of shaft coupling flanges at pitch circles is not to be less than the required diameter of shaft coupling bolts determined by the formula in **-1** above. However, such a value is not to be less than 0.2 times the required diameter of the corresponding shaft.

3 Fillet radii at the base of flanges are not to be less than 0.08 times the diameter of their respective shafts in cases where fillets are not to be recessed in way of nuts and bolt heads.

7.2.3 Impeller Blades

The strength of impeller blades at their root is to be determined so that the following formula is satisfied. In this case, the allowable stress value of the material is, in principle, to be 1/1.8 of the specified yield point (or 0.2 % of proof strength).

$$S \geq \frac{5.8 \times 10^7 H}{L t^2 Z N_o} + 2.2 \times 10^{-11} D^2 N_o^2$$

where

S : Allowable stress of impeller material (N/mm^2)

Z : Number of impeller blades

L : Width of impeller blade at root (mm)

t : Maximum thickness of impeller blade at root (mm)

D : Diameter of impeller (mm)

Other symbols used here are the same as those used in **7.2.1**.

7.2.4 Water Intake Ducts, etc.

Suction water intake ducts, impeller casings and nozzles are to have strength enough to handle their design pressure, and consideration is to be given to any corrosion.

7.2.5 Sealing Devices

The materials, constructions and arrangements of sealing devices for shaftings and waterjet pump units, other than gland packing type sea water sealing devices, are to be approved by the Society.

7.2.6 Torsional Vibration and Bending Vibration of Main Shaft

1 General

(1) Notwithstanding the requirements specified in **7.1.4** concerning to submission of torsional vibration calculation sheets for main shafting systems, the submission of such sheets may be omitted in cases where shafting systems are of the same type as one that has been previously approved or it can be readily assumed that such shafting systems will not cause any excessive vibration stress.

(2) Measurements of torsional vibrations to confirm the correctness of estimated values are to be carried out. However, in cases where the submission of torsional vibration calculation sheets is omitted according to the requirements in **(1)**, or the Society considers that there is no critical vibration within the service speed range, the measurement of torsional vibrations may be omitted.

2 Allowable Limits

Torsional vibration stresses of main shafting systems are to be in accordance with the following requirements in **(1)** and **(2)** within the service speed range of such shafting systems:

(1) Torsional vibration stresses within the range from 80 % up to and including 105 % of maximum continuous speed are not to exceed τ_1 given in the following:

$$\tau_1 = A - B\lambda^2 (0.8 < \lambda \leq 0.9)$$

$$\tau_1 = C (0.9 < \lambda \leq 1.05)$$

where

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 speed to maximum continuous speed

A, B and C : Values shown in **Table 7.7.2**

In cases where the specified tensile strength of materials of carbon steel shafts or low alloy steel shafts of Kind 1 exceeds 400 N/mm^2, the value of τ_1 may be increased by multiplying the factor k_m given in the following formula:

$$k_m = \frac{T_s + 160}{560}$$

where

k_m : Correction factor

T_s : Specified tensile strength of main shaft material (N/mm^2)

(2) Torsional vibration stresses of within the range of 80 % and below of maximum continuous speed of engines are not to exceed τ_2 given below. In cases where torsional vibration stresses exceed the value calculated by the formula of τ_1 shown in **(1)**, barred speed ranges are to be imposed. In this case, the formula for τ_1 is the one for the range of $\lambda \leq 0.9$.

$$\tau_2 = 2.3\tau_1$$

where

τ_2 : Allowable limit of torsional vibration stresses for the range of $\lambda \leq 0.8$ (N/mm^2)

Table 7.7.2 Values of A, B and C

	Carbon steels or low alloy steels		Austenitic stainless steels	Martensite precipitation hardened type stainless steels
	Shaft of Kind 1	Shaft of Kind 2		
A	24.3	9.0	26.4	39.6
B	24.1	6.2	26.4	37.1
C	4.8	4.0	5.0	9.6

3 Bending Vibrations

For main shafting systems of propulsion systems, consideration is to be given to natural vibrations due to bending of shafting systems.

7.3 Steering and Reversing Systems

7.3.1 Capability of Steering and Reversing

1 Deflectors are, in principle, to be capable of changing direction of the ship's directional control system from one side to the other at declared steering angle limits at an average rotational speed of not less than 2.3°/s with the ship running ahead at speeds specified in **2.3.16**, **Part 1**. In addition, ships are to have sufficient steering capability according to their ship type. The wording "declared steering angle limits" refers to the operational limits of deflectors in terms of maximum steering angle according to manufacturer guidelines for safe operation.

2 Reversers are to be such that they provide sufficient power for going astern to secure proper control of the ship under all normal circumstances, and when transferred from ahead to astern runs, they are to have astern power to provide effective braking for ships.

7.3.2 General Construction of Steering and Reversing Systems

1 Design pressures of the scantlings of piping and other components of hydraulic power systems subject to internal hydraulic pressure are to be at least 125 % of the maximum working pressure expected under the worst permissible operating condition, taking into account any pressure which may exist in the low pressure side of systems. Design pressures are not to be less than relief valve setting pressures.

2 Reversers are to have sufficient strength against any thrusts at maximum astern power output.

3 The construction and strength of hydraulic pumps and hydraulic systems are to comply with the requirements in **10.4**, **13.3.1**, **12.4**, **13.5.2** through **13.5.4** and **11.2.1**.

4 The arrangements of piping, relief valves and measuring devices for hydraulic systems and the construction of liquid level indicators are to comply with the requirements in **13.2.1** and **11.11.4**, **Part 6**.

7.3.3 Hydraulic Actuators

1 The strength of hydraulic actuators is to comply with the requirements specified in **3.4.2**, **Part 6**.

2 The construction of oil seals in hydraulic actuators is to comply with the requirements specified in **3.4.3**, **Part 6**.

7.3.4 Hydraulic Power System

1 Suitable arrangements to maintain the cleanliness of hydraulic fluid are to be provided after taking into consideration the types and designs of hydraulic power systems.

2 Arrangements for bleeding air from hydraulic power systems are to be provided where necessary.

3 Relief valves are to be fitted to any parts of hydraulic power systems which can be isolated and in which pressure can be generated from power sources or from external forces. Setting pressures of relief valves are not to be less than 125 % of the maximum working pressure expected in the protected part. Minimum discharge capacities of relief valves are not to be less than 110 % of the total capacity of pumps which provide power for hydraulic actuators. Under such conditions, any rise in pressure is not to exceed 10 % of the setting pressure. In this regard, due consideration is to be given to any anticipated extreme ambient conditions in respect of oil viscosity.

4 Low level alarms are to be provided for hydraulic fluid tanks to give the earliest practicable indication of any hydraulic fluid leakage. These alarms are to be audible and visual and to be given on navigation bridges and at positions from which main engines are normally controlled.

5 In cases where flexible hoses are used for hydraulic power systems, the construction and strength of such flexible hoses are to comply with the requirements specified in **3.4.4**, **Part 6**.

7.3.5 Stoppers

1 Propulsion systems are to be provided with stoppers for deflectors in order to limit steering angles.

2 Propulsion systems are to be provided with positive arrangements, such as limit switches, for stopping deflectors before coming in contact with any stoppers. These arrangements are to be activated by the actual movements of deflectors and not through control systems for steering. Mechanical links may be used for this purpose.

7.4 Electric Installations

7.4.1 General

For items not specified in this section **7.4**, the requirements specified in **Part 8** are to apply.

7.4.2 Maintenance of Electric Supply

1 Main sources of electric power are to be so arranged that electric supplies to relevant equipment are maintained, or restored immediately in the case of a loss of any one of the generators in service, to ensure the functions of propulsion, steering and reversing of at least one of the propulsion systems, its associated control systems and its indication devices for deflector positions by the following arrangements:

(1) In cases where electrical power is normally supplied by one generator, adequate provisions are to be made for automatic starting and connecting to main switchboards of standby generators of sufficient capacity to maintain the functions of the above with automatic restarting of important auxiliaries including sequential operations in cases where there is a loss of electrical power of the generator in operation.

(2) If electrical power is normally supplied by more than one generator simultaneously in parallel operations, provisions are to be made to ensure that, in cases where there is a loss of electrical power of one of generating sets, the remaining ones are kept in operation to maintain the functions of the above. (*See* **2.3.6**, **Part 8**)

2 In cases where the propulsion power exceeds 2,500 *kW* per thruster unit, 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; 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 alternative power within 45 *seconds* to the deflector and its associated control system and its indication devices for deflector positions. In this case, the alternative source of power is to be capable of changing direction of the ship's directional control system from one side to the other at declared steering angle limits at an average rotational speed of not less than 0.5*°/s* with the ship running ahead at one half of the speeds specified in **2.3.16**, **Part 1** or 7 *knots*, whichever is greater. Alternative sources of power are to have enough capacity for the continuous operation of such systems for at least 30 *minutes* in every ship of 10,000 *estimated gross tonnage* or more, and for at least 10 *minutes* in every other ship. However, for the gas turbine as the alternative source of power approved by the Society, the requirements may be waived.

(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 8**.

7.4.3 Electrical Installations for Steering and Reversing Systems

In cases where hydraulic pumps for hydraulic power systems are driven by electric motors, electrical installations for steering and reversing systems are to comply with the following requirements in **(1)** through **(7)**:

(1) Each propulsion system is to be served separately by exclusive circuits fed directly from main switchboards. In cases where three or more propulsion systems are provided, at least two those exclusive circuits are required. One of these circuits, however, may be supplied through the emergency switchboard.

(2) Cables used in those exclusive circuits required in **(1)** are to be separated as far as practicable throughout their length.

(3) Audible and visual alarms are to be given on navigation bridges in the event of any power failure to electric motors for hydraulic pumps.

(4) Means for indicating that electric motors for hydraulic pumps are running are to be installed on navigation bridges and positions from which main engines are normally controlled.

(5) Short circuit protection and overload alarms are to be provided for such circuits and motors respectively. Overload alarms are to be both audible and visible and are to be situated in conspicuous positions in places from which main engines are normally controlled.

(6) Protection against excess current, including starting currents, if provided, is to be for not less than twice the full load current of those motors or circuits so protected, and to be arranged to permit the passage of any appropriate starting currents.

(7) In cases where a three-phase supply is used, alarms are to be provided that will indicate failure of any one of the supply phases. Such alarms are to be both audible and visible and are to be situated in conspicuous positions in places from which main engines are normally controlled.

7.5 Controls

7.5.1 General

1 Propulsion systems are to be capable of being brought into operation and being controlled on navigation bridges.

2 Steering systems are to be controlled in auxiliary steering stations. Means are to be provided in auxiliary steering stations specified in **7.7** for disconnecting any control systems, operable from navigation bridges, from steering systems they serve.

3 Reversing systems are to be controlled in local control stations for main propulsion or in auxiliary steering stations. Means are to be provided in local control stations for main propulsion or in auxiliary steering stations for disconnecting any control systems, operable from navigation bridges, from reversing systems they serve.

4 In the event of any failure of remote control devices for reversing systems, preset positions of reversers are to be maintained until control of such systems can be gained at local control stations for main propulsion or in auxiliary steering stations.

5 Independent control devices are to be provided for propulsion systems. In cases where multiple propulsion systems are designed to operate simultaneously, they may be control by a single device such as a joystick.

6 Those control devices specified in **-5** are to be so designed that any failure of one such control device does not result in the failure of the others.

7 Cables and pipes of control systems are to be separated as far as practicable throughout their length.

8 If electric, it is to be served by its own separate circuit supplied directly from a switchboard busbars supplying that power circuit for propulsion system at a point on the switchboard adjacent to the supply to the power circuit for propulsion system.

9 Short circuit protection only is to be provided for control supply circuits.

10 Audible and visual alarms are to be given on navigation bridges and at positions from which main engines are normally controlled, in the event of any failure of control systems or electrical power supplies to such control systems.

11 Means of communication are to be provided between navigation bridges and all control stations including auxiliary steering stations.

12 Propulsion systems of ships provided with automatic steering are to be capable of immediate change-overs from automatic to manual steering.

13 For those items concerned with safety, alarms and control devices for propulsion systems not specified in this paragraph **7.5.1**, the requirements specified in **15.1** through **15.3** and **15.7** are to apply.

7.5.2 Indication Devices

1 Indication devices for deflector positions are to comply with the following **(1)** and **(2)**

(1) Deflector positions are to be indicated on navigation bridges and in auxiliary steering stations.

(2) The devices are to be independent of control systems.

2 Indication devices for reverser positions

Reverser positions are to be indicated on navigation bridges and at control stations including auxiliary steering stations and monitoring stations for propulsion systems.

3 Indication devices for impeller speed

Impeller speeds are to be indicated on navigation bridges and at control stations including auxiliary steering stations and monitoring stations for propulsion systems.

7.6 Lubricating Oil Systems

7.6.1 General

1 Lubricating oil systems for propulsion systems are to comply with those relevant requirements specified in **13.8** (in this case the term "main propulsion machinery, propulsion shaftings and power transmission systems" is to be read as "propulsion systems"). Additionally, it is recommended to use, for propulsion systems, strainers with magnets.

2 Lubricating oil arrangements of propulsion systems are to be provided with alarm devices which give visible and audible alarms on navigation bridges and at positions from which main engines are normally controlled in the event of any failure of the supply of lubricating oil or an appreciable reduction of lubricating oil pressure.

7.7 Auxiliary Steering Station

7.7.1 General

1 Auxiliary steering stations, in cases where steering systems are to be operable other than from navigation bridges, are to be provided.

2 Auxiliary steering stations are to comply with the following requirements **(1)** through **(3)**:

(1) Auxiliary steering stations are to be enclosed compartments that are readily accessible, and, as far as possible, separated from machinery spaces.

(2) Auxiliary steering stations are to be provided with adequate space so as to permit propulsion systems to be operated effectively.

(3) Auxiliary steering stations are to be provided with suitable arrangements to ensure working access to steering positions. These arrangements are to include handrails and gratings or other non-slip surfaces to ensure suitable working conditions in the event of any hydraulic fluid leakage.

7.8 Instructions, etc.

7.8.1 Display of Operating Instructions, etc.

Simple operating instructions with block diagrams showing the change-over procedures for propulsion systems and control systems are to be permanently displayed on navigation bridges and at auxiliary steering stations.

7.8.2 Operating and Maintenance Instructions for Propulsion Systems

Operating and maintenance instructions and engineering drawings for propulsion systems are to be provided and written in a language understandable by officers and crew members who are required to understand such information in the performance of their duties.

7.9 Tests

7.9.1 Shop tests

1 The following tests and inspections are to be carried out at manufacturing plants of propulsion systems.

(a) Hydrostatic tests at pressures 1.5 times design pressure for impeller casings, stator casings and bearing housings.

(b) Dynamic balancing tests of impellers

(c) Hydrostatic tests of forward bearing tubes of main shafts and sealing device tubes at pressures of at least 0.2 *MPa* or 1.5 times design pressure, whichever is higher.

(d) The tests specified in **3.5.1**, **Part 6** for hydraulic power systems
(e) Performance tests of control, safety and alarm devices

Chapter 8 TORSIONAL VIBRATION OF SHAFTINGS

8.1 General

8.1.1 Scope

1 The requirements in 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.

8.1.2 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 maximum continuous speed; 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 maximum continuous speed.

(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 (*i.e.*, no injection but with compression) 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.

8.1.3 Measurements

1 For the shafting systems where the submission of torsional vibration calculation sheets is required, measurements to confirm the correctness of the estimated value are to be carried out. However, where the submission of calculation sheets is omitted according to the requirement in **8.1.2-2**; and, the Society considers that there is no critical vibration within the service speed range, the measurement of torsional vibration may by omitted.

2 In cases where the barred speed ranges specified in **8.3.1** are marked for main diesel engines, the following **(1)** and **(2)** are to be confirmed and recorded.

(1) Passing time as well as the ship draft and speed of passing through the barred speed range (accelerating and decelerating). In the case of a controllable pitch propeller, the pitch is also to be confirmed and recorded.

(2) Running condition of engines at both the upper and lower borders of the barred speed range. In this case, the oscillation range of fuel index (fuel injection quantity (fuel rack position)) is normally to be less than 5 % of the effective stroke (maximum fuel injection quantity

(possible fuel rack range)). Alternatively, in the case of engines which do not have means to confirm fuel index, an oscillation range of speed less than 5 % of maximum continuous speed may be confirmed and recorded.

8.2 Allowable Limit

8.2.1 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 speed is within the range of 80 % to 100 % of maximum continuous speed, 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 *degrees* or 60 *degrees*, 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 speed to maximum continuous speed

(2) When the speed is within the range of 80 % and below maximum continuous speed, 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 **8.3** 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 speed to maximum continuous speed

(3) When the speed is within the range of maximum continuous speed 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 degrees or 60 degrees, 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 speed to maximum continuous speed

(4) In cases where the tensile strength of the shaft material exceeds 440 *N/mm*^{2}, or 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, or 1,080 *N/mm*^{2} for low alloy steel forgings.

Y : Specified yield strength of the shaft material (*N/mm*^{2})

8.2.2 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 speed is within the range of 80 % to 105 % of maximum continuous speed, 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 speed to maximum continuous speed

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 800 *N/mm*^{2} (600 *N/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. The upper limit of the value of T_s used for the calculation may be increased to 950 *N/mm*^{2} in intermediate shafts where deemed appropriate by the Society. 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 sea 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 7.8.1**.

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 shaft (*mm*)

(2) When the speed is within the range of 80 % and below maximum continuous speed, 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 $\lambda \leq 0.9$ in **(1)**, the barred speed ranges specified in **8.3** 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 $\lambda \leq 0.8$ (*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 speed is within the range of 80 % to 105 % of maximum continuous speed, the torsional vibration stresses are not to exceed τ_1 given in the following formulae:

$\tau_1 = A - B\lambda^2$ $(\lambda \leq 0.9)$

$\tau_1 = C$ $(0.9 < \lambda)$

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 speed to maximum continuous speed

A, *B*, *C*: Values determined by the materials used, given in **Table 7.8.2**. For the materials other than specified in the Table, however, the values are to be deemed appropriate by the Society.

(2) When the speed is within the range of 80 % and below maximum continuous speed, 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 $\lambda \leq 0.9$ in **(1)**, the barred speed ranges specified in **8.3** are to be imposed.

$\tau_2 = 2.3\tau_1$

τ_2 : Allowable limit of torsional vibration stresses for the range of $\lambda \leq 0.8$ (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 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 7.8.1 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 7.5.2**.

(2) To be in accordance with **note (4) of Table 7.5.2**.

(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 7.8.2 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

8.2.3 Shafting System of Generating Plants

1 The torsional vibration stresses on the crankshafts of diesel engines used for generating plants (hereinafter referred to in this Chapter 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 speed is within the range of 90 % to 110 % of maximum continuous speed, 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 *degrees* or 60 *degrees*, the value of τ_1 is given by the following formula:

$\tau_1 = 21$ (*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:

$\tau_1 = 16$ (*N/mm*^{2})

(2) When the speed is within the range of 90 % and below maximum continuous speed, 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 **8.3** are to be imposed.

$\tau_2 = 90$ (*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 speed is within the range of 90 % to 110 % of maximum continuous speed, the torsional vibration stresses are not to exceed τ_1 given in the following:

$\tau_1 = 31$ (*N/mm*^{2})

(2) When the speed is within the range of 90 % and below maximum continuous speed, 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 **8.3** 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}, or 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 **8.2.1(4)**.

8.2.4 Power Transmission Systems

1 The torsional vibration torques on the power transmission systems 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 **8.2.1**, **8.2.2** and **8.2.3**, 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 **8.3** 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 **8.2.2**.

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.

8.2.5 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 $0.8 \leq \lambda \leq 1.1$

For shafting system of generating plants $0.9 \leq \lambda \leq 1.1$

where

λ : Ratio of the speed at the major critical to maximum continuous speed

8.2.6 Detailed Evaluation for Strength

Special consideration will be given to allowable limits of torsional vibration stresses that do not comply with the requirements in **8.2.1**, **8.2.2** and **8.2.3**, provided that detailed data and calculations are submitted to the Society and considered appropriate.

8.3 Barred Speed Range

8.3.1 Barred Speed Range for Avoiding Continuous Operation

1 In cases where the torsional vibration stresses exceed the allowable limit τ_1 specified in **8.2**, 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.

$$\frac{16N_c}{18-\lambda} \leq N_0 \leq \frac{(18-\lambda)N_c}{16}$$

where

N_0 : The speed to be barred (min^{-1})

N_c : The speed at the resonant critical (min^{-1})

λ : Ratio of the speed at the resonant critical to maximum continuous speed

(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 **8.2** 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 9 BOILERS, ETC. AND INCINERATORS

9.1 General

9.1.1 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

9.1.2 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 **2.3.21, 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.

9.1.3 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) 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

9.2 Design Requirements

9.2.1 Symbols

Unless expressly specified otherwise, the symbols used in this Chapter are as follows:

L : Allowable stress (N/mm^2) conforming to the requirements in **9.3.1** or **13.3.1**.

T_r : Required thickness (mm) calculated by the design pressure. In addition, "allowable pressure" is the pressure obtained by replacing required thickness with actual thickness in any of the formula.

P : Design pressure (MPa)

J : Minimum value of the efficiency specified in **9.3.2**

R : Internal radius of drum (mm)

9.2.2 Design Pressure of Economizers and Exhaust Gas Economizers

1 The design pressure of an economizer is not to be less than the maximum working pressure of the economizer that is determined on the basis of the maximum working pressure of the feed pump.

2 The design pressure of an exhaust gas economizer is not to be less than the maximum working pressure of the exhaust gas economizer that is determined on the basis of the maximum working pressure of the boiler water circulating pump.

9.2.3 Considerations for Structural Strength

1 In cases where the effects from any additional stresses (*e.g.*, such as local stress concentration, repeated loads and thermal stress, etc.) are significant, suitable measures, such as increasing the thickness, are to be taken if necessary.

2 The fixed parts of the flue tubes for vertical boilers are to be designed so that the deformation of the shape of the flue tube induced by the thermal expansion of the hemispherical furnace is not excessively restricted.

3 Sufficient consideration is to be given to the following **(1)** and **(2)** to prevent the overheating of the water tubes for any boilers having a combustion chamber with a high calorific capacity:

(1) Water is to be sufficiently circulated throughout the boiler by water tubes, and
(2) In order to prevent any scale from adhering to the sides of the boiler, proper means, such as a water softener, etc., are to be provided.

9.2.4 Boilers of Unusual Shape

1 In cases where it is not practicable or reasonable to calculate the strength of the pressure receiving part of the boiler according to the requirements in **9.4** to **9.6** because the part is of an unusual shape, another detailed method of calculation is to be used after receiving the approval of the Society. Based on the results of this calculation, the part may be considered to be in compliance with the requirements in **9.4** to **9.6**.

2 In cases where it is not appropriate to design the pressure receiving part of the boiler according to the requirements in **9.4** to **9.6** because the part is of an unusual shape, strains or deformations are to be measured under a suitable load after receiving the approval of the Society. Based on the results of these measurements, the part may be considered to be in compliance with the requirements in **9.4** to **9.6**.

9.2.5 Considerations for Installing

1 Boilers are to be so installed as to minimize the effects of the following loads or external forces:

(1) Ship motions or any vibrations caused by machinery installations
(2) External forces caused by the piping or any other supports fitted onto the boiler

(3) Thermal expansions due to temperature fluctuation

2 Boilers are to be installed so that they are clear of any bulkheads as far as practicable. (The installation of boiler is to comply with the requirements in **21.3.3, Part C of the Rules for the Survey and Construction of Steel Ships**.)

3 Shell type exhaust gas economizers are to be installed so that the tube plate to shell connection can be inspected easily.

9.2.6 Protections against Flame

In cases where part of the boiler drum and the tube header construction will be exposed to flames or high temperature gas, proper thermal insulation or some other suitable means is to be provided. In addition, for shell type exhaust gas economizers, the insulation at the circumference of the tube end plate is to be detachable so that an ultrasonic examination of the tube plate to shell connection can be carried out.

9.2.7 Consideration for Soot Fire

Consideration is to be given to prevent exhaust gas boilers and exhaust gas economizers, from being damaged by a soot fire.

9.3 Allowable Stress and Efficiency

9.3.1 Allowable Stress

The allowable stress for each of the materials used for boilers is to be determined in accordance with the following. In this case, the material temperature used to evaluate the allowable stress of boilers is determined by increasing the designed maximum temperature of the internal fluid by the temperature increment at heating surface that is given in **Table 7.9.1**. However, the minimum temperature of the materials is not to be less than 250 °C.

(1) Excluding all cast steels, the allowable stress (*f*) of carbon steel (including carbon manganese steel, hereinafter referred to as the same in this Chapter) and low alloy steels is not to be greater than value obtained from the following formulae, whichever is the smallest. However, the values given in **Table 7.9.2** for the allowable stress for each material temperature may also be used instead those from the formulae.

$$f_1 = \frac{R_{20}}{2.7},\ f_2 = \frac{E_t}{1.6},\ f_3 = \frac{S_R}{1.6},\ f_4 = \frac{S_c}{1.0}$$

where

R_{20} : Specified tensile strength of the applicable steel at room temperature (N/mm^2).

E_t : Yield point of the applicable steel at material temperature (or 0.2 % proof stress) (N/mm^2).

S_R : Average stress of the applicable steel to produce a rupture in 100,000 *hours* at material temperature. However, when the average stress of the width of dispersion exceeds the average value by ±20 %, the value is 1.25 times the minimum stress that is required to produce rupture in 100,000 *hours* at material temperature (N/mm^2).

S_C : Average stress to produce a 1 % elongation (creep) in the applicable steel in 100,000 *hours* at material temperature (N/mm^2).

(2) The allowable stress of electric resistance welded steel pipes is to be 85 % of the values given in **Table 7.9.2**.

(3) The allowable stress of cast steels is to be 80 % of the value obtained by the formula in **(1)** or the value given in **Table 7.9.2**. Cast steel exceeding 50 *mm* in thickness is not to be used unless specially approved by the Society.

(4) The stress values of materials other than those specified in **(1)** and **(3)** will be considered in each case by the Society taking account of the mechanical properties of the materials.

Table 7.9.1 Temperature Increment to Internal Fluid Temperature for Material Temperature at Heating Surface

Heating surface		
Heating surface, in general	Heated by contact	25°C
	Heated by radiation	50°C
Heating surface of superheater	Heated by contact	35°C
	Heated by radiation	50°C
Heating surface of economizer and exhaust gas economizer		25°C

Table 7.9.2 Value of Allowable Stress

Kind of material (grade)	Allowable stress (f) N/mm^2											
	250°C or below	300 °C	350 °C	375 °C	400 °C	425 °C	450 °C	475 °C	500 °C	525 °C	550 °C	575 °C
Rolled steel plate for boilers												
*KP*42	110	104	103	96	88	76	57	39	-	-	-	-
*KP*46	122	117	113	106	95	80	58	39	-	-	-	-
*KP*49	124	122	121	114	102	84	58	39	-	-	-	-
*KPA*46	122	117	113	113	113	108	101	90	69	48	-	-
*KPA*49	124	122	121	121	121	117	106	91	69	48	-	-
Steel headers												
*KBH*1	105	104	103	97	88	76	57	39	-	-	-	-
*KBH*2	117	115	113	106	95	80	58	39	-	-	-	-
*KBH*3	102	99	96	96	96	93	91	87	67	-	-	-
*KBH*4	106	104	103	103	103	102	98	92	74	-	-	-
*KBH*5	106	104	103	103	103	102	98	92	81	64	-	-
*KBH*6	106	104	103	103	103	102	98	92	81	64	-	-
Steel tubes for boilers												
*KSTB*33	86	84	81	78	74	66	-	-	-	-	-	-
*KSTB*35	88	87	86	82	76	76	53	-				
*KSTB*42	113	104	103	97	88	94	57	-	-	-	-	-
*KSTB*12	102	99	96	96	96	102	91	87	69	-	-	-
*KSTB*22	106	104	103	103	103	102	98	92	81	64	44	-
*KSTB*23	106	104	103	103	103	102	98	92	81	64	47	34
*KSTB*24	106	104	103	103	103	102	98	92	81	64	48	36
Forged steel (*see* **Part 3**)	1/4 of the specified tensile strength of the material (where used at 350°C or below)											
Cast steel (*see* **Part 3**)	1/5 of the specified tensile strength of the material (where used at 350°C or below)											

Note:
In cases where the material temperature is between those given in the Table, the value of allowable stress is to be determined by interpolation.

9.3.2 Efficiencies of Joints and Ligaments

1 The efficiency of joints is to be as follows:

(1) Seamless shells: 1.00

(2) Welded shells

(a) Double-welded butt joints: 1.00

(b) Other cases: 0.90

2 The efficiency of ligaments is to be as follows:

(1) The efficiency of a longitudinal ligament (hereinafter referred to as “longitudinal efficiency”) along the row of tube holes of a shell plate having a row parallel or nearly parallel to the shell axis, or of a shell or tube plate having several parallel rows that are sufficiently apart from each other, is to be determined by the following formulae:

(a) In cases where the pitch of the tube holes is uniform:

$$J_1 = \frac{p-d}{p}$$

where

J_1 : Efficiency of the ligament

p : Pitch of the tube holes (mm)

d : Diameter of the tube holes (*mm*)

(b) In cases where the pitch of the tube holes is irregular:

$$J_2 = \frac{L - nd}{L}$$

where

J_2 : Efficiency of the ligament

d : As specified in **(a)**

L : Total length between the centres corresponding to *n* consecutive ligaments (*mm*)

n : Number of tube holes in the length *L*

(2) The efficiency of a circumferential ligament (hereinafter referred to as "circumferential efficiency") at the part of the tube holes drilled in the circumferential direction of the shell is to be calculated in a similar manner to that specified in **(1)**, and is not to be less than 50 % of the longitudinal efficiency. In this case, the pitch of the tube holes in the circumferential direction is to be measured either on the flat plate before rolling or along the median line of plate thickness after rolling.

(3) The efficiency of a ligament at the part of the tube holes drilled in a diagonal direction to the shell is to be determined by the following formula:

(a) In cases where the tube holes are drilled in a diagonal direction to the shell as shown in **Fig. 7.9.1** and **Fig. 7.9.2**: The efficiency obtained from the following formula or the longitudinal efficiency, whichever is smaller, is to be taken as the efficiency of the ligament at the part of the tube holes.

$$J_3 = \frac{2}{A + B + \sqrt{(A - B)^2 + 4C^2}}$$

where

J_3 : Efficiency of the ligament

$$A = \frac{cos^2\alpha + 1}{2\left(1 - \frac{dcos\alpha}{a}\right)}$$

$$B = \frac{1}{2}\left(1 - \frac{dcos\alpha}{a}\right)(sin^2\alpha + 1)$$

$$C = \frac{sin\,\alpha\,cos\,\alpha}{2\left(1 - \frac{dcos\,\alpha}{a}\right)}$$

$$cos\,\alpha = \frac{1}{\sqrt{1 + \frac{b^2}{a^2}}}$$

$$sin\,\alpha = \frac{1}{\sqrt{1 + \frac{a^2}{b^2}}}$$

α : As shown in **Fig. 7.9.1**, **Fig. 7.9.2** and **Fig. 7.9.3**

a, *b* : As shown in **Fig. 7.9.1**, **Fig. 7.9.2** and **Fig. 7.9.3** (*mm*)

d : Diameter of the tube holes (*mm*)

(b) In **(a)**, where the tube holes are arranged in a regular staggered spacing as shown in **Fig. 7.9.3**

The efficiency obtained from the formula in **(a)**, twice the circumferential efficiency or the longitudinal efficiency, whichever is the smallest, is to be taken as the efficiency of the ligament at the part of the tube holes.

Note: The efficiencies of the ligament obtained from **(a)** and **(b)** shown in **Fig. 7.9.4** and **Fig. 7.9.5** are from taking the ratio *b/a* on the abscissa and ratio $\frac{2a-d}{2a}$ as the parameter.

(4) The efficiency of a ligament per unit length, where the tube holes are irregularly arranged along the longitudinal direction of the shell, is to be the smaller of the two smallest values calculated by the following **(a)** or **(b)**. However, the efficiency need not be smaller than the minimum efficiency calculated by taking L_1 as the distance between the centres of tubes on both ends of the tube rows within a length equal to the inside diameter of the shell (the distance to the centre of the adjacent tube hole, in cases where there is only one tube hole within a length equal to the inside diameter of the shell).

(a) For a length L_1 equal to the inside diameter of the shell (1,520 *mm* maximum)

$$J_4 = \frac{a + b + c + \cdots\cdots\cdots}{L_1}$$

(b) For a length L_2 equal to the inside radius of the shell (760 *mm* maximum)

$$J_5 = \frac{a + b + c + \cdots\cdots\cdots}{L_2} \times 1.25$$

where

J_4 and J_5: Efficiency of the ligament

a, b, c : Distances between the tube holes arranged along the longitudinal direction of shell. If they are arranged in a diagonal direction, the distances are to be the length projected on the longitudinal direction multiplied by the efficiency obtained from **(3)**.

Fig. 7.9.1 Spacing of Holes on a Diagonal Line

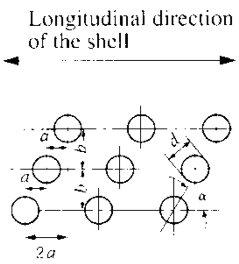


Fig. 7.9.2 Saw Tooth Pattern of Holes

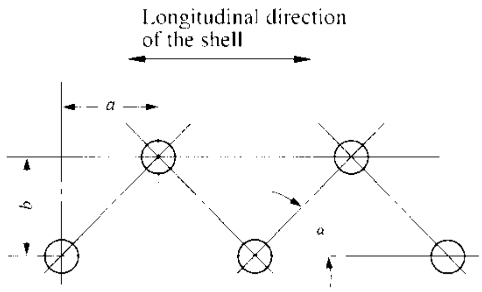


Fig. 7.9.3 Regular Staggered Pattern of Holes

Fig. 7.9.4 The Efficiency of Ligament at the Part of the Tube Holes drilled in a Circumferential Direction

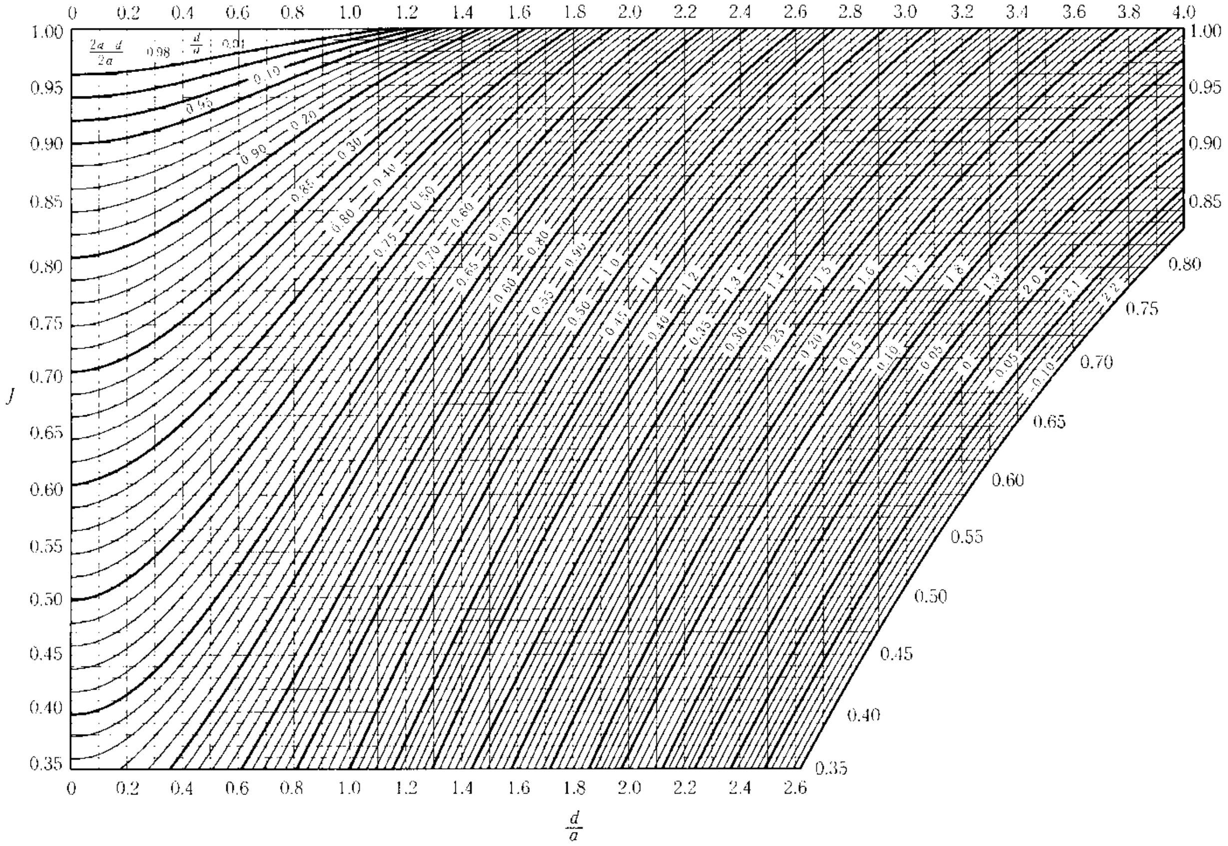
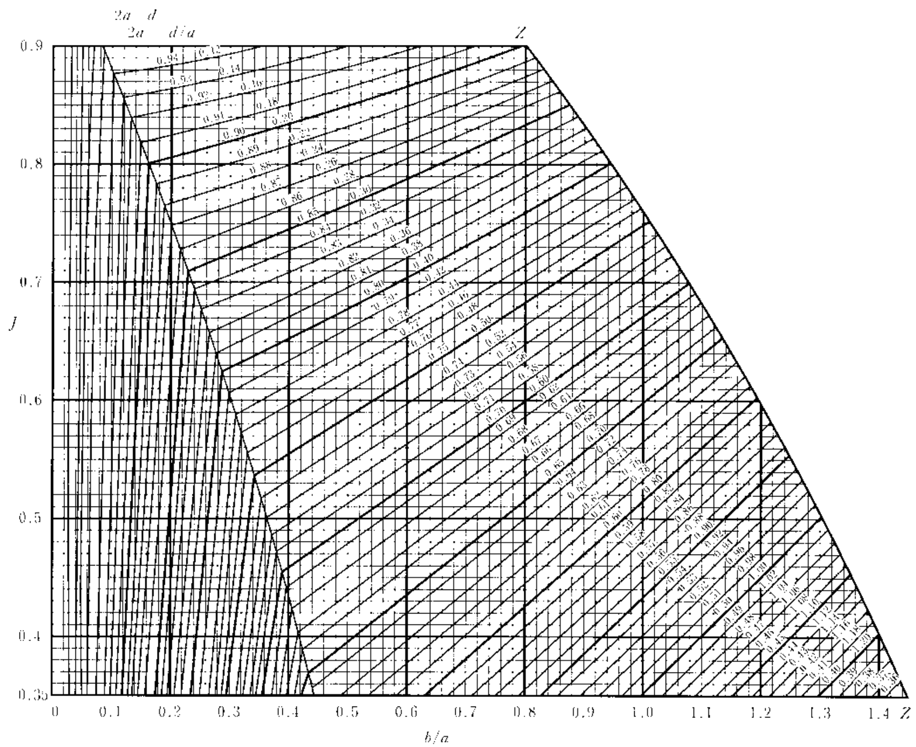


Fig. 7.9.5 The Efficiency of Ligament at the Part of the Tube Holes drilled in a Diagonal Direction



Note:

In cases where a point falls in the field on the right side of the intersection *Z-Z*, the longitudinal efficiency is to be deemed as the efficiency at the part of the tube holes

9.4 Calculations of Required Dimensions of Each Member

9.4.1 Restrictions to Thickness of Each Member

1 The thickness of shell plates and end plates are not to be less than 6 *mm*. The thickness of a formed end plate, except for a full hemispherical end plate, is not to be less than the thickness (calculated by using an efficiency value equal to 1.00) of the shell to which the end plate is attached.
2 The thickness of tube plates and flat plates is not to be less than 10 *mm* for the tube plates and 6 *mm* for the flat plates.
3 The thickness of nozzles welded to drum shells and connected with mountings, etc. 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 given in **9.6.4**. However, this value need not be more than the thickness of the drum onto which the nozzle is welded.
4 The thickness of furnace plates is not to be less than 5 *mm* or more than 22 *mm*.

9.4.2 Required Thickness of Cylindrical Shell Plates subjected to Internal Pressure

The required thickness of cylindrical shell plates subjected 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, the openings are to be reinforced in accordance with the requirements in **9.5.3**.

$$T_r = \frac{PR}{fJ - 0.5P} + 1$$

9.4.3 Required Thickness of Formed End Plates Subjected to Pressure on Concave Side without Stays or Other Supports

1 The required thickness of end plate having no opening is to be calculated by the following formula:
(1) Dished and hemispherical end plates

$$T_r = \frac{PR_1W}{2fJ - 0.5P} + 1$$

where

$$W = \frac{1}{4}\left(3 + \sqrt{\frac{R_1}{r}}\right) \text{ for a dished end plate}$$

$W = 1$ for a hemispherical end plate
R_1 : Inside crown radius
To be less than the outside diameter of the end plate
r : Inside knuckle radius
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
(2) Semi-ellipsoidal end plates (in cases where half of the inside minor axis of the end plate is not less than 1/4 of the inside major axis of the end plate)

$$T_r = \frac{PR}{fJ - 0.25P} + 1$$

2 The required thickness of end plates having openings is to comply with the following requirements in **(1)**, **(2)** or **(3)**:
(1) In cases where no reinforcement for openings is necessary according to the requirements in **9.5.2**, or the openings are reinforced in accordance with the requirements in **9.5.3-3** to **-5**, the required thickness is to be calculated by the formula specified in **-1** above.
(2) 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 **9.5.3-7**, the thickness is to be calculated as follows:
(a) Dished or hemispherical end plates
The thickness is to be increased by not less than 15 % (if the calculated value is less than

3 *mm*, the value is to be taken as 3 *mm*) of the required thickness calculated by the formula specified in **-1(1)**. 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 an end plate having two manholes in accordance with **(a)**, the distance between the two manholes is not to be less than 1/4 of the outside diameter of the end plate.

(b) Semi-ellipsoidal end plates

The requirements specified in **-1(1)** 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.

(3) The required thickness, where the openings are not reinforced in accordance with the requirements in **(1)** or **(2)**, is to be calculated by the following formula. However, the thickness is not to be less than the value obtained by the formula given in **-1**.

$$T_r = \frac{PD_0}{2f}K + 1$$

where

D_0: Outside diameter of the end plate (*mm*)

K: As shown in **Fig. 7.9.6**, however, this is only applicable to the end plates complying with the following conditions:

Hemispherical end plates:

$0.003D_0 \leq T_e \leq 0.16D_0$

Semi-ellipsoidal end plates:

$0.003D_0 \leq T_e \leq 0.08D_0$

$H \geq 0.18D_0$

Dished end plates:

$0.003D_0 \leq T_e \leq 0.08D_0$

$r \geq 0.1D_0$

$r \geq 3T_e$

$R_1 \leq D_0$

$H \geq 0.18D_0$

or $0.01D_0 \leq T_e \leq 0.03D_0$

$r \geq 0.06D_0$

$H \geq 0.18D_0$

or $0.02D_0 \leq T_e \leq 0.03D_0$

$r \geq 0.06D_0$

$0.18D_0 \leq H \leq 0.22D_0$

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(1)**

9.4.4 Required Thickness of Formed End Plates subjected to Pressure on 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.

9.4.5 Required Thickness of Flat End Plates and Cover Plates, etc., without Stays or Other Supports

1 In cases where the flat end plates and cover plates without stays or other supports are welded to the shell plates, the required thickness is to be calculated by the following formulae:

(1) Circular plates

$$T_r = C_1 d \sqrt{\frac{P}{f}} + 1$$

(2) Non-circular plates

$$T_r = C_1 C_2 d \sqrt{\frac{P}{f}} + 1$$

where

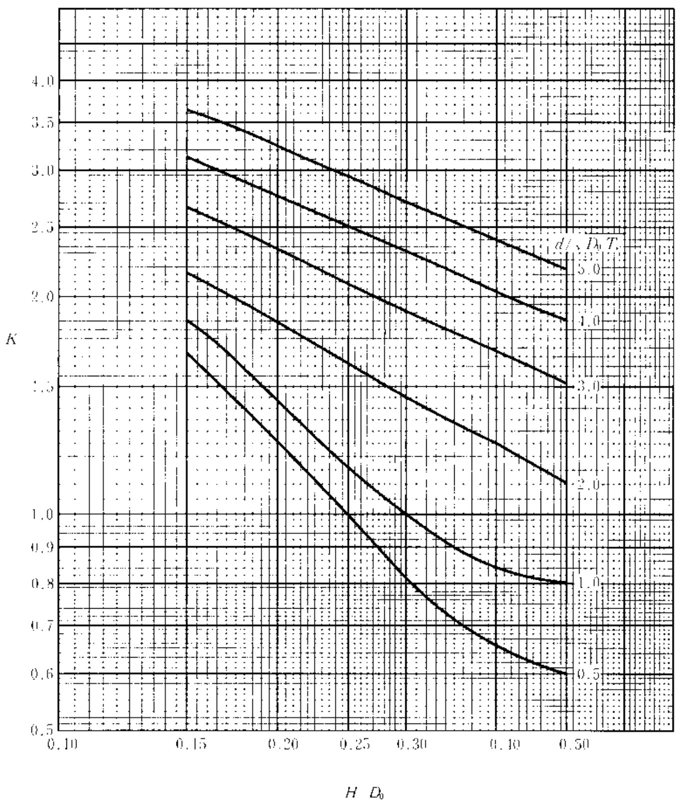
C_1 : Constant shown in **Fig.7.9.9**

C_2 : $\sqrt{3.4 - 2.4\frac{d}{D'}}$, but need not be over 1.6.

d : Diameter shown in **Fig. 7.9.9** (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*)

Fig. 7.9.6 Value of *K*



Notes:

d : Diameter of the opening (*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*)

D_0 : Outside diameter of the end plate (*mm*)

2 In cases where the flat cover plates without stays are bolted to the shell plate, the required thickness is to be calculated by the following formulae:

(1) In cases where full face gaskets are used;

For circular plates

$$T_r = d\sqrt{\frac{C_3 P}{f}} + 1$$

For non-circular plates

$$T_r = d\sqrt{\frac{C_3 C_4 P}{f}} + 1$$

(2) In cases where moment due to gasket reaction is to be taken into account;

For circular plates

$$T_r = d\sqrt{\frac{C_3 P}{f} + \frac{1.78 W h_g}{f d^3}} + 1$$

For non-circular plates

$$T_r = d\sqrt{\frac{C_3 C_4 P}{f} + \frac{6 W h_g}{f L d^2}} + 1$$

where

C_3 : Constant determined by bolting methods as shown in **Fig. 7.9.10**

C_4 : $3.4 - 2.4\frac{d}{D'}$, but need not be over 2.5.

d : Diameter shown in **Fig. 7.9.10** (for circular plates), or 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 allowable load of the bolt actually used

L : Total length of the circle passing through bolt centers (mm)

h_g : Arm length of moment due to the gasket reaction shown in **Fig. 7.9.10** (mm)

9.4.6 Required Thickness of Flat Plates with Stays or Other Supports

1 The required thickness of flat plates, except tube nests supported by stays or stay tubes, is to be calculated by the following formula:

$$T_r = C_5 S\sqrt{\frac{P}{f}} + 1$$

where

C_5 : Constant determined by the fixing methods of the stays or stay tubes as given in **Table 7.9.3**. In cases where various fixing methods are used, the value C_5 is to be the mean of the constants for the respective methods.

Table 7.9.3 Value of Constant C_5

Fixing method of stay or stay tube		In cases where the plates are not exposed to flames	In cases where the plates are exposed to flames
(1)	In cases where the stays are inserted into the plate as (5) *A* in **Fig. 7.9.9**	0.35	0.38
(2)	In cases where the stays are inserted into the plate as (5) *B* in **Fig. 7.9.9**	0.37	0.40
(3)	In cases where the stays are inserted into the plate as (5) *C* in **Fig. 7.9.9**	0.41	0.44
(4)	In cases where the stays are inserted into the plate as (5) *D* in **Fig. 7.9.9**	0.50	0.53
(5)	In cases where the stay tubes are inserted into the plate as (6) *A* in **Fig. 7.9.9**	0.42	0.45
(6)	In cases where the stay tubes are inserted into the plate as (6) *B* in **Fig. 7.9.9**	0.49	0.52
(7)	In cases where the stay tubes are inserted into the plate as (6) *C* in **Fig. 7.9.9**	0.49	0.52

S : In cases where the stays or stay tubes are arranged regularly, "S" is to be calculated by the following formula:

$$S = \sqrt{a^2 + b^2} \quad (mm)$$

a : Horizontal pitch of stays or stay tubes (mm)

b : Vertical pitch of stays or stay tubes (mm).

In cases where stays or stay tubes are arranged irregularly, "S" is the diameter (mm) of the maximum circle drawn to pass through at least three supported points, but not including any supported point in the circle.

2 The position and constant C_5 of the supported point at the welding part between the plain end and the curved flange or shell, furnace, etc. are as follows

(1) The commencement of the curvature of the flange is to be regarded as the point of support. Where, however, the inner radius of the curvature is greater than 2.5 times the thickness of the plate, the points located at a distance of 3.5 times the thickness of the plate from the outer surface of the flange may be considered as a commencement of the curvature. In this case, the value of constant C_5 is to be 0.39 where the plates are exposed to flames or 0.36 where the plates are not exposed to flames.

(2) The inside of the welding part between the plain ends and the shell, furnaces, etc. are to be regarded as points of support. In this case, the value of constant C_5 is to be 0.47 where the plates are exposed to flames or 0.43 where the plates are not exposed to flames.

3 The required thickness of the tube nests of the boiler tube plate supported by stay tubes is to be calculated by the following formula:

$$T_r = C_6 p \sqrt{\frac{P}{f}} + 1$$

where

C_6 : Constant determined by the fixing method of the stay tubes as given in **Table 7.9.4**

Table 7.9.4 Values of Constant C_6

Fixing method of stay or stay tubes	In cases where the plates are not exposed to flames	In cases where the plates are exposed to flames
In cases where the stay tubes are inserted into the plate as (6) *A* in **Fig. 7.9.9**	0.51	0.54
In cases where the stay tubes are inserted into the plate as (6) *B* in **Fig. 7.9.9**	0.57	0.61
In cases where the stay tubes are inserted into the plate as (6) *C* in **Fig. 7.9.9**	0.57	0.61

p : In cases where the stay tubes are arranged regularly, the mean pitch of the stay tubes is obtained by dividing the sum of the four sides of a quadrilateral formed by four supports (mm). In cases where the stay tubes are arranged irregularly, "S" (mm) is the diameter of a maximum circle drawn to pass through at least three supported points, but not including any supported point in the circle and $S/\sqrt{2}$ is to be used in lieu of "p"

4 The required thickness of the tube plates of vertical boilers having horizontal smoke tubes which form smoke tube nests is to be calculated by the formula in **-3** or by the following formula, whichever is greater:

$$T_r = \frac{PDp}{1.97f(P - d_s)} + 1$$

where

D : Twice the distance from the centre of the outer row of tube holes of the tube plate to the axis of the shell (*mm*)

p : Vertical pitch of the tubes (*mm*)

d_s : Diameter of the tube holes in the tube plate (*mm*)

5 The required thickness of the back tube plates in a cylindrical boiler with a wet combustion chamber is to be calculated by the formula in **-3** or by the following formula, whichever is greater:

$$T_r = \frac{PWH}{183(H - d_i)}$$

where

H : Horizontal pitch of the smoke tube (*mm*)

d_i : Inside diameter of the ordinary smoke tube (*mm*)

W : Depth of the upper part of the combustion chamber (*mm*)

6 As for the scantlings of the stayed top plate and the stayed side plate of the combustion chamber of a cylindrical boiler, the distance between the row of stays nearest to the tube plate or the back plate and the commencement line of curvature of the tube plate or the back plate is not to be greater than "*a*" determined by the formula in **-1**, substituting the actual thickness for the required thickness.

9.4.7 Required Thickness of Corrugated Furnaces

The required thickness of a corrugated furnace is to be calculated by the following formula:

$$T_r = \frac{PD}{C} + 1$$

where

D : Minimum outside diameter at the corrugated part of the furnace (*mm*)

C : Constant given in **Table 7.9.5**

Table 7.9.5 Value of Constant *C*

Type of furnace	*C*
Morrison, Deighton and similar furnaces	107
Leeds forge bulb furnace	104

9.4.8 Required Thickness of Plain Cylindrical Furnaces

The required thickness of a plain cylindrical furnace or a cylindrical bottom, which is not reinforced by stays or any other means, and the smoke uptake of a combustion chamber are to be calculated by the following formulae, whichever is greater:

$$T_r = \sqrt{\frac{PD(L + 610)}{10500}} + 1$$

$$T_r = \frac{1}{325}\left(\frac{PD}{0.35} + L\right) + 1$$

where

D : External diameter of the furnace or the combustion chamber bottom (*mm*)

L : Length of the furnace or depth of the combustion chamber bottom (*mm*)

The length of a furnace is measured from the commencement of curvature in cases where the furnace plates are flanged and jointed to other plates, reinforcing rings, etc.

9.4.9 Required Thickness of Hemispherical Furnaces without Stays or Other Supports

The required thickness of a hemispherical furnace without any stays or other supports is to be calculated by the following formula:

$$T_r = \frac{PR_f}{62} + 1$$

where

R_f : Outer radius of the curvature of the furnace (*mm*)

9.4.10 Required Thickness of Ogee Rings of Vertical Boilers

The required thickness of any ogee rings, which sustain the whole vertical load of the furnace, connecting the furnace bottom of a vertical boiler to the shell is to be calculated by the following formula:

$$T_r = \sqrt{\frac{PD(D-d)}{1010}} + 1$$

where

D : Inside diameter of the shell (*mm*)

d : External diameter of the lower part of the furnace where it joins the ogee ring (*mm*)

9.4.11 Required Thickness of Furnace Foundation Ring Plates of Vertical Boilers

The required thickness of a furnace foundation ring plate (refer to **Fig. 7.9.9(4) E**) connecting the furnace bottom of a vertical boiler to the shell is to be calculated by the following formula:

$$T_r = 1.28\sqrt{DP}$$

where

D : Inside diameter of the shell (*mm*)

9.4.12 Required Diameter of Stays

1 The required diameter of a stay is to be calculated by the following formula:

$$d = C\sqrt{PA} + 3$$

where

d : Required diameter of the stay (*mm*)

A : Net area supported by one stay (mm^2)

C : 0.13

2 In applying the formula in **-1** to diagonal stays, C in the formula is to be replaced by C_1 given by the following formula:

$$C_1 = 0.13\sqrt{\frac{L}{H}}$$

where

L : Length of the diagonal stay (*mm*)

H : Equivalent length of the stays perpendicular to the support surface (*mm*)

9.4.13 Required Dimensions of Stay Tubes

The required dimensions of stay tubes supporting the tube plates are to be calculated by the following formula. However, the thickness of the stay tubes is not to be less than 6 *mm* for those in the bounding rows of tube nests or less than 4.5 *mm* for all others.

$$a = \frac{PA}{51.7}$$

where

a : Minimum net sectional area of one stay tube (mm^2)

A : Net area supported by one stay tube (mm^2)

9.4.14 Required Thickness of Girders Supporting Top Plates of Combustion Chambers and their Distance to Side Plates

1 The required thickness of steel girders supporting the top plates of combustion chambers is to be calculated by the following formula:

$$T_r = \frac{DLP(L-p)}{Cd^2 S}$$

where

T_r : Required thickness of the girders (*mm*). However, in the case of double plate construction, the sum of the thickness of each plate

d : Depth of the girders at their centre (*mm*)

L : Width of the combustion chamber measured along inner upper part (*mm*)

p : Pitch of the stays supporting the girder (*mm*)

D : Pitch of the girders (*mm*)

S : Specified tensile strength of the material used for the girders (N/mm^2)

C : Constant given in **Table 7.9.6**

2 The distance between the inner surface of the side plate and the centre of the supporting beam nearest to it is not to be more than the pitch D in cases where the outer radius of the knuckle, used to connect the top plate of the combustion chamber of a boiler to a side plate, is less than 1/2 of the pitch D of the supporting beam obtained from the formula in **-1**, after substituting the actual thickness of girders of a boiler into the formula. And, where the outer radius of the knuckle is larger than $D/2$, the width of the flat surface measured from the centre of the supporting beam to the starting point of the knuckle is not to be more than $D/2$.

Table 7.9.6 Value of Constant C

When the number of stays (n) in each girder is odd	$\frac{0.253n}{n+1}$
When the number of stays (n) in each girder is even	$\frac{0.253(n+1)}{n+2}$

9.4.15 Required Thickness of Cylindrical Headers

The required thickness of any cylindrical headers is to be calculated by the formula in **9.4.2**. However, in cases where the thickness of the header exceeds 1/2 of the inside radius of the header and the material temperature is 375 °C or below, the required thickness is to be calculated by the following formula:

$$T_r = R\left(\sqrt{\frac{fJ+P}{fJ-P}} - 1\right) + 1$$

9.4.16 Required Thickness of Square Headers

The required thickness of any square headers made of forged or welded steel plates is to be calculated by the following formula:

(1) In cases where the holes are not arranged in succession:

$$T_r = \frac{Pl_2}{4f}\left(1 + \sqrt{1 + 4f\frac{{l_1}^2}{P{l_2}^2}}\right) + 1.5$$

(2) In cases where the holes are arranged in succession:

$$T_r = \frac{Pl_2}{4f}\left(1 + \sqrt{1 + \frac{8f{l_1}^2}{(1+J)P{l_2}^2}}\right) + 1.5$$

where

l_1 : Inside breadth measured between the supports of any flat surfaces needed for strength calculation (mm)

l_2 : Inside breadth of another side adjacent to l_1 (mm)

9.5 Manholes, Other Openings for Nozzles, etc. and their Reinforcements

9.5.1 Manholes, Cleaning Holes and Inspection Holes

1 Boilers are to be provided with manholes or cleaning holes of sufficient size at suitable positions, so that they permit easy access for the inspection and the maintenance. However, in cases where it is impractical to provide manholes or cleaning holes due to construction or dimension concerns, two or more inspection holes provided at positions suitable for internal inspection will be accepted as a substitute for them.

2 The construction of all manholes or cleaning holes is to comply with the following requirements in **(1)** to **(3)**:

(1) The minor axis of any oval manhole provided on the shell plate is to be parallel to the longitudinal direction of the drum.

(2) Internal type manhole covers are to be provided with a spigot which has a clearance of not more than 1.5 mm all-round.

(3) Covers are to have sufficient strength and be constructed so that the repetition of covering and uncovering does not to impair safety. In cases where covers are bolted shut, they are to be of such construction so that the breakage of a bolt will not cause any danger.

3 The inspection holes of headers are to be machine-finished so that all inspection hole covers can be effectively fitted.

9.5.2 Reinforcement of Openings

In cases where manholes, other openings for nozzles, etc. are provided in the shell, the openings are to be reinforced. However, this reinforcement may be omitted for any of the following single openings:

(1) Openings having a maximum diameter (in threaded openings, the diameter of the root) of not more than 60 mm or more than 1/4 of the inside diameter of the shell.

(2) Openings provided on the shell plate having a maximum diameter not exceeding the value given in **Fig. 7.9.7**. In this case, unreinforced openings are not to exceed 200 mm in diameter.

(3) Openings provided on the end plate where no reinforcement is required due to the increased thickness of the end plates in compliance with the requirements in **9.4.3-2(3)**.

(4) Openings provided on the end plate or cover plate where the thickness of the end plate or cover plate is increased in accordance with the requirements in **9.5.3-3(2)**.

9.5.3 Reinforcing Procedures of Openings

1 The meanings of the symbols used in **9.5.3** are as follows:

a : Area of the shell or end plate available for reinforcement (mm^2)

A_0 : Required cross sectional area of the reinforcement (mm^2)

d_1 : Diameter of the opening in the cross section where reinforcement is intended (mm)

d_0 : Maximum diameter of the finished opening in the longitudinal cross section of the shell plate or in the cross section of the end plate (mm)

h : Depth of the flange measured along the major axis of opening from the outer surface of end plate (mm)

t_n : Actual thickness of the nozzle (mm)

t_{nr} : Required thickness of the nozzle (mm)

T : Actual thickness of the shell plate or end plate (mm)

T_0 : Required thickness of the shell plate or of the blank end plate (mm) calculated by assuming an efficiency of 1.00. However, where the opening and its reinforcement are entirely within the spherical portion of a dished end plate, T_0 is the thickness required for a hemispherical end plate having the equal radius to the spherical portion of the end plate. In addition, where the opening and its reinforcement of a semi-ellipsoidal end plate and are located entirely within a circle on the end plate with the diameter of the circle taking 80 % of the inside diameter of the shell, T_0 is the thickness required for a hemispherical end plate of a radius equal to 90 % of the inside diameter of the shell.

2 For openings in shell plates and formed end plates, reinforcement is to be provided in such a manner that the area of its cross section through the centre of the opening and normal to the surface of the opening is not less than that calculated by the following formula:

$A_0=d_0T_0$

3 In cases where flat end plates or cover plates specified in **9.4.5** have openings, they are to comply with the following:

(1) In cases where flat end plates or cover plates have openings with a diameter not exceeding one-half of the diameter for the circular plates or the minimum length (d shown in **Fig. 7.9.9** and **Fig. 7.9.10**) for non-circular plates, the end plates or cover plates are to have a total cross sectional area of reinforcement not less than that calculated by the following formula:

$A_0=0.5d_0T_0$

(2) In cases where flat end plates or cover plates have openings with a diameter exceeding one-half of the diameter for the circular plates or the minimum length (d shown in **Fig. 7.9.9** and **Fig. 7.9.10**) for non-circular plates, the thickness of end plates or cover plates is to be 1.5 times the required thickness specified in **9.4.5** except for the corrosion allowance.

4 Reinforcement is to be provided within its effective limit. The effective limit of reinforcement is the range on a vertical plane to the wall containing the centre of the opening that is enclosed by two lines along the wall and also by two lines parallel to the axis of the opening. The lengths of the four lines are as follows: (*See* **Fig. 7.9.8**)

(1) The length of lines measured along the wall is to be measured, in both directions from the centre of the opening and is to be equal to the greater of the following:
  (a) The diameter of the finished opening in the cross section (*mm*)
  (b) The radius of the finished opening in the cross section plus the thickness of the wall plus the thickness of the nozzle wall (*mm*)

(2) The length of the lines measured parallel to the axis of the opening from each surface of the wall is to be equal to the smaller of the following (*mm*)
  (a) 2.5 times the thickness of the wall (*mm*)
  (b) 2.5 times the thickness of the nozzle wall plus the thickness of any added reinforcement exclusive of any welded metal

5 Any part of the shell, end plate or nozzle that exceeds its required thickness as calculated according to the requirements in **9.4** as well as any deposit metal for welding may be considered as part of the reinforcement, provided that it lies within the effective limit of reinforcement. In this case, the area of the shell or end plate available for reinforcement is to be the area calculated by the following formulae, whichever is greater.

$a = d_1(T - T_0)$

$a = 2(T - T_0)(T + t_n)$

6 In cases where the allowable stress of the reinforcing material differs from that of the material used for the shell, correction is to be made by the following formula:

$$K_R = \frac{f_R}{f_S}$$

where

K_R : Coefficient to be multiplied with the area of reinforcement. This is not to exceed 1.0.

f_S : Allowable stress of the material used for the shell (N/mm^2)

f_R : Allowable stress of the reinforcement (N/mm^2)

7 Openings in the end plate may be reinforced by flanged-in. In this case, the depth of the flange is not to be less than the value calculated by the following formula:

In cases where the thickness of the plate is not greater than 38 *mm*;

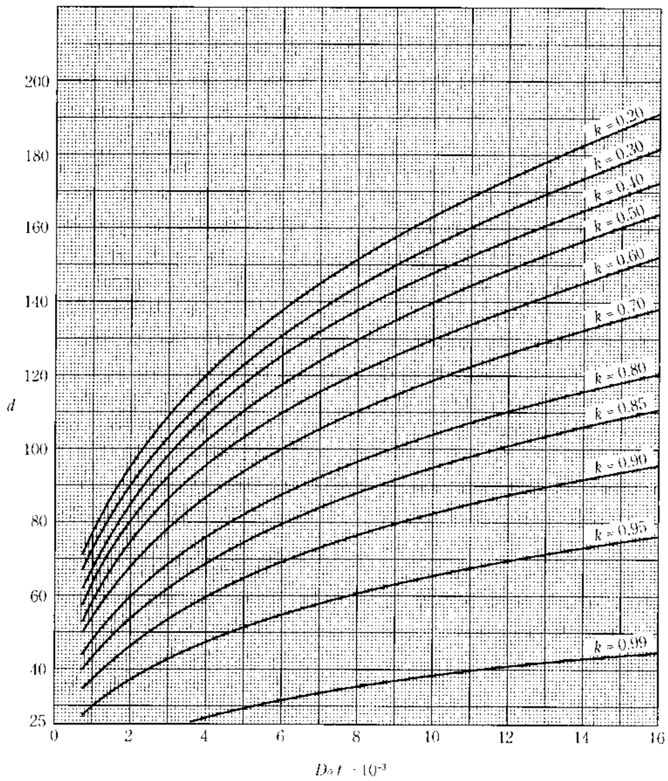
$h = 3T_0$

In cases where the thickness of the plate is greater than 38 *mm*;

$h = T_0 + 76$

Fig. 7.9.7 Maximum Diameter of Openings provided on the Shell for which Reinforcement may be Omitted

(A)



Notes:

d: Maximum diameter of openings (*mm*) which are not required to be reinforced, in this case the maximum diameter of the oval opening means the mean of major and minor axes.

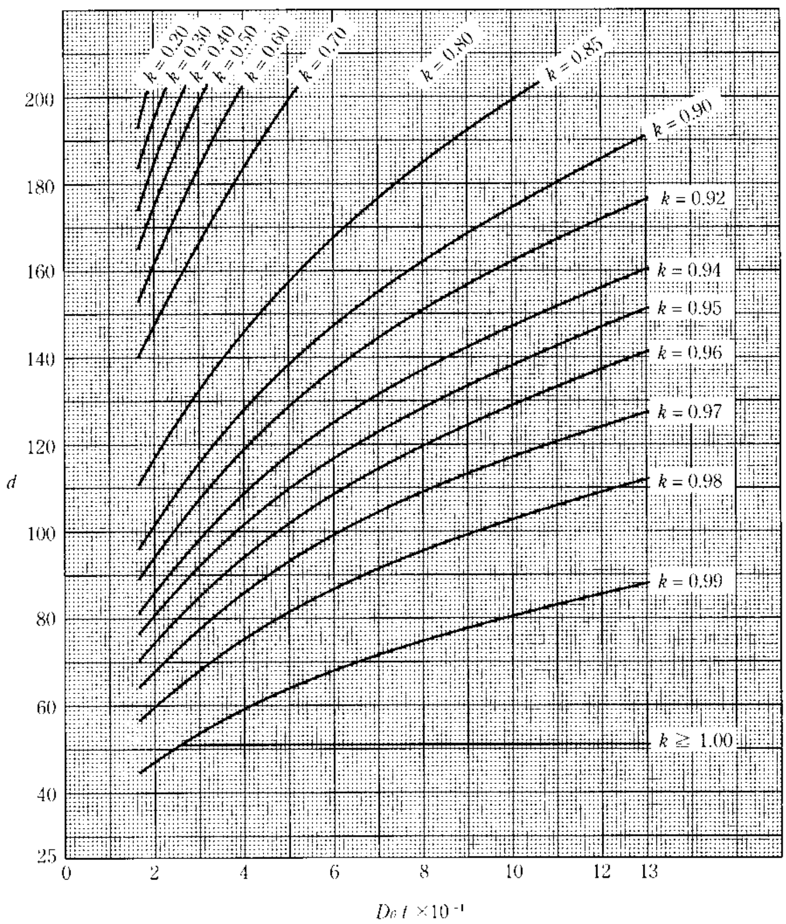
D_0: Outside diameter of the shell (*mm*)

t: Actual thickness of the shell plate (*mm*)

$k = \frac{PD_0}{1.82ft}$

Fig. 7.9.7 Maximum Diameter of Openings Provided on the Shell for which Reinforcement may be Omitted (continued)

(B)



Notes:

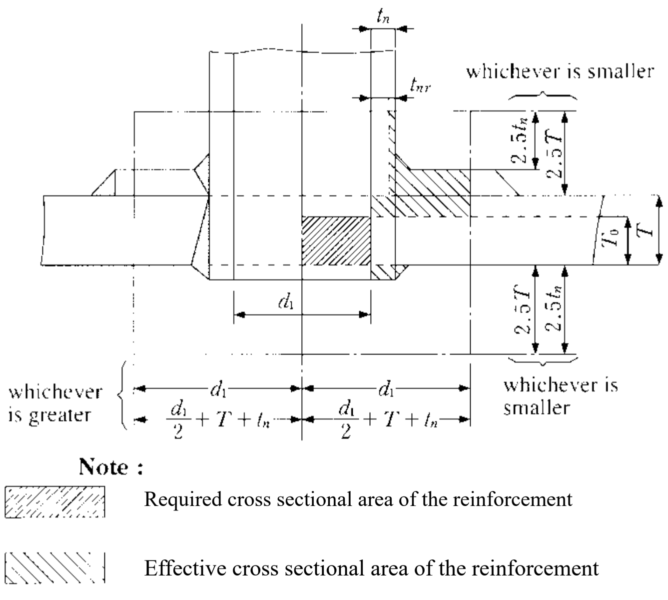
d: Maximum diameter of openings (mm) which are not required to be reinforced, in this case the maximum diameter of the oval opening means the mean of major and minor axes.

D_0: Outside diameter of the shell (mm)

t: Actual thickness of the shell plate (mm)

$$k = \frac{PD_0}{1.82ft}$$

Fig. 7.9.8 Effective Limit of Reinforcement



9.6 Tubes

9.6.1 Fitting of Tubes

1 Tubes are to be attached to the tube plate by expanding or another suitable method and the tubes are to project through the neck or belt of the parallel seating by not less than 6 *mm*, except for those attached by welding. In cases where the tube end is fitted by welding, consideration is to be given for preventing the deformation (thermal ratchet effect) of tubes due to tube-to-tube differentials in thermal expansion.

2 In cases where water tubes are secured against being pulled out by means of bellmouthing only, the included angle of belling is to be not less than 30 *degrees*.

3 Tube holes are to be formed so that the tubes can be effectively tightened inside them. Where the tubes are practically normal to the tube plates, the parallel seating of the holes is not to be less than 10 *mm* in depth. Where the tubes are not normal to the tube plate, the depth of the holes perpendicular to the tube plate is not to be less than 10 *mm* for tubes not exceeding 60 *mm* in outside diameter, and not to be less than 13 *mm* for tubes exceeding 60 *mm* in outside diameter.

4 In horizontal smoke tube type vertical boilers, each alternate smoke tube in the outer vertical rows of tubes is to be a stay tube.

9.6.2 Minimum Thickness of Tubes

The thickness of tubes used for boilers is not to be less than 2 *mm* for any tubes with an outside diameter less than 30 *mm*, or 2.5 *mm* for any tubes with an outside diameter of 30 *mm* or more.

9.6.3 Required Thickness of Smoke Tubes

The required thickness of smoke tubes is to be calculated by the following formula:

$$T_r = \frac{Pd}{70} + 2$$

where

d : Outside diameter of the smoke tube (*mm*)

9.6.4 Required Thickness of Tubes subjected to Internal Pressure

The required thickness of tubes (evaporating tubes, water wall tubes, downcomers, superheater tubes, economizer tubes and exhaust gas economizer tubes, etc.) subjected to internal pressure is to be calculated by the following formula:

$$T_r = \frac{Pd}{2f + P} + 1.5$$

where

d : Outside diameter of the tube (*mm*)

9.7 Joints and Connection of Each Member

9.7.1 Welded Joints

1 The dimensions and shapes of edge preparation are to be such that satisfactory penetration is obtainable without failure. The welded joint is to be so designed as not to be subjected to excessive bending stress. Where the construction is such that bending stress is concentrated at the root of the welded joints due to deformation caused by bending, single welded butt joints of fillet welded joints are to be avoided.

2 In cases where plates of unequal thickness are jointed by butt welding, the thicker plate is to be reduced in thickness to a taper of a distance not less than 4 times the offset so that the two plates are of equal thickness at the portion of the weld. In this case, the taper may be made only on one side for circumferential joints of shells. However, for longitudinal joints, as a rule, the taper is to be made on both sides so that the centre lines of both plates may coincide. In cases where the reduction in thickness is made on one side of the longitudinal joints, the distance between the centre line of the weld and the origin of the taper is not to be less than the thickness of the thinner plate.

3 The circumferential joints and the longitudinal joints of shells are to be double welded butt joints, or be single-welded butt joints that have been approved by the Society.

9.7.2 Shapes of Joints and Connections

The shapes of welded joints and connections are to be as shown in **Fig. 7.9.9**, or be of an equivalent shape that has been approved by the Society.

9.7.3 Construction of Bolted Cover Plates

The construction of unstayed flat cover plates bolted to shells is to be as shown in **Fig. 7.9.10** or be of an equivalent construction that has been approved by the Society.

Fig. 7.9.9 Examples of Welded Joints Approved for Each Case

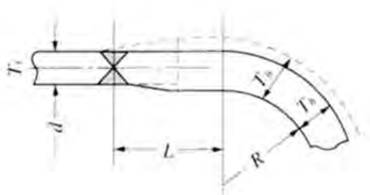
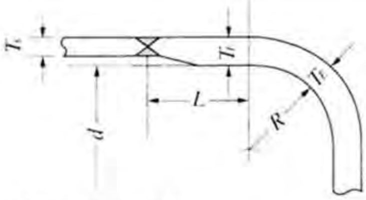
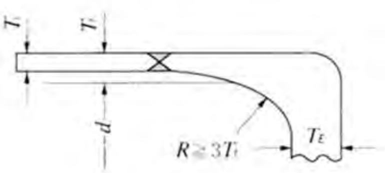
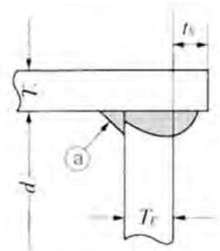
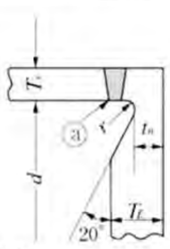
Welding part	Symbol	Welding mode and value of constant C_1	Remarks
(1) Welding joint between formed end plate and shell	A		$L \geqq 3T_h$, but need not be more than 38 *mm*. Where $T_h = 1.25T_s$, the above-mentioned value may be reduced.
(2) Welding joint between flat end plate or cover plate and shell	A	 In case L is not restricted, $C_1 = 0.50$ (circular or non-circular) $R \geqq 3T_E$ In case $L \geqq (1.1 - 0.8 \times \frac{T_S^2}{T_E^2})\sqrt{dT_F}$ $C_1 = 0.39$ (circular only).	
	B	 $C_1 = 0.50$ (circular or noncircular)	$T_f \geqq 2T_S$
	C	 $C_1 = 0.70$ (circular or noncircular)	(1) $T_S \geqq 1.25T_{ro}$ (2) $t_n \geqq T_S$ (3) Where the welding of part ⓐ, is considered difficult, the backing strip is to be used or the welding process, which ensures a good penetration to the root, is to be employed.
	D	 $C_1 = 0.55$ (circular) $C_1 = 0.70$ (noncircular)	(1) $r \geqq 0.2T_E$, but not less than 5*mm* (2) $t_n \geqq 1.25T_{ro}$ (3) In welding the part ⓐ, such a welding process as to have a good penetration to the root, is to be employed. (4) End plates or cover plates are to be made of forged steel

Fig. 7.9.9 Examples of Welded Joints Approved for Each Case (continued)

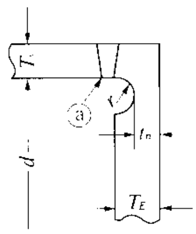
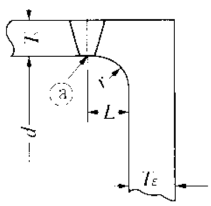
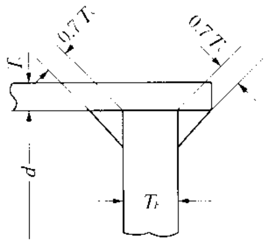
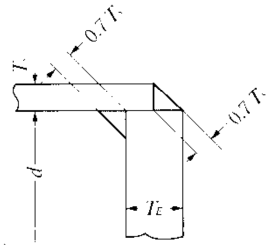
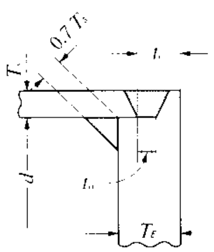
Welding part	Symbol	Welding mode and value of constant C_1	Remarks
(2) Welding joint between flat end plate or cover plate and shell	*E*	 C_1 = 0.55 (circular) C_1 = 0.70 (noncircular)	(1) $r \geq 0.2T_E$, but not less than 5 *mm* (2) $t_n \geq 1.25T_m$ (3) In welding the part ⓐ, such a welding process as to have a good penetration to the root, is to be employed. (4) End plates or cover plates are to be made of forged steel
	F	 C_1 = 0.55 (circular) C_1 = 0.70 (noncircular)	(1) $r \geq 0.3T_E$ (2) $L \geq T_E$ (3) For the part ⓐ, the same is required as above. (4) End plates or cover plates are to be made of forged steel.
	G	 C_1 = 0.55 (circular) C_1 = 0.70 (noncircular)	$T_S \geq 1.25T_m$
	H	 C_1 = 0.55 (circular) C_1 = 0.70 (noncircular)	$T \geq 1.25T_m$
	I	 C_1 = 0.55 (circular only)	(1) $T_S \geq 1.25T_m$ (2) $t_a \geq T_S$, but need not be over 6.5 *mm*. (3) t_b is not be less than $2T_m$ or $1.25T_S$, whichever is the greater.

Fig. 7.9.9 Examples of Welded Joints Approved for Each Case (continued)

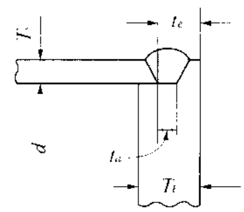
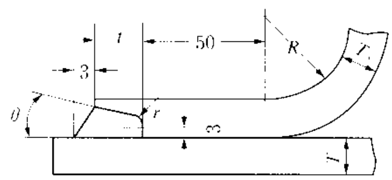
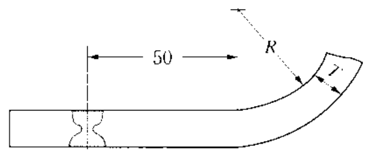
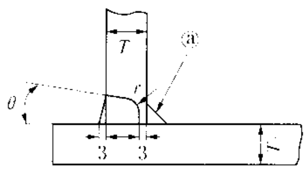
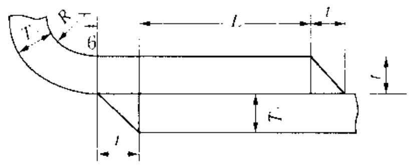
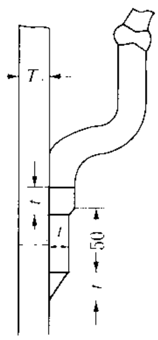
Welding part	Symbol	Welding mode and value of constant C_1	Remarks
(2) Welding joint between flat end plate or cover plate and shell	J	 $C_1 = 0.70$ (circular or noncircular)	(1) Tube headers only. (2) $T_S \geqq 1.25T_{ro}$, (circular only). (3) $T_a \geqq T_S$, but need not be over 6.5 mm (4) t_c is not to be less than $2T_{ro}$ or $1.25T_S$, whichever is the greater.
(3) Welding joint between furnace and shell plate or end plate	A		(1) To be applied to welding joint on the front side of boiler. (2) $t \geqq T_S - 3$ (3) θ ranges between 10° and 20° inclusive. (4) $10 \geqq r \geqq 5$
	B		
	C		(1) To be applied to welding joint on the front side of boiler. (2) The part ⓐ is to be of light fillet weld (throat thickness 4～6 mm) (3) θ ranges between 10° and 20° inclusive. (4) $10 \geqq r \geqq 5$
	D		(1) To be applied to welding joint on the front side of boiler. (2) $t > T_f$ (3) $L \geqq 2T_S$
(4) Welding joint between ogee ring and shell plate	A		$t \geqq T_S$

Fig. 7.9.9 Examples of Welded Joints Approved for Each Case (continued)

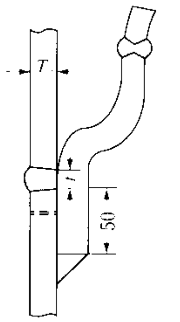
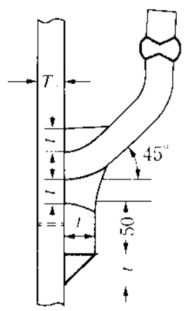
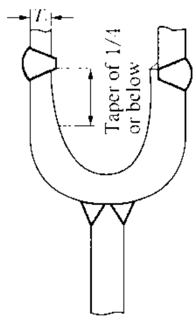
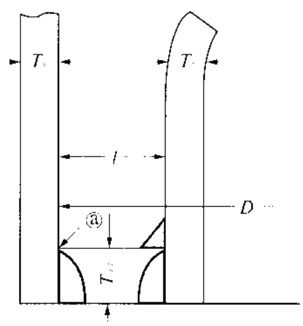
Welding part	Symbol	Welding mode	Remarks
(4) Welding joint between ogee ring and shell plate	*B*		$t \geq T_S$
	C		$t \geq T_S$
	D		$t \geq T_S$
	E		(1) If $D \leq 750$, $l \geq 50$. If $D > 750$, $l \geq 60$. (2) In welding the part ⓐ, such a welding process as to have a good penetration to the root, is to be employed.

Fig. 7.9.9 Examples of Welded Joints Approved for Each Case (continued)

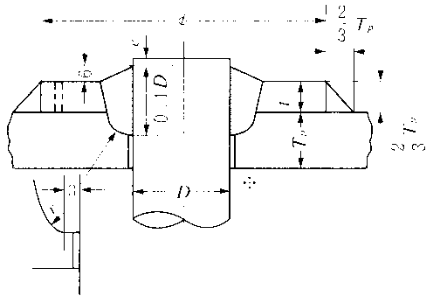
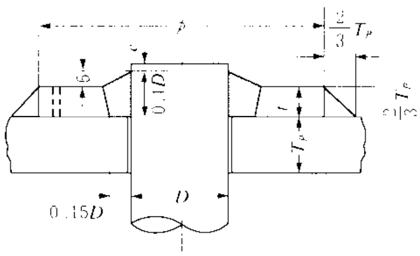
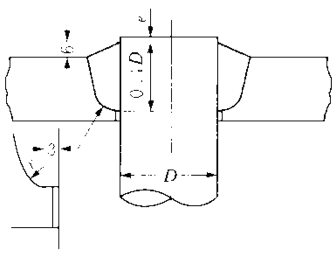
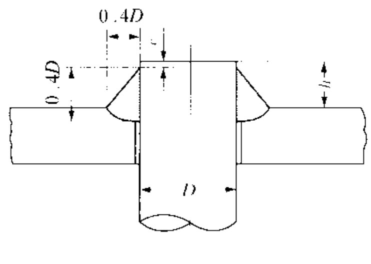
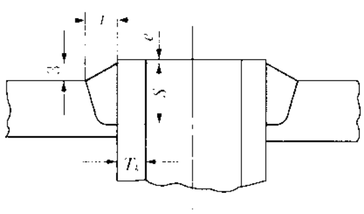
Welding part	Symbol	Welding mode	Remarks
(5) Welding joint between stay and tube plate or end plate	A		(1) $\phi \geqq \frac{2}{3}p$ (p means the pitch of stays, hereinafter the same being referred) (2) $t_1 > \frac{2}{3}T_p$ (3) The part marked by ※ is to be applied with light fillet welding (root thickness, 4 ~ 6 *mm*) or caulking from the side of plate for filling the gap. (4) On the fire side, to be $e \leqq 1.5$
	B		(1) $\frac{2}{3}p > \phi > 3.5D$ (2) $t_1 \geqq \frac{2}{3}T_p$ (3) The part marked by ※ is to be same as above. (4) On the fire side, to be $e \leqq 1.5$
	C		On the side exposed to flame, $e \leqq 1.5$
	D		On the side exposed to flame, $h \leqq 10$ and $e \leqq 1.5$
(6) Welding joint between stay tube or tube and tube plate or end plate	A		(1) $t \geqq T_k$ (2) $S \geqq 2t$ (3) On the side exposed to flame, $e \leqq 1.5$

Fig. 7.9.9 Examples of Welded Joints Approved for Each Case (continued)

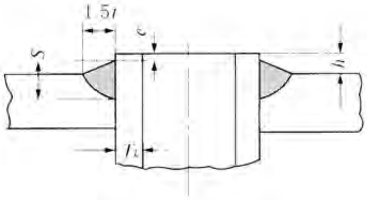
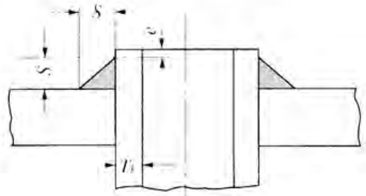
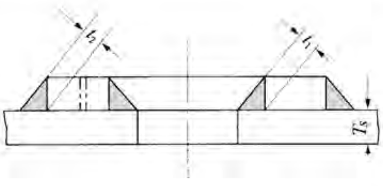
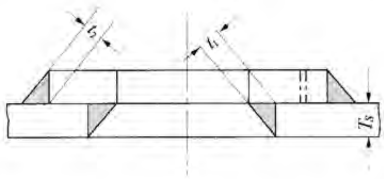
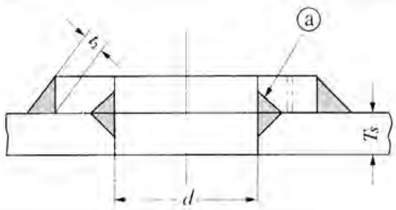
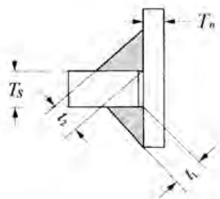
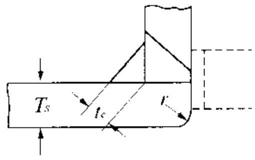
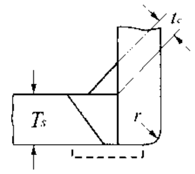
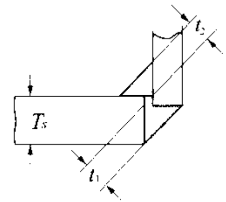
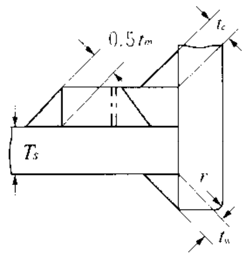
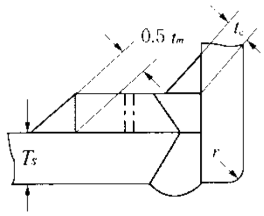
Welding part	Symbol	Welding mode	Remarks
(6) Welding joint between stay tube or tube and tube plate or end plate	*B*		(1) $t \geqq T_t$ (2) $S \geqq 1.5t$ or $t + 3$ (3) On the side exposed to flame, $h \leqq 10$ and $e \leqq 1.5$
	C		(1) $S \geqq T_t + 3$ (2) To be welded after having tube expansion. (3) On the side exposed to flame, $e \leqq 1.5$
(7) Welding joint between seat or reinforcement ring and shell plate or end plate	*A*		(1) $t_1 + t_2 \geqq 1.25t_m$ (2) $t_1, t_2 \geqq \frac{1}{3} t_m$, but the minimum is 6.5 *mm*
	B		
	C		(1) To be applicable only for the case of $d < 60$. (2) $t_2 \geqq 0.7t_m$ (3) The part ⓐ is to be welded for stopping leakage.
(8) Welding joint between nozzle and shell plate or end plate	*A*		(1) $t_1 \geqq 6.5$ or $0.7t_m$, whichever is the smaller (2) $t_1 + t_2 \geqq 1.25t_m$ (3) $t_1, t_2 \geqq \frac{1}{3} t_m$, but the minimum is 6.5 *mm*.

Fig. 7.9.9 Examples of Welded Joints Approved for Each Case (continued)

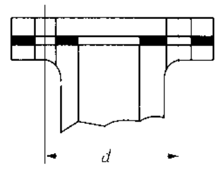
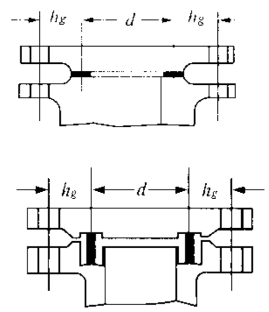
Welding part	Symbol	Welding mode	Remarks
(8) Welding joint between nozzle and shell plate or end plate	*B*		(1) $t_c \geq 6.5$ or $0.7t_m$, whichever is the smaller (2) $t_1 + t_2 \geq 1.25t_m$ (3) $t_1, t_2 \geq \frac{1}{3} t_m$, but the minimum is 6.5 *mm*.
	C		
	D		
	E		(1) $t_c \geq 6.5$ or $0.7t_m$, whichever is the smaller (2) $t_1 + t_2 \geq 1.25t_m$ (3) $t_1, t_2 \geqq \frac{1}{3} t_m$, but the minimum is 6.5 *mm*. (4) $t_w \geq 0.7t_m$
	F		

Notes:

1. Constant C_1 is the value used for the formula in **9.4.5**.
2. The dimensions of welded parts are their minimum values.
3. The unit of all values in the figures is in *mm*.
4. The definitions of the symbols used in the figures are as Follows (units: *mm*):

T_s : Actual thickness of the shell plate
T_h : Actual thickness of the formed end plate
T_E : Actual thickness of the flat end plate or cover plate
T_{ro} : Required thickness of the seamless shell
T_P : Actual thickness of the tube plate or flat end plate (formed end plate)
T_{rf} : Required thickness of the furnace foundation ring plate
T_k : Actual thickness of the stay tube or tube
T_n : Actual thickness of the nozzle
t_m : Smaller value of the thickness of plates to be welded, but the maximum value is 20 *mm*.

Fig. 7.9.10 Examples of Bolting Covers and End Plates

Joining method	Shape and dimensions	C_3
Bolted with full face gasket		0.25
Bolted		0.3

9.8 Fittings, etc.

9.8.1 Materials of Fittings

1 The material of the nozzles, flanges or distance pieces that attach directly to a boiler drum (including tube headers) is to be of steel which is suitable for the working temperatures.

2 Except for those specified in **-1,** the material of valve boxes or other fittings which are connected to a boiler and are subjected to its pressure is to be of steel which is suitable for the working temperature. However, the following cases are excluded:

(1) Copper alloy castings may be used in cases where the maximum working temperature does not exceed 210 °C.

(2) Grey cast iron is not to be used only for *GNS-D* vessels and the part without the influence of temperature, impact and so on. Grey cast iron may be used in cases where the maximum working temperature does not exceed 220 °C and the approved design pressure does not exceed 1 *MPa*, except for blow-off valves.

(3) Special cast iron made by approved manufacturers may be used in cases where the maximum working temperature does not exceed 350 °C and the approved design pressure does not exceed 2.5 *MPa*.

9.8.2 Construction of the Fittings

1 Fittings such as valves, flanges as well as bolts, nuts, gaskets, etc. are to have a construction and dimensions conform to the recognized standards of the Society. In addition, they are to conform to the service conditions specified in such standards.

2 Manual stop valves are to be provided with an indicator to show whether it is open or closed, except for rising-stem type valves.

3 Fittings are to be attached to boiler drums with flanged joints or by welding. However, in cases where the thickness of the drum is over 12 *mm* or in cases where a seat for screwing is fitted onto the drum, fittings of 32 *mm* or under in nominal diameter may be attached to the boiler by screwing.

4 In cases where boiler fittings are secured by studs, the stud holes are not to penetrate the whole thickness of the shell, and the depth of threaded part is not to be less than the diameter of the studs.

9.8.3 Safety Valves and Relief Valves

1 Each boiler is to be provided with at least two spring loaded safety valves. However, only one safety valve will be accepted for the following types of boilers:

(1) Boilers with heating surface of less than 10 m^2.

(2) Boilers with an approved design pressure of not more than 1 MPa, provided that they are equipped with a pressure controlling device and a device which cuts off the fuel supply automatically at a pressure not exceeding the approved design pressure.

(3) Exhaust gas boilers fitted with the relief valves specified in **-11**.

2 Safety valves that are attached with a spring pilot valve may be used in lieu of spring loaded safety valves.

3 The seat diameter of safety valves is not to be less than 25 mm, unless specifically approved.

4 Safety valves are to start releasing steam automatically at a set pressure in accordance with the requirements in **-14** and are to be capable of discharging the total evaporative capacity of the boiler under the maximum designed operating condition without raising steam pressure to 10 % or more above the approved working pressure of the boiler.

5 The total area of safety valves in consideration of the maximum designed evaporation of the boiler is not to be less than the required area which is calculated under each steam condition and for each type of safety valves specified below. However, safety valves of boilers having a superheater are to comply with the requirements in **-7**, **-8** and **-9**. Furthermore, for any boiler with an exhaust gas economizer which is so designed that it may be additionally heated while in use, the required area of the safety valves is to be calculated after the maximum evaporation of the boiler is added with the evaporation of the exhaust gas economizer.

(1) For saturated steam

(a) For low lift valves ($\frac{D}{24} \leq L < \frac{D}{15}$) :

$$A = \frac{W}{K_1(1.03P + 0.1)} \times 10^{-2}$$

(b) For high lift valves ($\frac{D}{15} \leq L < \frac{D}{7}$) :

$$A = \frac{W}{K_2(1.03P + 0.1)} \times 10^{-2}$$

(c) For full lift valves ($\frac{D}{7} \leq L$) :

$$A = \frac{W}{K_3(1.03P + 0.1)} \times 10^{-2}$$

(d) For full bore valves (Diameter of the seat is 1.15 times or more the diameter of the throat):

$$A' = \frac{W}{K_4(1.03P + 0.1)} \times 10^{-2}$$

where

D : Seat diameter of a safety valve (mm)

L : Lift of a safety valve (mm)

A : Required seat area of a safety valve (mm^2)

A' : Required nozzle throat area of a safety valve (mm^2)

W : Maximum designed evaporation capacity of a boiler (g/h)

P : Set pressure of a safety valve (MPa)

K_1 : 4.8

K_2 : 10.0
K_3 : 20.0
K_4 : 30.0
However, if the tests and examinations designated by the Society, such as a discharge capacity test and a measurement of lift have been carried out on each prototype under conditions equivalent to those of actual operation, the values of K_2, K_3 or K_4 may be increased to the values approved by the Society on the basis of these results.

(2) For superheated steam

$$A_s = \frac{A}{\sqrt{V_H / V_S}}$$

where

A_s : Required seat area of a safety valve (mm^2)
A : As specified in **(1)**
V_H : Specific volume of saturated steam (mm^3/g)
V_S : Specific volume of superheated steam (mm^3/g)

6 The area of steam passages of safety valve is to be of the following value for each type of safety valves.

(1) For steam passages of low lift safety valves, the minimum area at the chest inlet and at the outlet is not to be less than 0.5 times and 1.1 times the required valve seat area respectively.

(2) For steam passages of high lift safety valves, the minimum area at the chest inlet is not to be less than the required valve seat area at the chest inlet; and not less than 2 times the required valve seat area at the outlet.

(3) For steam passages of full lift safety valves, the minimum area at the chest inlet and outlet is not to be less than 1.1 times and 2 times the steam passage area respectively when the valve is lifted to 1/7 of the valve seat diameter.

(4) For steam passages at the valve seats of full bore safety valves, the minimum area is not to be less than 1.05 times the area at the throat, when the valve is open. Furthermore, for steam passages at the valve inlet and the nozzle, the minimum area is not to be less than 1.7 times the area at the throat. And, for steam passages at the outlet, the minimum area is not to be less than 2 times the area at the valve seat when the valve is open.

7 In cases where a boiler is provided with a superheater, at least one safety valve is to be fitted at the outlet of the superheater.

8 The discharge capacity of any safety valve attached to a superheater is to be such that the superheater is not damaged when the main steam supply is shut down in an emergency as well as when the boiler is being operated under the stress of maximum continuous output. In cases where this purpose is not fulfilled, means are to be provided to automatically shut off or to control the fuel supply to the boiler in an emergency in order to prevent the superheater from damage.

9 In cases where there is no intervening device between a superheater and a boiler, the area of the superheater safety valve may be included in the total area of the safety valves of the boiler. However, the total area of any safety valves fitted to the evaporating parts of the boiler is not to be less than 0.75 times the required area calculated by the formulae in **-5**.

10 Safety valves are to be fitted at the inlets and the outlets of independent reheaters or independent superheaters respectively and the total discharge capacity of these valves is not to be less than the maximum passing steam quantity. The total discharge capacity of the safety valves fitted at outlets is to be not less than the quantity necessary to keep the steam temperature of the independent reheater or independent superheater from not exceeding its designed value. However, for independent superheaters which are connected directly to the boiler and designed with the same approved design pressure as that of the boiler drum, one safety valve that is capable of discharging the quantity of steam necessary to keep the steam temperature of the independent superheater from exceeding its designed value may be fitted at its outlet.

11 In cases where economizers and exhaust gas economizers (including the heating element of the exhaust gas boiler) are equipped with an intervening valve between the boiler and the economizer or exhaust gas economizer, they are to be provided with at least one relief valve capable of discharging a quantity not less than that calculated from the maximum absorbable energy. However, shell type exhaust gas economizers which have a total heating surface of 50 m^2 or more are to be provided with at least two relief valves.

12 The construction of safety valves and relief valves is to comply with the following requirements:

(1) Safety valves and Relief valves are to be so constructed that the spring and the valve are housed in a cage so that they cannot be overloaded intentionally from outside, and that in case of spring failure they will not come out of their cage.

(2) Safety valves and Relief valves are to be fitted to boiler shells, headers, or outlet connections of a superheater by flanged or welded joints. The valve chests of these safety valves are not to be also used as the valve chests for other valves. However, safety valves of superheaters may also be fitted by attaching them to the flanges of any distance pieces welded to the outlet connection.

(3) Safety valves and Relief valves are to be provided with easing gears and their handles are to be so arranged that they can be operated from an accessible place that is free from danger.

(4) The housings of safety valves, relief valves or waste steam pipes are to be fitted with drainage arrangements from their lowest part, directed so that any drainage will continuously fall to a position clear of the boiler or exhaust gas economizer where it will not pose any threat to either personnel or machinery. No valves or cocks are to be fitted in these drainage arrangements.

13 Waste steam pipes for safety valves and relief valves are to comply with the following requirements:

(1) Waste steam pipes for safety valves and relief valves are to be of such construction that back pressure does not interfere with operation of the valves. Waste steam pipes are to have an inside diameter that is not to be less than the diameter of the valve outlet and the design pressure of these pipes is to be 1/4 or more than the set pressure of the valves.

(2) In cases where a common waste steam pipe is provided for two or more safety valves or relief valves, its cross sectional area is not to be less than the aggregate area of the steam passages of each safety valve or relief valve. However, waste steam pipes of boiler safety valves are to be separated from any pipe lines likely to contain a large amount of drainage such as steam blow-off pipes to the atmosphere or waste steam pipes of relief valves for exhaust gas economizers.

14 Safety valves or relief valves are to be set in accordance with the following requirements **(1)** to **(5)** after their installation on board the ship:

(1) Safety valves are to be set to blow-off steam automatically at a pressure not greater than 1.03 times the approved working pressure of the boiler.

(2) Superheater safety valves are to be set to blow-off steam automatically at a pressure not greater than the value obtained by subtracting the set pressure of the safety valve(s) on the boiler drum by the value of 0.035 *MPa* plus the steam pressure drop in the superheater at the normal load. However, in cases where this pressure exceeds 1.03 times the nominal pressure of the boiler, at least one safety valve is to be set to blow-off steam at a pressure not greater than 1.03 times the nominal pressure, and the other valve(s) at a pressure not greater than 1.05 times the nominal pressure.

(3) The blow-off pressure of a safety valve at the outlet of a superheater is to be set lower than that at the inlet.

(4) The blow-off pressure of relief valves provided on an economizer or an exhaust gas economizer is to be set at a pressure not greater than the respective approved design pressure.

(5) Safety valves or relief valves are to function satisfactorily while blowing-off at the set pressure specified by the respective requirements **(1)** to **(4)**.

15 In cases where the calculated discharge capacity of the safety valves do not comply with the requirements in **-5** on account of the reduction of the approved working pressure of the boiler, it may be accepted, provided that an accumulation test deemed appropriate by the Society has been carried out and it has been confirmed that the pressure in the boiler drum has not exceeded 110 % of the approved working pressure.

9.8.4 Steam Connections

1 A stop valve is to be fitted directly to the boiler drum at each steam outlet.

2 In cases where the steam from more than two boilers is led to one common steam pipe, the stop valve to be provided on each steam outlet as required in **-1** is to be a screw-down non-return type valve and one additional stop valve is to be provided on each steam pipe between the non-return valve and the point of steam pipe connection.

3 In ships provided with two or more essential auxiliary boilers, steam lines are to be led in such a way that an uninterrupted steam supply to the auxiliary machinery for manoeuvring and the safety can be ensured even in cases when one of the boilers fails.

9.8.5 Feed Water Systems

1 A stop valve is to be fitted to the feed water connection and a screw-down non-return valve is to be provided at a point as close to the stop valve as practicable. An approved feed regulator may, however, be installed between the screw-down non-return valve and the stop valve.

2 Notwithstanding the requirement in **-1**, in cases where the boiler has an economizer which is recognized to be an integral part of the boiler, a feed water stop valve may be provided at the economizer inlet. In such cases, a screw-down non-return valve is to be provided at a point as close to the stop valve as practicable.

3 The part of the boiler drum where feed water is fed into is to be provided with sleeves or other suitable devices so that extreme thermal stress does not occur due to the direct contact of the cold feed water with the drum. This requirement also applies to the desuperheater in the boiler drum, if installed, where superheated steam pipes penetrate through the drum. Furthermore, feed water is to be fed into the drum so that it does not come into direct contact with any of the high temperature heating surfaces of the boiler drum.

9.8.6 Blow-off Systems

1 Each boiler is to be provided with a blow-off valve fitted directly to its drum so that boiler water may be discharged from the bottom of its water space. The nominal diameter of this blow-off valve is not to be less than 25 *mm* and not to be more than 65 *mm*. However, boilers with heating surface of 10 m^2 or less, may have a blow-off valve with a nominal diameter of 20 *mm*.

2 In cases where blow-off pipes are exposed to the flue, they are to be protected by thermal insulation materials and be so arranged that they may be readily inspected.

3 The design pressure of blow-off piping is not to be less than 1.25 times the design pressure of the boiler drum.

4 Blow-off valves are to be of such construction that they are free from any deposits of scales and other sediments.

5 In cases where the blow-off pipes of two or more boilers are connected to one common discharge, a screw-down non-return valve is to be provided in each pipe line from each boiler.

9.8.7 Burning Systems

1 Fuel Burners

(1) Fuel burners are to be so arranged that they cannot be withdrawn without shutting off the fuel supply to those burners.

(2) For top firing boilers, in order to absorb vibrations, flexible joints approved by the Society are to be provided at the connections between the boiler and the fuel supply pipe.

2 Draught Fans

Boilers are to be provided with draught fans of sufficient capacity to attain the designed maximum steam evaporation of the boiler and to ensure stable combustion in the boiler within its service range. In the case of failure of any one draught fan, an alternative means is to be provided to ensure normal navigation as well as a continuous flow of heat to any cargo that requires heating.

9.8.8 Water Level Indicators

1 Each boiler is to be provided with at least two independent water level indicators, one of which is to be a glass water gauge and the other which is to comply with either of the following requirements:

(1) A glass water gauge that is located at a position where the water level may be readily sighted.

(2) A remote water level indicator

2 For forced circulation or once-through boilers, where water level indication is difficult according to the requirements in **-1**, a suitable level detector and a low water level safety device which is comprised of two detectors so designed as to prevent the overheating of any part of the boiler by lack of water supply are to be provided.

3 In cases where the water space in the boiler is long in the transverse direction of the ship or excessive differences in water level may occur, the water level indicators specified in **-1** are to be so arranged as to indicate the water levels at both ends of the water space.

4 The lowest visible part of a glass water gauge is to be not less than 50 *mm* above the lowest critical water level. The visible range of a remote level indicator is to cover all ranges related to the water level control in the boiler.

5 Construction of water level indicators is to comply with the following requirements:

(1) Construction of glass water gauges is to be of the built-up rectangular-section box type (double-plate-type) specified in the recognized standards or the equivalent approved by the Society.

(2) In cases where the water gauge is placed outside the boiler, a stop valve (or cock) is to be fitted on the top and bottom of the gauge respectively. In addition, an effective draining device is to be provided.

(3) In cases where the water gauge or the water column is connected by a pipe to the boiler drum, a stop valve is to be fitted to the boiler drum.

(4) Stop valves (or cocks) for water gauges and connection pipes to boiler drums are to be of a shape that is free from any deposits of scale and other sediments from the boiler water.

(5) The water column to which the water gauge(s) are attached is to be strongly supported so that it may maintain its correct position. The inside diameter of the water column is not to be less than 45 *mm* and a draining hole of sufficient size is to be provided at the bottom of the column.

(6) Connection pipes to boiler drums are to be 15 *A* or over in nominal diameter for the water gauge, and 25 *A* or over in nominal diameter for the water column.

(7) In cases where connection pipes from the water column to the boiler penetrate the uptake, they are to be enclosed all the way through the uptake. Furthermore, an air passage of not less than 50 *mm* is to be provided around the pipes.

9.8.9 Pressure and Temperature Measuring Devices

1 Each boiler is to be provided with a set of pressure measuring devices at both the boiler drum and the superheater outlet respectively. Pressure indicators are to be provided in the monitoring station.

2 Pressure indicators are to be such that they have a scale of 1.5 times or over the set pressure of the safety valves. Both the approved working pressure of the drum and the nominal pressure of the superheater are to be specially marked on the pressure gauges.

3 Pressure measuring and indicating devices are to be operation while the boiler is in operation.

4 At the steam outlets of superheaters and reheaters, temperature measuring devices are to be provided.

9.8.10 Safety Devices and Alarm Devices

1 Fuel oil shut-off devices

Each boiler is to be fitted with a safety device which is capable of automatically shutting off the fuel supply to all burners in any of the following cases:

Alarms which indicate the action of the safety device are to be in accordance with **15.2.6-2**.

(1) When automatic ignition fails.

(2) When the flame vanishes (in this case, the fuel oil supply is to be shut-off within 4 *seconds* after the flame has been extinguished).

(3) When the water level falls.

(4) When the combustion air supply stops.

(5) When the fuel oil supply pressure to the oil burners falls at times of pressure atomization, or when the steam pressure to the burners falls at times of steam atomization.

(6) All other cases considered necessary by the Society.

2 Alarm devices

(1) Each boiler is to be provided with an alarm device which operates when the water level in the drum falls.

(2) For auxiliary boilers supplying steam to the turbines driving the main generators, alarm devices which operate when the water level in the boiler drum reaches a high level are to be provided in addition to those alarm devices given in **(1)**.

3 Water level detectors

The water level detectors of the devices specified in **-1(3)** are to be separate from those of the feed regulating system and the remote water level indicator specified in **9.8.8-1(2)**.

9.8.11 Monitoring of Boiler Water

1 Each boiler is to be provided with a boiler water sampling connection in a convenient location, but its sampling valve is not to be connected to the water column for the water gauge.

2 Boilers are to be provided with means such as water analyzer or other suitable devices to supervise and control the quality of the feed water and the boiler water.

9.8.12 Drainage Arrangements of Superheaters and Reheaters

Superheaters and reheaters are to be provided with effective drainage systems and means for preventing damages arising from any thermal stresses or thermal shocks caused by drains.

9.9 Tests

9.9.1 Shop Tests

1 Tests for welds are to conform to the requirements specified in **Part 3**.

2 Boilers are to be subjected to hydrostatic tests at a pressure of 1.5 times the design pressure for boilers and at a pressure of 2 times the design pressure for boiler fittings.

9.10 Construction etc. of Small Size Boilers

9.10.1 General

Notwithstanding the requirements in **Part 3** and **9.2** to **9.9**, the requirements in **9.10** may be applied to boilers with a design pressure that does not exceed 0.35 *MPa* (hereinafter referred to as the "small boilers").

9.10.2 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.

9.10.3 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 at manufacturing plants of small boilers.

9.11 Construction of Thermal Oil Heaters

9.11.1 General

Thermal oil heaters heated by flame or combustion gas are to comply with the relevant requirements specified in **9.1** through **9.9** (in this case, the term "boiler" is to be read as "thermal oil heater") as well as the requirements in **9.11**.

9.11.2 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.

9.11.3 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 **9.10.2-1**, **-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 fire fighting 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.

9.11.4 Thermal Oil Systems

The thermal oil systems for the thermal oil heaters are to comply with the requirements in **13.9**.

9.12 Incinerators

9.12.1 General

1 Notwithstanding the requirements in **Part 3** and **9.2** to **9.11**, incinerators are to comply with the requirements in **9.12**. However, the requirements in **9.12** do not apply to the incinerators with maximum capacity less than 34.5 *kW*.
2 Notwithstanding **-1**, incinerators for oil or rubbish other than those produced by normal ship operation or the like will be specially considered.

9.12.2 Drawings and Data to be Submitted

Notwithstanding the requirements in **9.1.3**, 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

9.12.3 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 **13.7**.

(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 supply of fuel does not precede ignition spark in cases where an 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 **15.4.2-2(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 **3.2.2-4, Part 9**.

9.12.4 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

9.12.5 Tests

Operation tests of the safety devices and the alarm devices specified in **9.12.4** as well as a burning test are to be carried out.

Chapter 10 PRESSURE VESSELS

10.1 General

10.1.1 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).

10.1.2 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 **2.3.21**, **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*

10.1.3 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.

10.1.4 Drawings and Data

Drawings and data to be submitted are generally as follows. However, for pressure vessels of Group III applied to *GNS-C* vessels and *GNS-D* vessels, 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

10.2 Design Requirements

10.2.1 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 **10.3.1-1**, **-2** or **13.3.1**

a : Corrosion allowance (*mm*) conforming to the requirements in **10.3.3**

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 **10.3.2**

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})

10.2.2 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**.

10.2.3 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 **10.4** and **10.5**, 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 **10.4** and **10.5** after taking account of the results of these measurements.

10.2.4 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.

10.2.5 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.

10.3 Allowable Stress, Efficiency and Corrosion Allowance

10.3.1 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 1.5, respectively.

$$f_1 = \frac{R_{20}}{2.7},\ f_2 = \frac{E_{20}}{1.6}$$

(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 7.10.1**.

(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.

$$f_1 = \frac{R_{20}}{3.5},\ f_2 = \frac{E_{20}}{1.5}$$

(6) The allowable stress (f) of aluminum alloy is to be obtained from the following f_1 or f_2, whichever is smaller.

$f_1 = \frac{R_{20}}{4.0}$, $f_2 = \frac{E_{20}}{1.5}$

2 For the allowable stress of materials used for pressure vessels for high temperature service, the requirements in **9.3.1** 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) $\frac{R_{20}}{5.0}$

(b) $\frac{E_{20}}{4.0}$

(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:

$$\sigma_Z = \frac{0.3ET_0}{D_m\left(1 + 0.004\frac{E}{E_{20}}\right)}$$

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:

$$P_m \le f$$
$$P_L \le 1.5f$$
$$P_b \le 1.5f$$
$$P_L + P_b \le 1.5f$$
$$P_m + P_b \le 1.5f$$
$$P_L + P_b + Q \le 3f$$

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})

Table 7.10.1 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

10.3.2 Efficiencies of Joints

The efficiency of joints is to be as follows:

(1) Seamless shells: 1.00

(2) Welded shells: As given in **Table 7.10.2**

(3) Where electric resistance welded steel tubes are used for the shell: As given in **Table 7.10.2(1)**

Table 7.10.2 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.

10.3.3 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.

10.4 Strength

10.4.1 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 **10.4.2-2**. 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 **10.4.2-2**.

10.4.2 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

$\frac{T_r}{D} > 0.25$ or $P > \frac{fJ}{2.5}$

(2) Spherical pressure vessels

$\frac{T_r}{D} > 0.185$ or $P > \frac{fJ}{1.5}$

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 **10.5.3**.

$$T_r = \frac{PR}{fJ - 0.5P} + a$$

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 **10.5.3**.

$$T_r = \frac{PR}{2fJ - 0.5P} + a$$

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

$W = \frac{1}{4}\left(3 + \sqrt{\frac{R_1}{r}}\right)$ 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 half of the inside minor axis of the end plate is not less than 1/4 of the inside major axis 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 **10.5.2**, or the openings are reinforced in accordance with the requirements in **9.5.3-3** to **-5**, 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 **9.5.3-7**, 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. 7.9.6**. However, this is applicable to end plates complying with the following conditions:

Hemispherical end plates:

$0.003D_0 \leq T_e \leq 0.16D_0$

Semi-ellipsoidal end plates:

$0.003D_0 \leq T_e \leq 0.08D_0$

$H \geq 0.18D_0$

Dished end plates:

$0.003D_0 \leq T_e \leq 0.08D_0$

$r \geq 0.1D_0$

$r \geq 3T_e$

$R_1 \leq D_0$

$H \geq 0.18D_0$

or $0.01D_0 \le T_e \le 0.03D_0$

$r \geq 0.06D_0$

$H = 0.18D_0$

or $0.02D_0 \le T_e \le 0.03D_0$

$r \geq 0.06D_0$

$$0.18D_0 \le H \le 0.22D_0$$

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. 7.9.9**

$C_2 = \sqrt{3.4 - 2.4\frac{d}{D'}}$ but need not be over 1.6

d : Diameter shown in **Fig. 7.9.9** (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

$$T_r = d\sqrt{\frac{C_3 C_4 P}{f} + \frac{6 W h_g}{f L d^2}} + a$$

where

C_3 : Constant determined by the bolting methods as shown in **Fig. 7.9.10**

$C_4 = 3.4 - 2.4\frac{d}{D'}$ but need not be over 2.5

d : Diameter shown in **Fig. 7.9.10** (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. 7.9.10** (*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 **9.4.7**, **9.4.13** and **9.4.14**.

10.4.3 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:

$$T_r = \frac{C_5 D}{2}\sqrt{\frac{P}{f_b}} + a$$

$$T_r = \frac{PA}{\tau L} + a$$

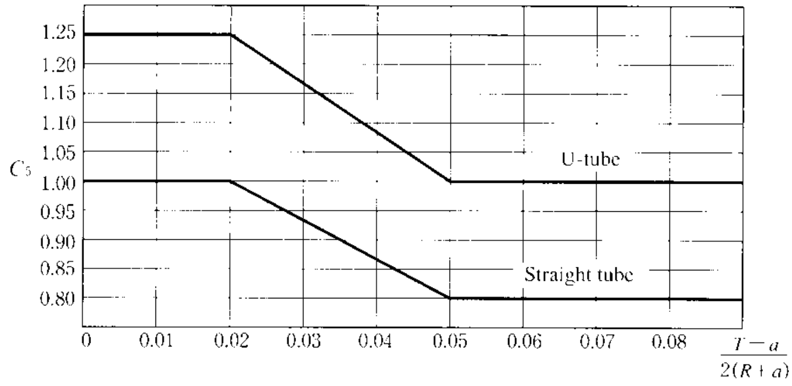
where

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. 7.10.1** is to be used.

Fig. 7.10.1 Value of C_5

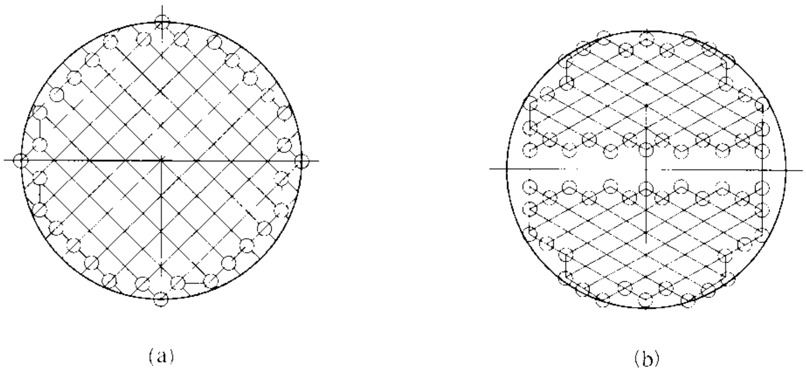


T = Actual thickness of shell plate (mm)

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. 7.10.2**) (mm^2)

Fig. 7.10.2 Polygon used for Tube Plate Calculation



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 **10.3.3** 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.

10.4.4 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 **10.3.1** or **Table 7.10.3**

Table 7.10.3 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

Notes: Intermediate values are to be determined by interpolation.

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.

10.4.5 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.

10.4.6 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

10.4.7 Considerations for Secondary Stress

In cases where deemed necessary by the Society, consideration is to be given to the strength against secondary stress.

10.4.8 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.

10.4.9 Strength Calculation by Special Method

Even in cases where the dimensions of each component of pressure vessels do not conform to the requirements in **10.4**, 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.

10.5 Manholes, Other Openings for Nozzle, etc. and Their Reinforcements

10.5.1 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 7.10.4**. 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 7.10.5**
3 The construction of holes and covers is to comply with the requirements in **9.5.1-2**.

Table 7.10.4 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 7.10.5**
(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 7.10.5 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*

10.5.2 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. 7.9.7**. In this case, no unreinforced opening is to exceed 200 *mm* in diameter.

(3) Openings provided on end plates complying with the requirement in **10.4.2-4(2) (c)** where no reinforcement is required due to the increased thickness of the end plates.

10.5.3 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 **9.5.3**. 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.

10.6 Joints and Connections of Each Member

10.6.1 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 **9.7.1-1** and **-2**.

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.

10.6.2 Shape of Welded Joint and Connection

The shape of welded joints and connections are to be as shown in **Fig. 7.9.9**, or be a shape which is considered by the Society to be equivalent.

10.6.3 Construction of Bolted Cover Plates

The construction of unstayed flat cover plates bolted to the shell is to comply with the requirements in **9.7.3**.

10.7 Fittings, etc.

10.7.1 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.

10.7.2 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.

10.7.3 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 the paragraph 4.2, 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 **9.8.3**.

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.

10.7.4 Pressure and Temperature Measuring Devices

Pressure and temperature measuring devices are to be provided on pressure vessel where considered necessary.

10.7.5 Fittings of Air Reservoir

1 Pressure relieving devices for air reservoirs are to comply with the requirements in **10.7.3**.

2 Air reservoirs are to be provided with effective drainage systems.

3 Air reservoirs are to be provided with pressure measuring devices.

10.8 Tests

10.8.1 Shop Tests

1 Tests for welds are to conform to the requirements in **Part 3**.

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 11 AUXILIARIY MACHINERY

11.1 General

11.1.1 Scope

The requirements in this Chapter apply to auxiliary machineries.

11.2 Construction of Auxiliary Machinery

11.2.1 Auxiliary machinery and storage tanks

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.

4 Auxiliary machinery is to be designed to give consideration to no harmful vibration and minimizes noise. The foundations, connecting pipes, etc. specified in the rules are to be fitted with vibration prevention.

11.2.2 Distilling Plants

In ships using distilled water as feed water, at least one distilling plant with a sufficient capacity is to be provided.

11.2.3 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.

3 Lubricating oil filters specified in the above **-2** are to be provided with valves or cocks for depressurizing before being opened.

4 One or more lubricating oil filters are, in principle, to be provided for each machinery space.

5 The construction of filters is to be designed for easy operation and rigid construction.

11.3 Tests

11.3.1 Shop Tests

1 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 the design pressure or 0.2 *MPa*, whichever is greater.

2 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.

3 Auxiliaries (excluding auxiliary machinery for specific use etc.) are to be subjected to running tests as deemed appropriate by the Society.

Chapter 12 FUNNEL

12.1 General

12.1.1 Scope

The requirements in this Chapter apply to uptakes, funnels and ducts.

12.2 Uptakes and Funnels

12.2.1 Structure, etc.

1 Uptakes and funnels are to be appropriate for the hull. The funnel outer shells are to be designed the shape to minimize the resistance of wind pressure. The funnels and the funnel inner shell are to be designed the shape so that minimizes the pressure loss of exhaust gas flow. Uptakes and funnels are to be of sufficient strength withstand impacts, blasts, etc.

2 Uptakes are to be installed so as to enable to disassembly and maintenance for the main engine and auxiliaries. In case where the removal of uptakes is unavoidable, the removal of uptakes is to be so as to minimize.

3 Uptakes and funnels are to be designed to prevent inrush of rainwater, etc., and provided the drain eliminate device.

4 Uptakes which penetrate decks, bulkheads, etc., are to be sufficiently covered with thermal insulation in the penetrations.

5 The exhaust gas pipe are to be provided with an appropriate bend or provided with an expansion joint so that there is no detrimental deformations of the pipe by thermal expansion.

6 The exhaust gas piping systems are to be designed to prevent the harmful vibrations from intake and exhaust pipes, silencers, and the propagation of these vibrations to the hull structure.

7 The position of each opening is to be determined so that exhaust gases may not be drawn into the air from intake.

8 The exhaust gas outlets at the top of the funnels are to be provided the *IRS* (Infra-Red Suppressor) as deemed necessary. The consideration is to be given to the reduction of *RCS* (Radar Cross Section) for the funnel outer shells and exhaust gas pipe, etc., as deemed necessary.

12.2.2 Insulation

The thermal insulations are to be applied within the following range.

(1) Uptakes in engine room

(2) Locations of uptakes outside the engine room suspected to touch the human body.

(3) Locations in the exhaust gas pipe room, etc., suspected that the room temperature is likely to rise excessively.

(4) For locations of the upper deck where the heat insulating material is exposed to the outside air, the outer surfaces of the thermal insulation are to be covered with galvanized steel sheet to prevent the damage from rainwater or seawater.

12.2.3 Strength

The strength calculations for the funnels are to be calculated in consideration of the instantaneous wind speed specified in **3.1.3-2**, **Part 1**.

12.3 Ventilation Ducts in Machinery Space

12.3.1 Structure, etc.

1 Ventilation ducts are to be arranged to sufficiently satisfy its purpose. The structure of ventilation ducts is to be designed to minimize the pressure loss of air flow.

2 Ventilation ducts are to be designed appropriately to prevent the propagation of harmful noises and vibrations.

3 The structure of Ventilation ducts is to be of sufficient strength withstand impacts, etc.

4 Ventilation ducts are to be installed so as to enable to disassembly and maintenance for the main engine and auxiliaries.

5 Ventilation ducts are to be prevented the condensation on the outside of these ducts.

6 In case where shutters or dampers are provided in ventilation ducts, the operating handles for these shutters or dampers are to be provided at the position in consideration of easy operation.

7 The air intake of the main engine and the prime mover of generator engine are to be planned to be lead directly from overboard as deemed necessary. The air intake of the gas turbine engine are especially to be provided with an intake demisters, bypass doors, protection wire meshes, intake silencers, etc., as deemed necessary.

8 The position of air intake is to be arranged in consideration of the inclination, motion and green water of the ship, and taken measures of anti-freezing as deemed necessary.

9 The air intakes are, in principle, to be arranged distributively on the port side and starboard side as deemed necessary from the point of view of redundancy.

10 The consideration is to be given to the reduction of *RCS* (Radar Cross Section) for the air intakes as deemed necessary.

11 The air intake pipes are to be carried out the necessary noise insulation work.

12.3.2 Material

The noise insulation materials are to be non flammable or incombustibility.

Chapter 13 PIPING SYSTEMS

13.1 General

13.1.1 Scope

The requirements in this Chapter apply to pipes, valves, fittings and piping systems for machinery spaces of category *A*.

13.1.2 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 other overpressure protective devices, the pressure based on the set pressure of the relief valve or overpressure protective device. 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 pressure for the shells of pressure vessels.

(2) For piping on the discharge side of pumps, the pressure based on 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, the pressure based on the set pressure of the relief valves or the set pressure of the over pressure protective devices.

(3) For the blow-off piping of boilers, the design pressure is specified in **9.8.6-3**.

(4) For pipes, valves and fittings containing fuel oil, the maximum working pressure or 0.3 *MPa*, whichever is greater. However, for those containing fuel oil with a working temperature above 60 °C and a working pressure above 0.7 *MPa*, the maximum working pressure or 1.4 *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.

13.1.3 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) Methods for preventing oil from spraying out from flange joints and special joints (threaded pipe joints, mechanical joints, etc.) in fuel oil, lubricating oil and other flammable oil piping (if any)
   (d) Other drawings considered necessary by the Society

(2) Data
   (a) Machinery particulars
   (b) Other data considered necessary by the Society

13.2 Piping

13.2.1 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 in cargo holds or 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.

10 Piping systems concerning the main propulsion directly are to be operated independently. The piping systems are to be arranged so that the damage of the piping system of one compartment does not render continuous operation for the piping system of other compartments. The piping systems are to be considered the efficiency of operation with interconnection pipes between each compartment necessary. In case where machinery spaces being damage, the piping systems are to be designed so that the maximum output of machinery is ensured.

13.2.2 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.

(4) Oil pipes and heating pipes in deep tanks which may be used for carriages of general cargo are to be capable of being disconnected or are to be provided with suitable arrangements such as blank flanges or spool pieces. Bilge pipes and ballast pipes in such deep tanks are to comply with the requirements in **13.6.1-10**.

2 Common use of sea water pipes and fresh water pipes

Sea water pipes and fresh water pipes are to be separated, unless adequate measures are taken to avoid any accidental contamination between the two.

13.2.3 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.

13.2.4 Slip-on Joints

Slip-on joints are not to be used on pipe lines in cargo holds, deep tanks and other spaces which are not easily accessible, unless approved by the Society.

13.2.5 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, and that the space in which they are located is not a cargo space. 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.

13.2.6 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.

13.2.7 Prevention of Counterflow through Drain Pipes

When any drain pipes in the engine room are led into double-bottom tanks, and when, in cases where sea water flows into the tank by grounding, etc., there is a danger of flooding from these drain pipes, a stop valve or other suitable device that stops the counterflow of sea water is to be provided. This device is to be readily operable from the engine room floor. However, these requirements do not apply to ships of a length less than 100 *m*.

13.2.8 Drain Installation around Boilers

A coaming of at least 100 *mm* in height is to be provided around boilers, and the drain inside the coaming is to be into a bilge well or bilge tank etc.

13.3 Thickness of Pipes

13.3.1 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 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 7.13.1(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 7.13.1(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 7.13.2** and **Table 7.13.3** respectively.

Table 7.13.1(1) Values of Allowable Stress of Steel Pipes (f)

Material \ Design Temperature		Allowable stress of steel pipes (f) N/mm^2													
		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 3**.

Table 7.13.1(2) Values of Allowable Stress of Copper and Copper Alloy Pipes (f)

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)											
*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

Notes: Intermediate values are to be determined by interpolation.

Table 7.13.2 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 cargo oil tanks	2
	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
Cargo oil systems		2
Primary refrigerant systems for refrigerating plants		0.3
Fresh water systems		0.8
Sea 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 sea water steel pipes whose nominal diameter is 25 *A* or below, the corrosion allowance may be reduced to 1.5 *mm*.
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 7.13.3 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 7.13.1(2)**	0.8
Copper nickel seamless pipes specified in **Table 7.13.1(2)**	0.5

Note:
For media without corrosive action in respect of the material employed, the corrosion allowance may be reduced to zero.

13.3.2 Minimum Thickness of Pipes

1 The thickness of steel pipes is to comply with the requirements in **13.3.1** and is not to be less than the value shown in **Table 7.13.4(1)** 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 7.13.4(2)** may be reduced by an amount up to but not more than 1 mm except for steel pipes for CO_2 fire extinguishing.

3 In determining the thickness of pipes from **Table 7.13.4(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 7.13.5**.

Table 7.13.4(1) Minimum Thickness of Steel Pipes

Services of pipes	Location of pipes		Minimum thickness of the encircled alphabets correspond to those in **Table 7.13.4(2)**
Bilge pipes	Passing through tanks except for cargo oil tanks		Ⓔ
	Passing through cargo oil tanks		16 *mm*
	Not passing through tanks		Ⓗ
Ballast pipes	Passing through tanks except for cargo oil tanks (Note 1)		Ⓔ
	Passing through cargo oil tanks	For outboard discharge	16 *mm*
		For the ballast tanks forward of the collision bulkhead	16 *mm*
		For other cases	Ⓔ,but Ⓓ when $D \geqq 100\ A$
	Not passing through tanks		Ⓗ
Fuel oil pipes	Passing through tanks except for fuel oil tanks		Ⓔ
Sea water pipes	Passing through tanks		Ⓔ
	Not passing through tanks		Ⓗ
Fresh water pipes	Passing through tanks		Ⓔ
Cargo oil pipes	Passing through ballast tanks		Ⓔ, but Ⓓ when $D \geqq 100\ A$
	Passing through cargo oil tanks		Ⓔ, but Ⓕ when $D \geqq 250\ A$
	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			Ⓚ

Notes:

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 7.13.4(2) Minimum Thickness of Steel Pipes[1][3] (*mm*)

Nominal dia. (*A*) \ Corresponding Alphabet	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)[2]	(J)[2]	(K)
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	6.4	—	4.9	—	6.3	3.6	4.5	3.6	4.0	3.2	2.0
40	7.1	—	5.1	—	6.3	3.7	4.5	3.6	4.0	3.2	2.3
50	8.7	8.7	5.5	—	6.3	3.9	4.5	4.0	4.5	3.6	2.3
65	9.5	8.7	7.0	7.0	6.3	5.2	4.5	4.5	5.0	3.6	2.6
80	11.1	8.7	7.6	7.6	7.1	5.5	4.5	4.5	5.6	4.0	2.9
90	12.7	8.7	8.1	8.0	7.1	5.7	4.5	4.5	6.3	4.0	2.9
100	13.5	11.1	8.6	8.6	8.0	6.0	4.5	4.5	7.1	4.5	3.2
125	15.9	11.1	9.5	9.5	8.0	6.6	4.5	4.5	8.0	5.0	3.6
150	18.2	11.1	11.0	11.0	8.8	7.1	4.5	4.5	8.8	5.6	4.0
175	20.6	11.1	11.9	11.8	8.8	7.7	5.3	5.3	—	—	4.5
200	23.0	12.7	12.7	12.5	8.8	8.2	5.8	5.8	—	—	4.5
225	25.8	12.7	13.9	12.5	8.8	8.8	6.2	6.2	—	—	5.0
250	28.6	15.1	15.1	12.5	8.8	9.3	6.3	6.3	—	—	5.0
300	33.3	15.1	17.4	12.5	8.8	10.3	6.3	6.3	—	—	5.6
350	35.7	—	19.0	12.5	8.8	11.1	6.3	6.3	—	—	5.6
400	40.5	—	21.4	12.5	8.8	12.7	6.3	6.3	—	—	6.3
450	45.2	—	23.8	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 7.13.5 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

13.4 Construction of Valves and Pipe Fittings

13.4.1 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.

13.4.2 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.

13.4.3 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. 7.13.1**, according to their respective application classifications shown in **Table 7.13.6** and **Table 7.13.7**.

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 the ship's side below the freeboard deck 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. Usage of slip type slip-on joints as the main means of pipe connection is not permitted except in cases where compensation of axial pipe deformation is necessary.

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.

13.4.4 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 sea 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 sea 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 **13.4.4-1(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.
(c) Non-metallic flexible hoses used for flammable oil and sea 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 and are not used for fuel oil lines.

4 The end fittings of flexible hose assemblies are to have flanges or to comply with **13.4.3** or **13.5.2**.

13.5 Connection and Forming of Piping Systems

13.5.1 Welding of Piping Systems

The welding for piping systems is also to comply with the requirements in **Part 3**.

13.5.2 Direct Connection of Pipe Lengths

1 Butt welded joints of pipe lengths are to comply with the following **(1)** and **(2)**.
(1) Butt welded joints are generally to be of a full penetration type.
(2) Except for pipes belonging to Group II and III, welding is to be as follows:
(a) double welded,
(b) use of a backing ring or inert gas back-up on first pass, or
(c) other equivalent methods recognized by the Society.

2 Slip-on sleeve welded joints are to comply with the following **(1)** and **(2)**.
(1) Slip-on sleeve welded joints are to have sleeves, sockets and weldments of adequate dimensions conforming to standards recognized by the Society.
(2) Except for pipes belonging to Group III, slip-on sleeve welded joints are not to be used for

pipes specified in any of the following **(a)** to **(c)**.

(a) Pipes having a nominal diameter of more than 80 *A*

(b) Pipes conveying toxic media

(c) Pipes servicing where fatigue, severe erosion or crevice corrosion is expected to occur

3 Threaded joints are to comply with the following **(1)** to **(3)**.

(1) Threaded joints are to comply with the requirements of standards recognized by the Society.

(2) Threaded pipe joints are not to be used for the following pipes. However, the Society may allow use for pipes specified in **(e)** or **(f)** after considering the service of the pipes.

(a) Pipes conveying flammable media, except for pipes with small diameter used for instrumentation.

(b) Pipes conveying toxic media.

(c) Pipes servicing where fatigue, severe erosion or crevice corrosion is expected to occur.

(d) Pipes for CO_2 systems, except inside protected spaces and in CO_2 cylinder rooms.

(e) Pipes belonging to Group I with a nominal diameter exceeding 25 *A*.

(f) Pipes belonging to Group II and Group III with a nominal diameter exceeding 50 *A*.

(3) For pipes belonging to Group I or Group II, threaded joints with tapered threads are to be used.

13.5.3 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. 7.13.2** according to their application classification shown in **Table 7.13.8**, 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 **13.5.2** and **-1**.

13.5.4 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 1,000 °C - 850 °C, however the temperature may be decreased to 750 °C during the forming process.

(2) For steel pipes of Grade 4 specified in **3.3.6**, **Part 3**, 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 **3.3.2**, **Part 3**.

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 **2.2**, **Part 3** as well as pipes of materials other than steel, they are to be approved by the Society.

13.6 Bilge and Ballast Piping

13.6.1 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 In cases where fixed pressure water-spraying fire-extinguishing systems or other fixed systems, which will supply copious quantities of water, are fitted for the following cargo spaces, and where fixed apparatuses of spraying nozzles or flooding the cargo space with water are fitted for cooling the underdeck cargo space loaded the dangerous goods specified in **10.1.4**, **Part 9**, bilge pumping systems for such cargo spaces are to comply with these requirements.

(1) Ro-ro spaces defined in **3.2.12**, **Part R of the Rules for the Survey and Construction of Steel Ships**.

(2) Cargo space intended for carriage of motor vehicles with fuel in their tanks for their own propulsion.

3 Suitable measures are to be taken so that bilge pumping systems prevent the possibility of any ingress of sea 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 used for draining cargo holds and machinery room and shaft tunnels are to be entirely separate from any other pipe that is not a bilge suction pipe.

5 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 7.13.4(1)** and **Table 7.13.4(2)**.

6 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.

7 In cases where a tank is intended to be used for both fuel oil and ballast water, adequate provisions, such as blank flanges or spool pieces, are to be made to prevent any mixing of fuel oil and ballast water in the ballast pipe when carrying fuel oil and in the fuel oil pipe when carrying ballast water. In this case, these provisions are also to be complied with **the Rules for Marine Pollution Prevention Systems**.

13.6.2 Terminology

1 A Main Bilge Line is the part of a bilge suction line which forms the main of bilge suction line connected to independently powered bilge pumps specified in **13.6.4-1** and to which all branch bilge suction pipes from the bilge suctions specified in **13.6.5** and **13.6.7-1** to **-4** are connected.

2 A Branch Bilge Suction Pipe is a pipe connected to the main bilge line from the bilge suction of each compartment.

3 A Direct Bilge Suction Pipe is a bilge suction pipe which is connected directly to an independently powered pump specified in **13.6.4-1** and arranged entirely separately from other pipes.

4 An Emergency Bilge Suction Pipe is a bilge suction pipe which is to be used in an emergency and is connected directly to an independently powered pump specified in **13.6.7-6(1)**.

13.6.3 Size of Bilge Suction Pipes

1 The internal diameter of main bilge lines, direct bilge suction pipes 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 13mm or more, a standard pipe of one grade higher is to be used.

(1) For main bilge lines and direct bilge suction pipes:

$$d = 1.68\sqrt{L_f(B + D)} + 25 \ \ (mm)$$

(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_f : Length (*m*) for freeboard specified in **2.3.2, Part 1**.

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 Internal diameters of direct bilge suction pipes are also to comply with the requirements in **13.6.7-5(1)** and **(2)**.

4 In cases where bilge suctions are provided at the fore and after parts of the cargo hold in accordance with the requirements in **13.6.5-1**, the internal diameter of the branch bilge suction pipe at the fore part may be reduced to 0.7 times that obtained from the formula in **-1(2)**.

5 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 and any direct bilge suction pipes 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**.

6 The internal diameters of branch bilge suction pipes are not to be less than 50 *mm*. However, the internal diameters of those used for the drainage of a small compartment may be reduced to 40*mm* where considered acceptable by the Society.

7 The internal sectional area of bilge suction pipes connecting two or more branch bilge suction pipes to the main bilge line is not to be less than the sum of internal sectional areas of the largest two branch bilge suction pipes, but need not exceed the internal sectional area of the main bilge line obtained from the formula in **-1(1)**.

8 The internal diameters of bilge suction pipes in fore and after peaks as well as shaft tunnels are not to be less than 65 *mm*. However, the internal diameter of these pipes may be reduced to 50*mm* in ships less than 60 *m* in length.

13.6.4 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, in ships not more than 90 *m* in length, one of the required pumps may be driven by the main propulsion machinery.

(2) Ballast, sanitary and general service pumps driven by independent power may be accepted as independently powered bilge pumps, provided that they are connected properly to the main bilge line.

(3) In cases where considered acceptable by the Society, one of the independently powered bilge pumps prescribed in **(1)** may be substituted for by an eductor that is driven by a sea water pump and not driven by a bilge pump. In this case, the capacity of the eductor is to comply 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 **13.6.3**, 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 **13.6.3** (*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 holds, engine rooms and shaft tunnels.

13.6.5 Bilge Suction Arrangement in Holds

1 In ships having only one hold exceeding 33 *m* in length, bilge suctions are to be provided in suitable positions in both the after half-length and in the forward half-length of the hold.

2 In cases where inner bottom plating extends to the ship's sides, bilge suctions are to be placed in wells at both wings and also at the centre line if the top plating has an inverse camber.

3 In cases where a ceiling is fitted over the bilges of the holds, proper arrangement is to be made whereby water in the hold compartments may find its way to the suctions.

4 In refrigerated chambers, the insulation for bilge wells and bilge suction hoses in bilge ways is to be of plug type and removable.

5 In refrigerated chambers, the insulation in way of bilge suction pipes is to be removable only to a degree necessary to allow proper inspection.

13.6.6 Bilge Drainage from the Top of Deep Tanks, Fore and After Peak Tanks and Chain Lockers

1 Efficient means are to be provided for draining bilge from the top of deep tanks and other watertight flats.

2 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 65*A* in nominal diameter and are to be provided with quick-acting self-closing valves located in an accessible position.

3 In cases where a suction line passes through a collision bulkhead, it is to comply with the requirements in **13.2.5-2**.

13.6.7 Bilge Suction Arrangements in Engine Rooms

1 In cases where there is no double bottom in the engine room, at least two bilge suctions are to be provided near the centre line of the ship. One of these suctions is to be for a branch bilge suction pipe and the other is to be for a direct bilge suction pipe. If the rise of floor is less than 5 *degrees*, additional bilge suctions are to be provided at wings.

2 In cases where there is a double bottom in the engine room with bilge ways on both wings, one branch bilge suction and one direct bilge suction are to be provided at each wing.

3 In cases where double bottom plating extends to the ship's sides, bilge wells are to be placed at each side so far as is reasonable and practicable, and one branch bilge suction and one direct bilge suction are to be provided for each bilge well.

4 In cases where the engine room is separated by watertight bulkheads from a boiler compartment and auxiliary engine room, the bilge suction pipe arrangements in the boiler room and the auxiliary engine room are to comply with the requirements in **-1** in the case of no double bottom construction; and, they are to comply with the requirements in **-2** or **-3** in the case of double bottom construction. However, only one direct bilge suction will be accepted even in the case of double bottom construction.

5 Direct bilge suction pipes are to comply with the following requirements:

(1) The internal diameter of direct bilge suction pipes is not to be less than that obtained from the formula in **13.6.3-1(1)**. In cases where a direct bilge suction pipe is provided on each side of the engine room in accordance with the requirements in **-2** or **-3**, the internal diameter of one of these direct bilge suction pipes may be reduced to that obtained from the formula in **13.6.3-1(2)**. In this case, the pipe reduced in diameter is to be located on the same side as the emergency bilge suction pipes specified in **-6** or **-7**.

(2) Notwithstanding the requirements in **(1)**, in cases where the compartments with small dimensions, the internal diameter of the direct bilge suction pipes may be adequately reduced.

6 Emergency bilge suction pipes for ships with diesel engines or gas turbines used as main propulsion machinery are to comply with the following requirements:

(1) In ships with diesel engines or gas turbines used as main propulsion machinery, an emergency bilge suction pipe with a screw-down non-return valve having a wheel handle which is extended above the lower platform in the engine room is to be fitted to the main cooling water pump. The suction pipe is to be fed into a suitable level in the engine room to discharge bilge in case of emergency. The internal diameter of such suctions pipe is to be equal to that of pump suction.

(2) In cases where the main cooling water pump is not considered suitable for bilge discharge, the emergency bilge suction pipe may be fed into the largest available power pump in the engine room other than the bilge pumps specified in **13.6.4-1** in lieu of the main cooling water pump. The capacity of this pump is not to be less than that required by **13.6.4-2**. The internal diameter of such a suction pipe is to be equal to that of pump suction.

(3) In cases where the pump prescribed in **(1)** or **(2)** is of a self-priming type, any direct bilge suction arranged on the same side of the ship as the emergency bilge suction may be omitted.

13.6.8 Bilge Wells

1 The depth of bilge wells constructed in double bottoms and the vertical distance between the bottom plating and the bottom of bilge wells are to comply with the requirements in **1.4.1-6**, **Part 5**.

2 The capacity of each bilge well is not to be less than 0.17 m^3.

3 Bilge wells may be substituted for by steel bilge hats of a reasonable capacity where the spaces to be drained are small or not capable of being provided with bilge wells of the volume prescribed in **-2**.

4 In cases where access manholes to bilge wells of cargo holds are necessary, they are to be located as near to the bilge suctions as practicable. The placing of any of the aforementioned manholes on the fore and aft bulkheads as well as the inner bottom plating of the engine room is to be avoiding as far as practicable.

13.6.9 Mud Boxes and Strum Boxes

1 Bilge suction pipes, except for those emergency bilge suction pipes in engine rooms and shaft tunnels, are to be provided with mud boxes that are easily accessible from above the platform in the engine room, and have covers which are easily opened and closed. In addition, straight tail pipes to bilge wells are to be fitted to the suction side of these mud boxes.

2 Bilge suction ends in hold spaces are to be provided with strum boxes that have a perforation approximately 10 *mm* in diameter, except in cases approved by the Society, and that have an open area of more than twice the area of the suction pipes. In addition, strum boxes are to be so constructed that they can be cleaned without disconnecting any joint of the suction pipes.

13.7 Fuel Oil Systems

13.7.1 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 Stop valves or cocks are to be fitted on both the suction and the delivery sides of fuel oil pumps.

3 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* .

4 Union joints used for any connections of fuel oil injection pipes of diesel engines or any pipes of burning systems of boilers are to be of rigid construction and to have metal contact capable of providing sufficient oil tightness.

5 In cases where a ship alternates between carrying fuel oil and ballast water in the same compartment, pipes are to be so arranged that the fuel oil can be pumped out from any compartment at the same time that ballast water is being discharged from any other compartment. In cases where settling or service tanks are provided, each having a capacity sufficient to permit 12 *hours* of normal service without replenishment, the above requirement may be modified. In this case, these provisions are also to be complied with **the Rules for Marine Pollution Prevention Systems**.

6 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.

7 The capacity of each fuel service tank required in **-6** is to be sufficient for at least 8 *hours* at maximum continuous rating of the main engine and normal operating load of the generators at sea.

8 In addition to **13.7**, fuel oil systems are to comply with the requirements in **2.2**, **Part 9**.

13.7.2 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 **2.2.2(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.

13.7.3 Fuel Oil Transfer Pumps

In ships where power pumps are used for pumping fuel into settling and service tanks, at least two independently powered fuel oil transfer pumps are to be provided; and, these pumps are to be connected and ready for use. In cases where any suitable independently powered driven fuel oil pump for other purposes is available for use as a fuel oil transfer pump, such a pump may be used as a fuel oil transfer pump.

13.7.4 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 such as fuel oil settling and service tanks. In cases where it is not practicable to provide metal drip trays, coamings are to be provided to hold any oil spillage.

2 Fuel oil settling tanks and service tanks are to be provided with drain valves or cocks for draining water from the bottom of the tanks.

3 Drain valves or cocks fitted to fuel oil tanks are to be of a self-closing type.

4 Drainage arrangements are to comply with the following requirements:

(1) Oil in drip trays or in the coamings prescribed in **-1**and **-2** as well as any drainage from drain valves or cocks fitted to fuel oil tanks are to be led into fuel oil drain tanks, or some other suitable arrangement.

(2) The fuel oil drain tanks prescribed in **(1)** are not to be part of an overflow system.

(3) Suitable means are to be provided for the disposal of any fuel oil drainage stored in the fuel oil drain tanks prescribed in **(1)**.

13.7.5 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 ℃ 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 ℃ 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.

13.7.6 Fuel Oil Systems for Diesel Engines

1 Number and capacity of fuel oil supply pumps for the main propulsion machinery

(1) The main propulsion machinery is to be provided with one main fuel oil supply pump of sufficient capacity to maintain the supply of the fuel oil at the maximum continuous output of the machinery as well as one stand-by fuel oil supply pump of sufficient capacity to supply fuel under normal service conditions. These pumps are to be connected and ready for use.

(2) In cases where two or more main propulsion machinery is provided and where each of them has a built-in main fuel oil supply pump as well as in cases where it is possible to obtain navigable speed even if one of them is out of use, stand-by fuel oil supply pumps may be dispensed with on the condition that one complete spare pump is carried on board.

2 Number and capacity of fuel oil supply pumps for diesel engines driving auxiliary machinery and electrical generators

(1) Diesel engines for driving electrical generators and auxiliary machinery for which duplication is required are to be provided with main and stand-by fuel oil supply pumps of sufficient capacity to maintain the supply of oil at the maximum continuous output of the engine. These pumps are to be connected and ready for use.

(2) In cases where each engine prescribed in **(1)** is provided with an exclusive main fuel oil supply pump, the stand-by fuel oil supply pump may be omitted.

3 Driving system of stand-by fuel oil supply pumps and use of other pumps

(1) Stand-by fuel oil supply pumps are to be driven by an independent power source.

(2) In cases where any fuel oil pump driven by an independent power source and intended for other purposes is available for use as a stand-by fuel oil supply pump; this pump may be used

as a stand-by fuel oil supply pump.

4 Fuel oil filters

(1) Fuel oil filters are to be provided for fuel oil supply piping lines of diesel engines.

(2) Fuel oil filters for diesel engines that are used as main propulsion machinery are to be capable of being cleaned without stopping the supply of filtered oil. The filters are to be provided with valves or cocks for depressurizing before being opened.

5 Fuel oil heating devices and fuel oil purifying devices

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.

13.7.7 Burning Systems for Boilers

1 Burning systems for auxiliary boilers

(1) With respect to essential auxiliary boilers and all other boilers that supply steam for fuel oil heating necessary for the operation of the main propulsion machinery or cargo heating that is required continuously, in cases where the boiler is provided with a combustion system of pressurized fuel injection type, at least two units of burning pumps and fuel oil heaters are to be provided respectively with each unit being capable of supplying a sufficient amount of oil to generate steam at the maximum evaporation rate of the boiler even in the case of failure of one unit. These pumps are to be connected and ready for use. However, where alternative means are available to ensure normal navigation and cargo heating even in cases where the burning system is out of operation, only one unit of burning system will be accepted.

(2) Filters are to be provided for the suction and delivery sides of fuel injection pumps. These filters are to be capable of being cleaned without stopping the supply of filtered oil. 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) The fuel oil filters specified in the above **(2)** are to be provided with valves or cocks for depressurizing before being opened.

2 Prevention of mixing of oil into steam pipes and air pipes

In cases where the removal of residual fuel oil in burners is conducted by means of steam or air, measures are to be taken to prevent the mixing of oil with any steam or air.

13.8 Lubricating Oil Systems and Hydraulic Oil Systems

13.8.1 General

1 The location, drip trays, drainage arrangements and heaters of lubricating oil systems are to comply with the requirements in **13.7.1-1**, **13.7.4-1** and **-4**, and **13.7.5** 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 **13.7.1-1**, **13.7.4-1** and **-4** (in these cases the term “fuel oil” is to be read as “hydraulic oil”).

3 In addition to **13.8**, lubricating oil systems and hydraulic oil systems are to comply with the requirements in **2.2.3** and **2.2.4**, **Part 9** respectively.

13.8.2 Lubricating Oil Pumps

1 Number and capacity of lubricating oil pumps for main propulsion machinery, propulsion shafting and power transmission systems

(1) Main propulsion machinery, propulsion shafting and their power transmission systems are to be provided with one main lubricating oil pump of sufficient capacity to maintain the supply of oil at the maximum continuous output of the machinery and one stand-by lubricating oil pump of sufficient capacity to supply oil under normal navigating conditions. These pumps

are to be connected and ready for use.

(2) In cases where two or more main propulsion machinery as well as propulsion shafting and their respective power transmission systems are each provided with a built-in main lubricating oil pump; and, in cases where it is possible to obtain navigable speed even if one of them is out of use, stand-by lubricating oil pumps may be dispensed with on the condition that one complete spare pump is carried on board.

2 Number and capacity of lubricating oil pumps for auxiliary machinery, electrical generators and their prime movers

(1) Electrical generators and auxiliary machinery for which duplication is required and their prime movers are to be provided with main and stand-by lubricating oil pumps of sufficient capacity to maintain the supply of oil at the maximum continuous output of the machinery. These pumps are to be connected and ready for use.

(2) In cases where each system prescribed in **(1)** is provided with an exclusive main lubricating oil pump, the stand-by lubricating oil pump may be omitted.

3 Driving systems of stand-by lubricating oil pumps and use of other pumps

(1) Stand-by lubricating oil pumps are to be driven by an independent power source.

(2) In cases where any lubricating oil pump driven by an independent power source and intended for other purposes is available for use, this pump may be used as a stand-by lubricating oil pump.

13.8.3 Stop Valves between Engine and Sump Tank

For ships of 100 *metres* or longer in length, in cases where a double bottom is used as a lubricating oil sump tank, a stop valve which can be easily operated from the engine room floor or a suitable counterflow prevention device is to be provided.

13.8.4 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.

13.9 Thermal Oil Systems

13.9.1 General

The location of thermal oil systems and the valves fitted to the pumps of such systems are to comply with the requirements in **13.7.1-1** and **-2**. Any filling pipes from outside the ship are to comply with the requirements in **13.7.2-2**. Drip trays and drainage systems are to comply with the requirements in **13.7.4-1** and **-4**. In these cases the term “fuel oil” is to be read as “thermal oil”. In addition to **13.9**, these systems are to comply with the requirements in **2.2.4**, **Part 9**.

13.9.2 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.

13.9.3 Pumps for Thermal Oil Heaters

Thermal oil heaters of important use are to be provided with two thermal oil circulating pumps and two fuel injection pumps. However, only one fuel injection pump may be acceptable, in cases where alternative means are available to ensure normal navigation and cargo heating in case

of pump failure.
(1) Thermal oil circulating pumps
(2) Fuel injection pumps

13.9.4 Heating of Liquid Cargo with Flash Points below 60 °C

The heating of liquid cargo with flash points below 60 °C is to be arranged by means of a separate secondary system, located completely within the cargo area unless in those cases deemed appropriate by the Society.

13.10 Cooling Systems

13.10.1 Cooling Pumps

1 Number and capacity of cooling pumps for main propulsion machinery.
(1) Main propulsion machinery is to be provided with a main cooling pump of sufficient capacity to maintain the supply of water (oil) at the maximum continuous output of the machinery as well as a stand-by cooling pump of sufficient capacity to supply cooling water (oil) under the normal navigating conditions. These pumps are to be connected and ready for use.
(2) In cases where two or more main propulsion machinery are provided, each of which has a built-in main cooling pump as well as cases where it is possible to obtain navigable speed in case of the failure of one of the main propulsion machinery, stand-by cooling pumps may be dispensed with on the condition that one complete spare pump is carried on board.
2 Number and capacity of cooling pumps for auxiliaries, electrical generators and their prime movers.
(1) Electrical generators and auxiliaries for which duplication is required and their prime movers are to be provided with main and stand-by cooling pumps of sufficient capacity to maintain the supply of water (oil) at the maximum continuous output of the machinery. These pumps are to be connected and ready for use.
(2) In cases where each of prime mover specified in **(1)** above is provided with an exclusive main cooling pump, the stand-by cooling pump may be omitted.
3 Drive system of stand by cooling pumps and use of other pumps.
(1) Stand-by cooling pumps are to be driven by an independent power source.
(2) In cases where a suitable pump driven by an independent power source and intended for other purposes is available for use, this pump may be used as a stand-by cooling pump.

13.10.2 Suction of Sea Water

Arrangements are to be provided to introduce cooling sea water from sea suction valves fitted on two or more sea chests or sea suction inlets.

13.10.3 Cooling Systems for Diesel Engines

In cases where sea 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 sea suction valve and the cooling sea water pump.

13.11 Pneumatic Piping Systems

13.11.1 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.

13.11.2 Relief Devices and Other Fittings for Air Tanks

Relief devices and other fittings for air tanks are to comply with the requirements in **10.7**.

13.11.3 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 specified in **-1** above 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** or **3.4.3-2**, corresponding to the type of prime mover, within one *hour*.

13.11.4 Emergency Air Compressors

1 In cases where prime movers driving air compressors specified in **13.11.3** are arranged for air starting, an independently power driven emergency air compressor is to be provided.

2 Prime movers driving emergency air compressors are to be capable of starting without compressed air.

3 The capacity of emergency air compressors is to be sufficient to start the prime movers of the air compressor prescribed in **13.11.3**. For this purpose, a small air reservoir for such an emergency air compressor may be provided.

13.11.5 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.

3 Starting air pipes from the air reservoirs to main propulsion machinery or auxiliary engines are to be entirely separate from the compressor discharge system prescribed in **-2**.

13.12 Steam Piping Systems

13.12.1 Drainage Arrangements

Drainage arrangements are to be installed at suitable locations in steam pipes.

13.12.2 Heating Coil for Oil

In cases where steam is used for heating fuel oil or lubricating oil, steam drain pipes are to be led to observation tanks or other oil detectors in a well-lit and accessible position in the machinery space.

13.12.3 Steam Pipes Passing through Cargo Holds

In principle, steam pipes are not to be led through cargo holds. However, in cases where it is impracticable to avoid such an arrangement, these pipes are to be insulated and protected by steel plates and all of the joints are to be welded.

13.13 Feed Water Systems for Boilers

13.13.1 Feed Water Systems for Auxiliary Boilers

1 Every auxiliary boiler (including steam generating systems, hereinafter in **13.13.1**) which provides services essential for the safety of the ship, or which could be rendered dangerous by the failure of its feed water supply, is to be provided with two separate feed water systems, each including a stop valve, a non-return valve specified in **9.8.5-1** and a feed pump. These feed water systems are to be capable of supplying feed water to the boiler in cases where any one of the systems being out of action. However, a single penetration of the steam drum is acceptable.

2 The boilers prescribed in **-1** are to be provided with two or more feed water pumps which can supply feed water sufficient for maximum evaporation with any one of the pumps being out of action. These feed pumps are to be connected and ready for use.

3 Feed water pumps prescribed in **-2** are to be driven by independent prime movers.

4 Feed water systems are to be provided with feed water regulators capable of automatically controlling the feed water rate.

5 Feed pumps are not to be used for any purpose other than to feed the boilers.

13.13.2 Pipes Passing through Tanks

Boiler feed water pipes are not to be led through tanks which contain oil or fuel, and oil or fuel pipes are not to be led through boiler feed water tanks.

13.14 Exhaust Gas Piping Arrangements

13.14.1 Exhaust Gas Pipes from Diesel Engines and Gas Turbines

1 In principle, the exhaust gas pipes from two or more diesel engines are not to be connected together except in the following **(1)** and **(2)** cases. In addition, the exhaust gas pipes from diesel engines and gas turbines as well as the exhaust gas pipes from two or more gas turbines are, in principle, not to be connected together.

(1) In cases where exhaust gas pipes of two or more diesel engines are connected to common silencers and effective means are provided to prevent any exhaust gas from returning into the cylinders of non-operating engines.

(2) In cases where exhaust gas pipes of two or more diesel engines are connected to common exhaust gas cleaning systems deemed appropriate by the Society.

2 Exhaust gas piping lines are to be arranged so that water does not enter the cylinders of diesel engines or gas turbines. In particular, exhaust gas piping lines that are led overboard near the water line are to be so arranged to prevent water from being siphoned into the line.

3 Boiler uptakes and exhaust piping lines from diesel engines are not to be connected together except in the following **(1)** and **(2)** cases. In addition, boiler uptakes and the exhaust gas pipes from gas turbines are not to be connected together except in case **(1)**.

(1) In cases where boilers or gas turbines are arranged to utilize waste heat from diesel engines.

(2) In cases where boiler uptakes and exhaust piping lines from diesel engines are connected to common exhaust gas cleaning systems deemed appropriate by the Society.

13.14.2 Exhaust Gas Pipes from Boilers

In cases where dampers are installed in the funnels or uptakes of boilers, their degree of opening is not to be reduced to 2/3 or less of the flue area when closed. They are to be capable of locking in any open position and the degree of opening is to be clearly indicated.

13.14.3 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.

13.15 Tests

13.15.1 Shop Tests

1 Tests of welds in piping systems and auxiliaries are to comply with the requirements in **Part 3**.

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 the design pressure.

6 Valves and distance pieces fitted to the ship's side below the load line are to be subjected to hydrostatic tests at a pressure of 1.5 times the 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 the 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.

Fig 7.13.1 Examples of Mechanical Joints

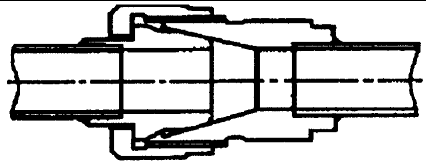
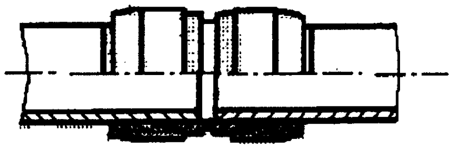
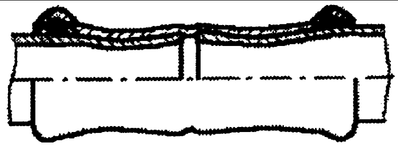
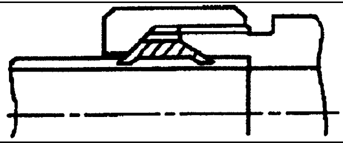
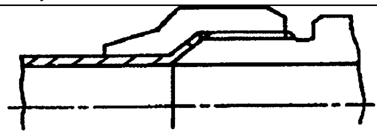
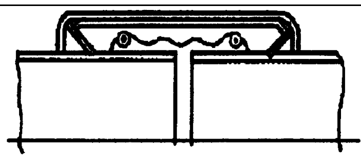
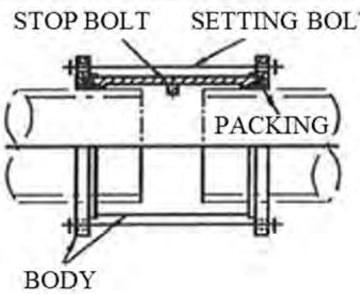
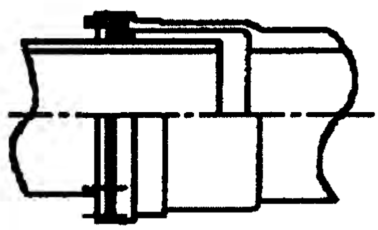
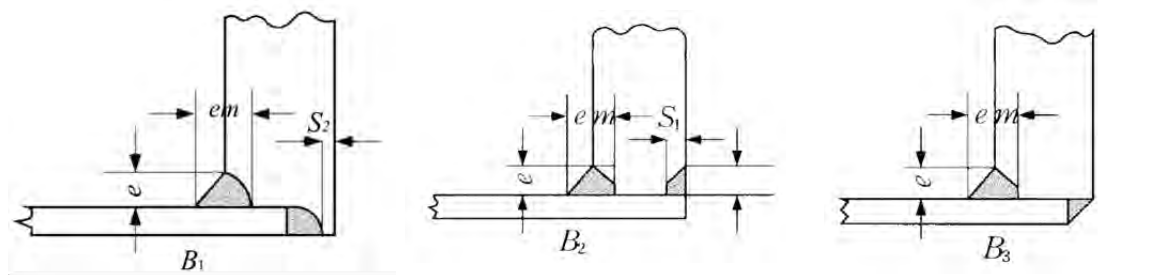
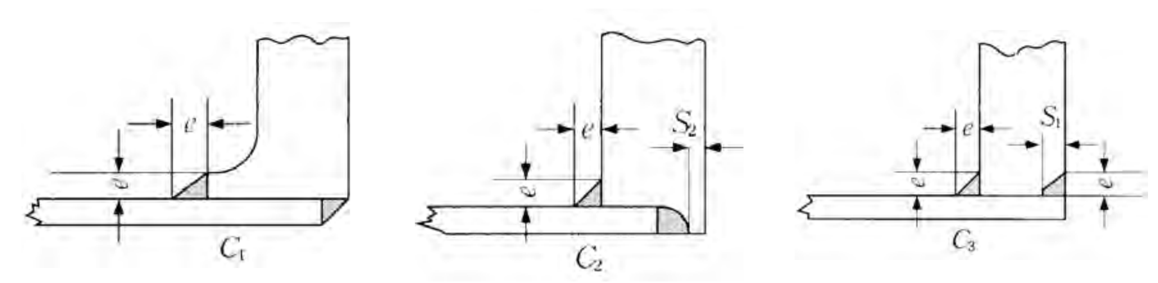
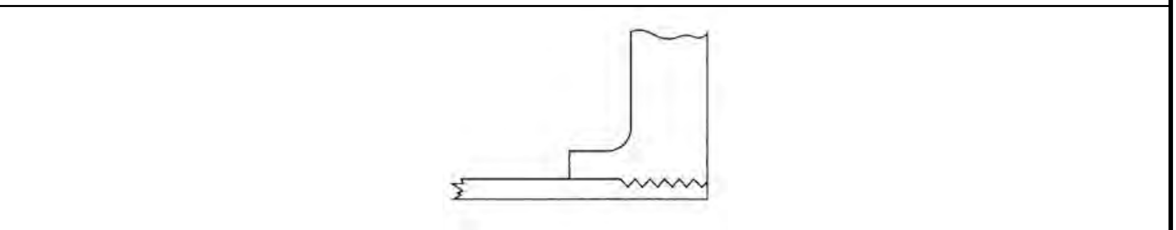
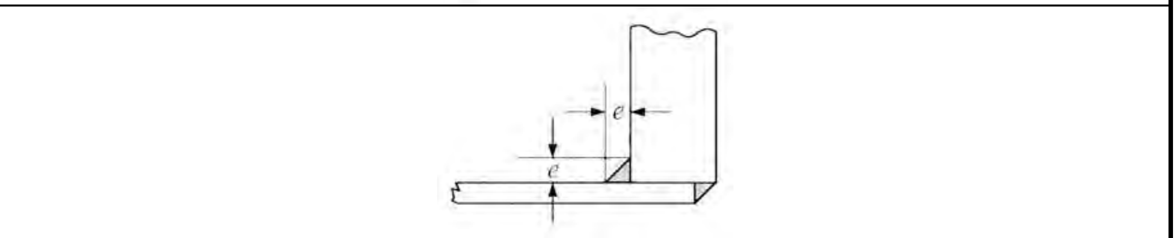
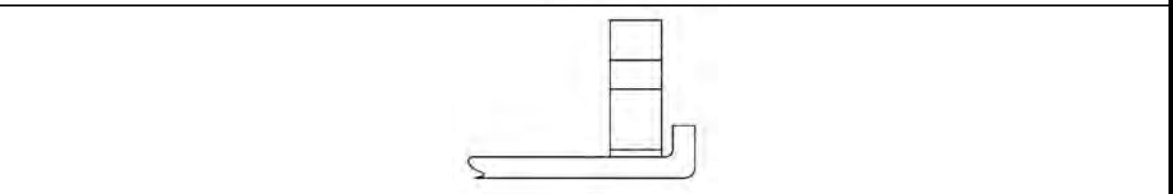
Pipe Unions	
Welded and Brazed Types	
Compression Couplings	
Swage Type	
Press Type	
Bite Type	
Flared Type	
Slip-on Joints	
Grip Type	
Machine Grooved Type	 Roll Groove  Cut Groove
Slip Type	 

Fig. 7.13.2 Type of Flange Connections

	Types of Joints and Dimensions
A	
B	
C	
D	
E	
F	

Notes:

1. Standard dimensions of welds are as follows:
   $e = 1.4\ t$, $m = t$, $S_1 = t$, $S_2 = 0.5\ t$
   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 7.13.6 Application Classifications of Mechanical Joints[1]

Application Purpose	System	Kind of Connections[2]		
		Pipe Union	Compression Coupling	Slip-on Joint[10]
Flammable fluids[8] (Flash point ≤ 60 Material °C)	Cargo oil lines[6]	+	+	+
	Crude oil washing lines[6]	+	+	+
	Vent lines[5]	+	+	+
Inert gases	Water seal effluent lines	+	+	+
	Scrubber effluent lines	+	+	+
	Main lines[4][6]	+	+	+
	Distributions lines[6]	+	+	+
Flammable fluids[8] (Flash point > 60 °C)	Cargo oil lines[6]	+	+	+
	Fuel oil lines[4][5]	+	+	+
	Lubricating oil lines[4][5]	+	+	+
	Hydraulic oil[4][5]	+	+	+
	Thermal oil[4][5]	+	+	+
Sea Water	Bilge lines[3]	+	+	+
	Water filled fire extinguishing systems, e.g. sprinkler systems[5]	+	+	+
	Non water filled fire extinguishing systems, e.g. foam, drencher systems[5]	+	+	+
	Fire main[5]	+	+	+
	Ballast systems[3]	+	+	+
	Cooling water systems[3]	+	+	+
	Tank cleaning services	+	+	+
	Non-essential systems	+	+	+
Fresh water	Cooling water systems[3]	+	+	+
	Condensate returns[3]	+	+	+
	Non-essential systems	+	+	+
Sanitary/ Drains/ Scuppers	Deck drains (internal)[7]	+	+	+
	Sanitary drains	+	+	+
	Scuppers and discharges (overboard)	+	+	-
Sounding/Vents	Water tanks/Dry spaces	+	+	+
	Oil tanks (f.p. > 60°C)[4][5]	+	+	+
Miscellaneous	Starting/Control air[3]	+	+	-
	Service air (non-essential)	+	+	+
	Brine	+	+	+
	CO_2 systems[3]	+	+	-
	Steam	+	+	-[9]

Notes:

(1) +: Application is allowed; -: Application is not allowed

(2) If mechanical joints include any components which readily deteriorate in case of fire, they are to be of a Society approved fire resistant type under consideration of the following **(3)** to **(6)**:

(3) Only Society approved fire resistant types may be used inside machinery spaces of category *A*.

(4) 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.

(5) Only Society approved fire resistant types may be used except in cases where such mechanical joints are installed on exposed open decks, as defined in **9.2.3-2(10)**, **Part R of the Rules for the Survey and Construction of Steel Ships**, except for the cargo areas of ships carrying flammable liquid, and are not used for fuel oil lines, fire extinguishing systems and fire mains.

(6) Only Society approved fire resistant types may be used in pump rooms and on open decks.

(7) May only be used above the free board deck.

(8) The number of mechanical joints in flammable fluid systems is to be kept to a minimum. In general, flanged joints

which conform to recognized standards are to be used.

(9) Slip type slip-on joints as shown in **Fig. 7.13.1** may be used for pipes on deck with a design pressure of 1.0 *MPa* or less.

(10) The use of slip joints is to comply with the requirements specified in **13.2.4**.

Table 7.13.7 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.

Table 7.13.8 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.

Chapter 14 MACHINERY SYSTEMS FOR SHIIPS CARRYING DANGEROUS CARGO SUCH AS FLAMMABLE LIQUID

14.1 General

14.1.1 Scope

1 The requirements in this Chapter apply to the piping systems for ships carrying flammable liquid having flash point under 60 °C which have the following features **(1)** to **(3)**. The piping systems for other types of ships carrying flammable liquid will be considered by the Society on a case by case basis. The requirements given in this Chapter are to especially apply in lieu of the requirements given in **Chapter 13**.

(1) Crude oil, petroleum products having vapour pressures (absolute pressures) less than 0.28 *MPa* at 38 °C or other similar liquid cargo are carried.
(2) Machinery spaces and cargo oil tanks (including slop tanks; hereinafter, this definition applies throughout this Chapter) are arranged in accordance with the requirements given in **2.5.1-1**, **Part 9**.
(3) Cargo loaded by land facilities and unloaded by cargo oil pumps onboard ships.

14.1.2 Drawings and Data

Drawings and data to be submitted for approval are generally as follows:

(1) Piping diagrams of cargo oil pipes and instrumentation (with materials, dimensions, design pressures of pipes, valves, etc. and arrangements of devices to prevent any passage of flame).
(2) Control system diagrams (including safety and alarm systems) of integrated cargo and ballast systems driven by electrohydraulic power.
(3) Other drawings and data considered necessary by the Society.

14.2 Cargo Oil Pumps, Cargo Oil Piping Systems, Piping in Cargo Oil Tanks, etc.

14.2.1 Cargo Oil Pumps

1 Cargo oil pumps are to comply with the following requirements **(1)** to **(5)**:

(1) Pumps are to be designed to minimize the risk of sparking and oil leakage at seals.
(2) Stop valves are to be provided on the delivery sides of pumps. However, such stop valves may be omitted, provided that cargo oil pipes on the delivery sides of pumps are provided with stop valves in proper positions.
(3) In cases where relief valves are provided on the delivery sides of pumps, arrangements are to be such that all escaped oil is led to the suction sides of pumps.
(4) Pressure measuring devices are to be fitted on the delivery sides of pumps. In cases where pumps are driven by prime movers which are installed in spaces other than pump rooms, additional pressure measuring devices are to be fitted at suitable positions visible from control positions.
(5) The requirements given in **2.5.10(1)**, **Part 9**.

2 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.

3 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.

4 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, the discharge of bilge as stipulated in **14.3.1-2** or the discharge of ballast as specified in **14.3.2-2**.

14.2.2 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 sea suction pipes for ballast purposes are connected to cargo oil pipes, stop valves are to be provided between sea suction valves and cargo piping.

5 Slip-on joints used in cargo oil pipes are to comply with the requirements specified in **12.4.3**.

6 Sea suction pipes and the discharge pipes for permanent ballast tanks are not to be connected to sea 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. The following tanks and piping systems which are not permanently connected to the hull of the ship are to be connected to the hull of the ship by bonding straps:

(1) Cargo tanks which are electrically separated from the hull of the ship (*e.g.*, independent cargo oil tanks);

(2) Pipe connections which can be removed (*e.g.*, spool pieces); and

(3) Wafer-style valves with non-conductive (*e.g.*, PTFE) gaskets or seals.

8 The bonding straps specified in **-7** above are to comply with the following requirements **(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.

14.2.3 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.

14.2.4 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 **14.2.2**, **14.3.1** and **14.3.2**.

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 Notwithstanding the preceding **-5**, in the case of ships carrying flammable liquid other than double hull ships, 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.

14.2.5 Bulkhead Valves of Cargo Oil Piping Systems

1 Cargo oil pipes passing through oiltight bulkheads between cargo oil tanks and pump rooms are to be provided with stop valves as close to 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.

14.2.6 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.

14.2.7 Piping in Cargo Oil Tanks

1 Pipes other than cargo oil pipes, cargo oil heating pipes, ballast pipes of cargo tanks and pipes permitted in **-2** to **-4** are not to pass through cargo oil tanks, 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 Notwithstanding the preceding **-4**, in the case of ships carrying flammable liquid other than double hull ships, 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.

14.2.8 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.

14.2.9 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.

14.2.10 Thermal Oil Pipes

1 Thermal oil piping arrangements for cargo oil tanks are to comply with following requirements **(1)** to **(4)**:

(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 **13.9.4** are also to be applied.

2 Thermal oil temperatures in cargo areas are not to exceed 220 °C.

14.2.11 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:

(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.

14.3 Piping Systems for Cargo Oil Pump Rooms, Cofferdams and Tanks adjacent to Cargo Oil Tanks

14.3.1 Bilge Piping Systems, etc. for Cargo Oil Pump Rooms and Cofferdams adjacent to Cargo Oil Tanks

1 Bilge piping systems consisting of a power driven pump or eductor are to be provided to discharge bilge in cargo oil pump rooms and in cofferdams adjacent to cargo oil tanks. The bilge in these spaces is not to be led to the engine room.

2 Cargo oil pumps may be used for bilge drainage purposes specified in **-1** provided that each bilge suction is fitted with a screw-down non-return valve, and a stop valve or cock is fitted on the suction side of the pump. In addition, a stop valve is to be fitted between the cargo oil pipe and the overboard discharge valve.

3 Bilge pipes for cofferdams adjacent to cargo oil tanks are to be entirely separate from those for spaces not adjacent to cargo oil tanks. However, common bilge pumps (except cargo oil pump) may be used for the bilge drainage purposes of such spaces subject to Society approval, provided that the bilge pipes for such spaces not adjacent to cargo oil tanks have a non-return valves.

4 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.

14.3.2 Ballast Tanks adjacent to Cargo Oil Tanks

1 The requirements given in **14.3.2** 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 **29.1.2-2(3), Part C of the Rules for the Survey and Construction of Steel Ships**. 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 7.13.4(1)**), 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 **13.4.3**.

14.3.3 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.

14.4 Ships Only Carrying Oils Having Flashpoints above 60 °C

14.4.1 General

In the case of ships only carrying oils having flashpoints above 60 °C, the requirements given in **14.1** to **14.3** will be partially modified in accordance with the following **(1)** to **(3)**:

(1) The requirements given in **14.1.2** to **14.2.9** may be properly modified.

(2) Bilges of cargo oil pump rooms and cofferdams adjacent to cargo oil tanks may be led to engine rooms (*see* **14.3.1**).

(3) Ballast pipes of ballast tanks adjacent to cargo oil tanks may be led to engine rooms (*see* **14.3.2-2**).

14.5 Tests

14.5.1 Shop Tests

After the manufacture of any piping systems for ships carrying flammable liquid, tests are to be conducted in compliance with the requirements given in **13.15**.

Chapter 15 AUTOMATIC AND REMOTE CONTROL

15.1 General

15.1.1 Scope

1 The requirements in this Chapter apply to automatic or remote control systems which are used to control the following machinery and equipment for ships with the notation M0 specified in **1.3.3, Part 1**:

(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)**.

3 Computer based systems, including the hardware and software which constitute such systems, are to be in accordance with the requirements of **Annex D18.1.1, "COMPUTER BASED SYSTEMS "of Part D of the Rules for the Survey and Construction of Steel Ships** specified otherwise by the Society in addition to those specified in **-1** and **-2** above and throughout the rest of this Chapter for design, construction, commissioning, maintenance, etc.

4 The requirement in **-3** above is not applicable to equipment mentioned below:

(1) navigating equipment specified in the **Rules for Safety Equipment**,
(2) radio installations specified in the **Rules for Radio Installations**,
(3) stability instruments, and
(4) loading computers.

15.1.2 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 system is defined as a combination of interacting programmable devices and/or sub-systems organized to achieve one or more specified purposes.

(11) A computer based system is defined as a system which provides control, alarm, monitoring, safety or internal communication functions and depends upon software for the proper achievement of these functions.

(12) A sub-system is defined as an identifiable part of a system, which may perform a specific function or set of functions.

(13) A programmable device is defined as a physical component where software is installed.

(14) 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 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

15.1.3 Drawings and Data

Drawings and data to be submitted are generally, 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) Drawings and data for approval
  - (a) Drawings and data concerning automation
    - i) List of measuring points
    - ii) List of alarm points
    - iii) Control devices and safety devices
      - 1) List of controlled objects and controlled variables
      - 2) Kinds of control energy sources (self-actuated, pneumatic, electric, etc.)
      - 3) List of conditions for emergency stopping, speed reduction (automatic or demand for reduction), etc.
  - (b) The following drawings and data for the automatic control devices and remote control devices for main propulsion machinery or controllable pitch propellers
    - i) Operating instructions of main propulsion machinery such as starting and stopping, change-over of direction of revolution, increase and decreased of output, etc.
    - ii) Arrangements of safety devices (including those attached to engines) and pilot lamps
    - iii) Controlling diagrams

(c) Following drawings and data for the automatic control devices and remote control devices for boilers:
   i) Operating instructions of sequential control, feed water control, pressure control, combustion control and safety devices
   ii) Diagrams for automatic combustion control devices and automatic feed water control devices
(d) 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.)
(e) Panel arrangements of monitoring panels, alarm panels and control stands at respective control stations
(f) Drawings and data deemed necessary by the Society for computer based systems specified in **15.1.1-3**

(2) Drawings and data for reference
Drawings and data deemed necessary by the Society for computer based systems specified in **15.1.1-3**.

15.2 System Design

15.2.1 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.

15.2.2 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.

15.2.3 Environmental Conditions

Automatic or remote control systems are to be capable of withstanding the environmental conditions of the places where they are installed.

15.2.4 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:

(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.

15.2.5 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.

15.2.6 Safety Systems

1 Independence of safety systems

Independence 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 **15.2.5** 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.

15.2.7 Use of Computers

1 The reliability and maintainability of computer based systems are not to be inferior to those of systems not relying upon computers.

2 Control systems, alarm systems and safety systems which constitute computer based systems are to comply with the following **(1)** to **(3)**:

(1) Requirements for computers
  - (a) The composition of computers is to be so planned that the extent of impact on the system as a whole of any failure in any part of a circuit or component is to be minimized as far as possible.
  - (b) Each component is to be protected against any possibility of overvoltage (electronic noise) which may originate 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.

(2) 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 the case of computer failure. However, where this requirement is impracticable, relevant 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) Safety systems are to be provided with back-up means which can be used in a timely manner in the event of the failure of the computer in service.
    - i) Stand-by computer
    - ii) Safety systems that do not rely on computers
  - (c) In cases where visual display units (*VDU*) are adopted as indicators for the alarm systems stipulated in this Chapter, at least two *VDU*s are to be installed, or other arrangements deemed appropriate by the Society are to be considered.

(3) Independence

Independence of computerized control systems and safety systems is to comply with the requirements in **15.2.4-1** and **15.2.6-1** respectively, except in cases where their constitution are comply with requirements specified below.
  - (a) In cases where secondary control systems or stand-by computers are installed for those control systems, 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 **15.3.2-3(2)** are not regarded as secondary control systems.

(b) In cases where safety systems conform to the requirement given in **(2) (b)** above, the independence of individual machinery and equipment in systems, and their independence from other systems may not be required, notwithstanding the requirements in **15.2.6-1**.

(c) 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.

15.3 Automatic and Remote Control of Main Propulsion Machinery or Controllable Pitch Propellers

15.3.1 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 **15.3**.

15.3.2 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:

(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 speed. 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 maneuvering 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)** and **(4)**.

3 Failure of remote control systems of main propulsion machinery or controllable pitch propellers

The following requirements 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.

15.3.3 Bridge Control Devices

Bridge control devices are to comply with the following **(1)** through **(4)** as well as requirements in **15.3.2**.

(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 maneuvering platforms which are capable of controlling main propulsion machinery or controllable pitch propellers.

(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 **15.1.2(14)(b)** or **(c)** go into effect.

(4) Bridge control devices are to be provided with an override arrangement specified in **15.2.6-3** for the following safety systems of main propulsion machinery:
   (a) Safety systems which perform as specified in **15.1.2(14) (b)**
   (b) Safety systems which perform as specified in **15.1.2(14) (c)** (except in cases where the total failure of main propulsion machinery will occur within a short period of time.)

15.3.4 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:

(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:

(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" speed 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** or **4.3.1-1** are to be provided.

(4) In cases where there is fear that the speed of a propulsion motor would exceed 125 % of the rated speed 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** or **4.3.1-1** are to be provided.

(4) In cases where there is fear that the speed of the propulsion motor would exceed 125 % of the rated speed when the propeller pitch is altered, overspeed protective devices, deemed

appropriate by the Society, are to be provided.

15.4 Automatic and Remote Control of Boilers

15.4.1 General

1 Automatic control systems for both combustion and feed water of oil-fired, dual-fuel-fired, gas-fired and multi-fuel-fired boilers are to comply with the requirements in **15.4.2** to **15.4.5** respectively.

2 Automatic control systems for either combustion or feed water of oil-fired, dual-fuel-fired, gas-fired and multi-fuel-fired boilers are to comply with the relevant requirements in **15.4.2** or **15.4.3** as well as the requirements in **15.4.4** and **15.4.5**.

3 Automatic control of boilers other than oil-fired, dual-fuel-fired, gas-fired and multi-fuel-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 **9.8.8**.

15.4.2 Automatic Combustion Control Systems

1 General

Automatic combustion control systems are to comply with the following requirements:

(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.

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**.

15.4.3 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.

15.4.4 Safety Measures

1 Safety devices

Safety devices are to comply with the requirements in **9.8.10-1**.

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.

15.4.5 Alarms

Alarm devices are to comply with the requirements in **9.8.10-2**.

15.5 Automatic and Remote Control of Electric Generating Sets

15.5.1 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 **15.5**.

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.

15.5.2 Emergency Source of Electric Power

Automatic or remote control devices for diesel engines driving emergency generators are to comply with the following requirements:

(1) Alarm devices, to be activated in the event of any of the abnormal conditions given in **Table 7.15.1**, are to be provided.

(2) Devices referred to in **(1)** are to provide alarms at both local and navigation bridge. Visual alarms at navigation bridge may be of group indication.

(3) Each diesel engine with a maximum continuous output of 220 *kW* or over is to be provided with an overspeed protective device specified in **2.4.1-4**.

(4) When devices, other than those referred to in **(3)**, are provided to shutdown diesel engines, means are to be provided to override those devices automatically during navigation.

(5) The silencing of the audible alarms from navigation bridge is not to cause the silencing of the audible alarms at local positions.

Table 7.15.1 Alarms for Diesel Engines to Drive Emergency Generators

Monitored Variables		Alarms	Remarks
Temperature	L.O. inlet	H	Applicable to engines with maximum continuous output of 220 *kW* or over.
	Cooling water or air outlet	H	
Pressure	L.O. inlet	L	
	Cooling water inlet	L	Applicable to engines with maximum continuous output of 220 *kW* or over. Low flow may be accepted.
Others	Leakage from F.O. burning pipe, level in leakage trunk	○	
	Overspeed	○	Applicable to engines with maximum continuous output of 220 *kW* or over.

Note: "H" and "L" mean high and low. "○" means abnormal condition has occurred.

15.6 Automatic and Remote Control of Auxiliary Machinery

15.6.1 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.

15.6.2 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.

15.6.3 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 **15.4.2-1** and **-2**, also with **9.11.2-1** and **-2**.

(2) Safety devices

Safety devices are to comply with **9.11.1** and **9.11.2-5**.

(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.

15.6.4 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.

15.6.5 Opening and Closing Devices for Sea Valves

In cases where sea valves to be fitted on the shell plating below the load water line are remotely or automatically controlled, other opening and closing devices which can be easily operated even in the event of failure of such automatic or remote control devices are to be provided.

15.6.6 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.

15.6.7 Mooring Arrangements

In cases where mooring arrangements are provided with remote control devices, these mooring arrangements are to be capable of being locally operated.

15.6.8 Fuel Filling Arrangements

In cases where arrangements for filling fuel into their respective fuel tanks from outside of the ships (hereinafter referred to as "fuel filling arrangements" in this Part) are provided with remote control devices, the fuel 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.

15.6.9 Diesel Engines

1 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.
2 The requirements in **15.5.2** apply correspondingly to the automatic or remote control devices for emergency diesel engines other than those mentioned in **15.5.2**.

15.7 Tests

15.7.1 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.

15.7.2 Approval of Use

1 In cases where automatic devices and automatic equipment have passed the environmental tests specified in **15.7.1**, 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 **15.7.1(1)** may be omitted.

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 For the electrical installations of ships those to which the Society approval are given, the application of the requirements in this Part may partly be modified except in cases where requirements are specified for the protection against shocks, fire and any other hazards caused by electricity.

3 Ships which are intended to navigate in the threat sea area specified in **2.2.2**, **Part 1** are to comply with the requirements of **3.3**, **Part 1**.

1.1.2 Definitions

Terms used in this Part are defined as follows:

(1) "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.

(2) "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.

(3) "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.

(4) "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.

(5) "Preference tripping" are those arrangements such that protective devices for unessential circuits are opened automatically in order to ensure power supplies for those services specified in **3.2.1-2**, in cases where any one generator becomes overloaded or there are fears of overloading.

(6) "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.

(7) "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.
(8) "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.
(9) "Main generating stations" are those spaces in which main sources of electrical power are situated.
(10) "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. However, independent panel may be provided in other compartment which distributes more than half numbers of main switchboards load, (hereinafter referred to as "ward panel" in this Part).
(11) "Emergency sources of electrical power" are those sources of electrical power, intended to supply emergency loads , such as propulsion and steering system, safety of navigation, fire protection and flooding protection, interior and outboard communication equipment, signal equipment, escape equipment and emergency boat winch in any event of failure of supply from main sources of electrical power.
(12) "Emergency generators" are to supply electrical power to emergency switchboards in any event of failure of supply from main sources of electrical power.
(13) "Emergency switchboards" are those switchboards which in any event of failure of main electrical power supply systems are directly supplied by emergency sources of electrical power or transitional sources of emergency power and are intended to distribute electrical energy to emergency services.
(14) "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.*)

1.1.3 Ambient Conditions

The ambient conditions given in **3.1**, **Part 1** are to be applied, unless otherwise specified, to the design, selection and arrangement of electrical installations in order to ensure their proper operation.

1.1.4 Maintenance Records of Batteries

As for batteries fitted for use of the services necessary to provide normal operational conditions of propulsion and safety of the ship, maintenance records included necessary information required by the Society are to be kept on board.

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) Ship service generators (main, auxiliary and emergency)
(3) Main and emergency switchboards
(4) Motors for auxiliary machinery specified in **1.1.2-1(1)** to **1.1.2-1(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 **1.1.2-1(4)** and **1.1.2-1(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 **(5)** are to be subjected to type tests for each type of products.
(1) Fuses
(2) Circuit breakers
(3) Electromagnetic contactors
(4) Explosion-protected electrical equipment
(5) 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 **2.18**.

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. In cases where adopting electrical equipment and cables and system design of electrical installations which is not general maritime supplies but required to design and make by peculiar standards must be the standards approved by the Society.

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 rooms, 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.

(4) 15,000 *V a.c.* for *a.c.* generators and *a.c.* power equipment which meets the requirements given in **2.17**.

2 A frequency of 60 *Hz* is recognized as the standard for all alternating current systems. However, load operating in shore connecting condition which is supplied 50 *Hz* shore power is to act without trouble in 50 *Hz*.

3 Electrical equipment supplied from main and emergency 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 (1)

Type of fluctuation	Fluctuation (4)			
	Voltage		Frequency	
	Permanent	Transient	Permanent	Transient
60*Hz*	90〜106%	80〜120% (within 1.5 sec)	95〜105%	90〜110% (within 5 sec)
440*V*,400*Hz*	97〜103%	93〜108% (within 0.25 sec)	99.5〜100.5%	99〜101% (within 0.25 sec)
115*V*,400*Hz*	95〜105%	90〜110% (within 0.25 sec)	99.5〜100.5%	99〜101% (within 0.25 sec)

(b) Voltage fluctuations for *d.c.* distribution systems (2)

Type of fluctuation	Fluctuation (4)
Voltage fluctuation (Permanent)	±10 %
Voltage cyclic fluctuation deviation	5 %
Voltage ripple	10 %

(c) Voltage fluctuations for battery systems

Systems	Fluctuation [4]
Components connected to the battery during charging [3]	+30 %, -25 %
Components not connected to the battery during charging	+20 %, -25 %

Notes:

(1) *A.C.* distribution systems mean *a.c.* generator circuits and *a.c.* power circuits produced by inverters.

(2) *D.C.* distribution systems mean *d.c.* generator circuits and *d.c.* power circuits produced by converters.

(3) Different voltage fluctuations as determined by charging and discharging characteristics, including voltage ripples from the charging devices, may be considered.

(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, sea 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.

11 Ships required special impact resistance and vibration resistance in addition to impact and vibration in normal navigation are not to use materials and parts which are insufficient impact resistance and vibration resistance to these requirements. In cases where these are used unavoidably for insulating material are to take sufficient reinforcement and suspension.

12 Ships required to maintain self propulsion capability in fire are essentially not to use the materials and parts which are flammable and generating toxic gas in event of fire.

13 Hygroscopic materials and parts are not to be used. In cases where using unavoidably for insulating materials is to take moisture proof treatment.

14 Hazardous materials and parts are not to be used.

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.

4 Equipment required *EMI* protection are surely to be grounded by bond straps and metal contact between mounting foot and foundation surface. Shield wire of bulk shielded cable is to be taken in consideration to be all round grounding at cable inlet.

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

1 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 Notwithstanding the requirements given in **-1** above, hull return distribution systems may be used for the following systems:

(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.

2.2.2 Insulation Monitoring Systems

In cases where primary and secondary distribution systems with no connection to earth are used for power, heating or lighting, devices capable of monitoring insulation levels to earth and of giving audible or visual indications of abnormally low insulation values are to be provided.

2.2.3 Unbalance of Loads

1 In the case of three-wire direct current systems, any load unbalance between outer conductors and middle wires at switchboards, section boards and distribution boards is not to exceed 15 % of the full-load current as far as possible.

2 In the case of three-wire or four-wire three-phase alternating current systems, any load unbalance on each phase at the switchboards, section boards and distribution boards is not to exceed 15 % of the full-load current as far as possible.

2.2.4 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.

2.2.5 Feeder Circuits

1 Feeder circuit of ships operating in high threat sea area is to supply required electric power from the sources of electric power to the load and is to keep the required power supply in case of partial damage and failure in feeder circuit. Also damage control considerations are to be taken.

2 Motors for essential services requiring dual arrangements are to be supplied by individual circuits without any use of common feeders, protective devices and controlgears.

3 Auxiliaries in machinery spaces, cargo gears and ventilating fans are to be independently supplied from switchboards or distribution boards.

4 Ventilating fans for cargo holds as well as those for accommodation spaces are not to be supplied from the common feeder circuits.

5 Lighting circuits and motor circuits are to be arranged so that they are supplied independently from switchboards.

6 Final sub-circuits of ratings exceeding 15 *A* are not to supply more than one appliance.

2.2.6 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 1 *kW* or more.

2.2.7 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 15 *A* or less is not to exceed:

(1) 10 for those circuits up to 50 *V*

(2) 14 for those circuits from 51 *V* up to 130 *V*

(3) 24 for those circuits from 131 *V* up to 250 *V*

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 10 *A* 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 an emergency lighting circuit.
5 Emergency lighting circuits are to be in accordance with the requirements given in **3.3**.

2.2.8 Circuits for Internal Communication Systems and Navigational Aids

1 Essential internal communication and signal systems as well as navigational aids are to have completely self-sustaining independent circuits for ensuring the perfect maintenance of their functions as far as possible.
2 Cables for communication systems are to be arranged so that no induced interference is caused.
3 No switches are to be provided for feeder circuits of general alarm devices, except for operating switches. In cases where circuit breakers are used, suitable means are to be taken to prevent such breakers from being kept in "off" positions.

2.2.9 Circuits for Radio Installations

Feeder circuits for radio installations are to be arranged in accordance with the requirements of relevant international and national regulations.

2.2.10 Circuits for Electric Heating and Cooking Equipment

1 Each item of electric heating and cooking equipment is to be connected to separate final sub-circuits. However, up to 10 small electric heaters of an aggregate current rating not exceeding 15 *A* may be connected to a single final sub-circuit.
2 Electric heating and cooking equipment are to be controlled by multipole linked switches mounted in the vicinity of the equipment. However, small electric heaters connected to final sub-circuits of ratings not exceeding 15 *A* may be controlled by a single-pole switch.

2.2.11 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 Power receiving circuit is to contain terminals to facilitate satisfactory connections and circuit-breakers or isolating switches with fuses. Means are to be provided for checking phase sequences.
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.

2.2.12 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. In addition, isolation switches are to be clearly labelled in order to identify any electrical equipment they are connected with.

2.2.13 Remote Stopping of Ventilating Fans and Pumps

1 Remote stopping of ventilating fans and pumps is to comply with the requirements given in **3.2.1-2** and from **3.2.2-2** to **3.2.2-4**, **Part 9**.

2 In cases where fuses are used to protect a remote stopping circuit specified in **3.2.1-2** and **3.2.2-2** through **-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 followings 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:

Ten times the sum of the rated currents of any generators which are connected (including spares).

Three 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, is 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 *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 Load Shedding

1 To protect main generators against overloads, means are to be provided to disconnect any unessential loads automatically. In such cases, these means may consist of two or more stage trippings.

2 In addition to the preference tripping given in **-1** above, further preference tripping may be arranged subject to any conditions otherwise specified by the Society.

2.3.7 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 **3.2.7**, **Part 6** 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.

2.3.8 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.

2.3.9 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 **3.2.7**, **Part 6**.

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.

2.3.10 Protection of Lighting

Lighting circuits are to be protected against short-circuit and overload.

2.3.11 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.

2.3.12 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. Emergency batteries supplying essential services may have short-circuit protection only.

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 ±5 % of the maximum rated speed.

2 The characteristics of governors on prime movers driving emergency generators are that such governors be capable of maintaining speeds with the following limits:

(1) Momentary speed variations are not to exceed those values specified in **-1(1)** in cases where total emergency consumer loads are suddenly thrown off.

(2) Momentary speed variations are not to exceed those values specified in **-1(2)** and speeds are to return to within 1 % of final steady speeds in not more than 5 *seconds* in cases where total emergency consumer loads are suddenly thrown on. Furthermore, if it is difficult to meet the above requirements, the characteristics of such governors are to be as deemed appropriate by the Society.

(3) At all loads in ranges between no loads and total emergency consumer loads, any permanent speed variations are not to exceed those values specified in **-1(3)**.

3 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 **2.4.13-4** 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 **2.5.8-2**.

2.4.4 Modification of Limits of Temperature Rise

1 In cases where ambient temperatures exceed 45 °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 °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 °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 °C.

Table 8.2.2 Limits of Temperature Rise for Rotating Machines (Based on Ambient Temperatures of 45 °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 30 *seconds*
  (b) *A.C.* motors
    150 % of rated current for 2 *minutes*.
    However, in the case of *A.C.* motors having rated outputs exceeding 315 *kW* or rated voltages exceeding 1 *kV*, the load and time of excess current capability may be increased or decreased in consideration of use conditions and the like.
(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 three 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

2.4.8 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 shaft materials for rotating machines used for essential services are to be in compliance with the requirements given in **Part K of the Rules for the Survey and Construction of Steel Ships**. But small capacity machines and auxiliary machinery for cargo handling specified in **1.1.2-1(3)**, **Part 7** are to be in accordance with the standard 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 **5.2.2**, **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 (min^{-1})
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 8**, **Part 7**.

Table 8.2.3 Values of F_1

Bearing arrangements of rotating machines	Generators driven by steam or gas turbines, as well as those 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 500 *V* 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 *A.C.* Generators

1 Each *a.c.* generator, except self-excited compound-wound types, is 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 %. However, in the case of emergency generators such voltage limits may be within ± 3.5 %.

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 **2.4.14-3**), 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*. However, in the case of emergency generators, such voltage values may be increased to ± 4% in a period of not more than 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.

2.4.14 Shop Tests

1 Rotating machines are to be tested in accordance with the requirements given in this **2.4.14**. 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 **2.4.13-2** and **-3**. In the absence of precise information concerning the maximum values of any sudden loads when applying the requirement given in **2.4.13-3**, 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. However, the voltage regulation during transient conditions may be calculated values based upon the test records of identical type generators subject to the Society's permission.

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**. However, the duration of a steady short-circuit may be of any time delay which will be fitted in the tripping device for selective tripping where precise data showing such time delay is available in accordance with the following **(1)** and **(2)**. The manufacturer's simulation model for the generator and the voltage regulator may be used where this has been validated through tests of identical types of the same model.

(1) In order to provide sufficient information to the party responsible for determining the discrimination settings in the distribution system where the generator is going to be used, the generator manufacturer is to provide documentation showing the transient behavior of the short-circuit current upon a sudden short-circuit occurring when excited, and running at nominal speed.

(2) The influence of the automatic voltage regulator is to be taken into account, and the setting parameters for the voltage regulator are to be noted together with the decrement curve. Such a decrement curve is to be available when the setting of the distribution system's short-circuit protection is calculated. The decrement curve need not be based upon physical testing.

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) $E_x \leq 500\ V$	$10E_x$ (Minimum 1,500)
	$500\ V < E_x$	$2E_x + 4{,}000$
	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 ten times the resistance of the winding	$10E_x$ (Minimum 1,500, Maximum 3,500)
	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, ten times the resistance of the winding	$2E_y + 1{,}000$ (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	$2E_s + 1{,}000$
	b) In the case of motors to be reversed or braked by reversing the primary supply while the motor is running	$4E_s + 1{,}000$
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 (*MΩ*)
$Un \leq 250$	$2 \times Un$	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 Precautions for Operator Safety

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 50 V $d.c.$ or 50 V $a.c.$ 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 0.5 m 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 Busbars, circuit-breakers and other electrical appliances of main switchboards are to be arranged so that essential electrical equipment required to be installed in duplicate will not become simultaneously unusable as the result of a single fault.
2 In cases where main sources of electrical power are necessary for ship propulsion, main switchboards are to comply with the following requirements or are to be equivalent in performance thereto:
(1) Generator switchboards are to be provided for each generator, and those switchboards adjoining each other are to be partitioned by walls of steel or flame-retardant material.
(2) Main busbars are to be subdivided into at least two parts which are to be normally connected by circuit breakers or other approved means. So far as it is practicable, any connection of generating sets and other duplicated equipment are to be equally divided among such parts.
3 Cable entries of switchboards are to be so constructed that no ingress of water into the switchboard is permitted along such cables.
4 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. Section boards and distribution boards for emergency distribution circuits are, in principle, to be provided independently.
5 The enclosures are to be of robust construction and any materials used are to be incombustible and non-hygroscopic.
6 Insulating materials are to be durable, flame-retardant and non-hygroscopic.
7 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 °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.

8 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 45 *K* at ambient temperatures of 45 °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 Measuring Instruments for *a.c.* Generators

Ship service *a.c.* generator panels are at least to be provided with the instruments given in **Table 8.2.8**.

Table 8.2.8 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.

2.5.6 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 Wattmeters for use with *a.c.* generators which may operate in parallel are to be capable of indicating reverse power up to 15 % respectively.

2.5.7 Transformers for Instruments

The secondary windings of transformers for instruments are to be earthed.

2.5.8 Shop Tests

1 Switchboards are to be tested and inspected in accordance with the requirements given in this **2.5.8**. 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 8.2.9** 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 1 *MΩ* when tested with *d.c.* voltages of at least 500 *V*.

Table 8.2.9 Limits of Temperature Rise of Electrical Appliances for Switch Boards (Based on Ambient Temperatures of 45 °C)

Item and part			Limits of temperature rise (*K*)
Coils	Thermal class *A*		45
	Thermal class *E*		60
	Thermal class *B*		75
	Thermal class *F*		95
	Thermal class *H*		120
Contact pieces	Mass forms	Copper or copper alloys	40
		Silver or silver alloys	70
	Multilayer forms or Knife forms	Copper or copper alloys	25
Terminals for external cables			45
Metallic resistors	Moulded-case types		245
	Those other than moulded-case types	For continuous service	295
		For intermittent service	345
	Exhaust (approx. 25 *mm* above exhaust ports)		170

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 45 *K* at ambient temperatures of 45 °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 degrees 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 45 *K* at ambient temperatures of 45 °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 8.2.10** 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 15 *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 living quarters

(6) Filled portion of gas-filled appliances

Table 8.2.10 Minimum Clearances and Creepage Distances for Control Appliances

Rated insulating voltage (*V*) (*d.c* & *a.c.*)	Clearance (*mm*)						Creepage[3][4] (*mm*)					
	Less than 15 *A*[5]		15 *A* or over and 63 *A* or under[5]		Exceeding 63 *A*[5]		Less than 15 *A*[5]		15 *A* or over and 63 *A* or under[5]		Exceeding 63 *A*[5]	
	L-L[1]	*L-A*[2]	*L-L*[1]	*L-A*[2]	*L-L*[1]	*L-A*[2]	*a*	*b*	*a*	*b*	*a*	*b*
Not exceeding 60	2	3	2	3	3	5	2	3	2	3	3	4
Exceeding 60 and 250 or under	3	5	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 °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.

7 In cases where controlgears for motors of essential services installed in duplicate are built in grouped starter panels; busbars, appliances and others are to be arranged so that a single fault in any one of the appliances or circuits does not render all of the motors designated for the same use simultaneously unusable.

8 Transformers for power supplies to control circuits are to be provided to each motor or each group of motors incorporated in an apparatus.

9 Running indicators and overload alarms for those motors of steering gears are to comply with those requirements given in **3.2.7**, **Part 6**.

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 8.2.11**, except as separately specified in this Part.

Table 8.2.11 Limits of Temperature Rise of Controlgears for Motors
(Based on Ambient Temperatures of 45 °C)

Item and part				Limits of temperature rise (*K*)
Coils (air)	Thermal class *A*			60
	Thermal class *E*			75
	Thermal class *B*			85
	Thermal class *F*			110
	Thermal class *H*			135
	Thermal class *N*			155
Contact piece	Mass form	Continuous use over 8 *hours*	Copper or copper alloy	40
			Silver or silver alloy	70
		Switch on & off one attempt or more in about 8 *hours*	Copper or copper alloy	60
			Silver or silver alloy	70
	Multilayer form or knife form		Copper or copper alloy	35
Busbar and connecting conductor (bare or Thermal class *A* and higher)				60
Terminals for external cables				45
Metallic resistors	Moulded-case type			245
	Those other than moulded-case type		For continuous use	295
			For intermittent use	345
			For starter use	345
	Exhaust (approx. 25 *mm* above exhaust port)			170

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 **Table 8.2.11**.

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 1 *MΩ* 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. However, cables such as flexible cables, fibre-optic cables, etc. used for special purposes may be accepted provided they comply with relevant standards deemed appropriate by the Society 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 °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)**:

In cases where special reason for not applying this requirement is exist, cables provided they comply with relevant standards deemed appropriate by the Society or any equivalent thereto are able to exclude this application.

(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 or sheaths deemed appropriate by the Society 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 **2.9.14-3(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. Cables of ships operating in high threat sea area are to be Halogen reduction cable in fire and take consideration for preventing damage.

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)**. In cases where planned cables provided they comply with relevant standards deemed appropriate by the Society or any equivalent thereto, all or some of requirements given in this section may be replaced to planned cables specification.

(1) The current rating of cables for continuous service is not to exceed the values given in **Table 8.2.12**.

(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 8.2.12** by the following correction factor.

correction factor: $\sqrt{1.12/\left(1-exp(-ts/0.245/d^{1.35})\right)}$

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 8.2.12** by the following correction factor.

correction factor: $\sqrt{\frac{1-exp(-10/0.245/d^{1.35})}{1-exp(-4/0.245/d^{1.35})}}$

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 8.2.13** may be applied.

Table 8.2.12 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 8.2.13 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 and avoid laying in same compartment as far as possible.

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: 4*d* ($d \leq 25$ *mm*) or 6*d* ($d > 25$ *mm*)
(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 Precaution against Fire

1 Cables are to be installed so as to not impair any of their original flame retardant properties.

2 All cables for power, lighting, internal communications, signals and navigational aids of essential and emergency services are to be, as far as practicable, routed clear of high fire risk areas, such as casings of all machinery spaces of category *A,* kitchen, serving room with cooking equipment, sauna, paint store, locker room and pantry more than 4 squar meter, and store with storage facility of flammable liquids. In addition, cables connecting fire pumps to emergency switchboards are to be fire resistant types complying with standards deemed appropriate by the Society in cases where they pass through high fire risk areas. All such cables are to be, as far as practicable, run in such a manner as to preclude their being rendered unserviceable by any heating of bulkheads that may be caused by fires in adjacent spaces.

3 Where cables used for the services specified in the following **(1)** to **(11)**, including their power supplies, pass through high fire risk areas other than those which they serve, they are to be so arranged that a fire in any of these areas or zones does not affect the operation of the service in any other area or zone.
(1) General alarm systems
(2) Fire alarm systems
(3) Fixed fire-extinguishing systems and their medium release alarms
(4) Fire detection systems
(5) Control and power systems to power operated fire doors and status indication for all fire doors
(6) Control and power systems to power operated watertight doors and their status indication
(7) Emergency lighting
(8) Public address systems or other equivalent means of communication
(9) Remote emergency stop/shutdown of equipment specified in **2.2.13-1**
(10) Emergency fire pump
(11) Low location lighting systems

4 In addition to the requirements given in **-3** above, the installation of cables connected to emergency fire pumps is to comply with the following **(1)** and **(2)**:
(1) The cables are not to pass through machinery spaces containing main fire pumps or their respective power sources and prime movers; and
(2) The cables may pass through other high fire risk areas mentioned in **-3** above only if they are fire resistant types which comply with standards deemed appropriate by the Society, and run continuous through such areas so as to maintain fire integrity.

5 Interconnecting cables between generators and main switchboards are to be routed clear of fuel oil purifier spaces, above other generator engines and fuel oil purifiers except in any of the following **(1)** to **(3)**:

(1) Cables connected to multiple generators or main switchboards which are separated into at least two groups throughout their length as far apart as practicable;

(2) Fire resistant cables which comply with the standards deemed appropriate by the Society; or

(3) Cables protected by fire prevention measures deemed appropriate by the Society.

2.9.12 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.

2.9.13 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.

2.9.14 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.

2.9.15 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 (≥ 6 *mm*) 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.

4 Penetration through bulkheads and decks, which are to have some degree of fire integrity, is to be so effected as to ensure that such fire integrity is not impaired.

2.9.16 Mechanical Protection of Cables

1 Cable protections are to comply with follows. In cases where special reason for not applying this requirement is exist, cables provided they comply with relevant standards deemed appropriate by the Society or any equivalent thereto are able to exclude this application.

2 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 **2.9.14-3(4)**.

3 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 **2.9.14-3(4)**, even in those cases where such cables are protected by metal armour.

2.9.17 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 Drawing-in factors (those ratios of the sum of cross-sectional areas of the cables to internal cross-sectional areas of pipes) are not to exceed 0.4.

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.

2.9.18 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.

2.9.19 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.

2.9.20 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, flame-retardant and, in cases where necessary, fire-resisting properties of the cable.

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 8.2.14** during any continuous operation at rated outputs.

Table 8.2.14 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				

2.10.4 Modification of the Limits of Temperature Rise

1 In cases where ambient temperatures exceed 45 °C, limits of temperature rise are to be decreased by the difference from those values given in **Table 8.2.14**.
2 In cases where temperatures of primary coolants do not exceed 45 °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 °C, limits of temperature rise may be increased by the difference from those values given by **Table 8.2.14**. In such cases, ambient temperatures are not to be set below 40 °C.

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 5 *kVA* or more and three-phase 15 *kVA* or more: 2.5 %
Single phase less than 5 *kVA* and three-phase less than 15 *kVA*: 5 %

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.* 1,000 *V* 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 1,500 *V*.

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 500 *Hz*. 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 the guideline of large capacity batteries which is enacted by the Society and etc; 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 living quarters.

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 Equipment

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*. However, the requirement given in **2.12.4** is to apply to converters less than 5 *kW*, too.
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 cannot 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 Harmonic Filters

1 Where the electrical distribution system on board a ship includes harmonic filters, except when the filters are installed for single application frequency drives such as pump motors, the ship is to be fitted with facilities to continuously monitor the Total Harmonic Distortion (*THD*) value experienced on the main busbar as well as to alert the crew in cases where the value exceeds the upper limits given in **2.1.2-4**. The Total harmonic distortion (*THD*) value is to be recorded in the engine log book, but this reading may be logged electronically in cases where the engine room is provided with systems which automatically log such values.
2 The protection arrangements for harmonic filters specified in **-1** are to comply with the following requirements:
(1) Arrangements are to be provided to alert in the event of activation of the protection of a harmonic filter circuit.
(2) The protection of a harmonic filter circuit is to be arranged in conformity with the following requirements:
  (a) A harmonic filter is to be arranged as a three-phase unit with individual protection provided for each phase. The activation of the protection arrangement for a single phase is to result in automatic disconnection of the entire filter.
  (b) A current unbalance detection system independent of the overcurrent protection is to be provided to alert the crew in the case of current unbalance.
(3) Consideration is to be given to additional protection for individual capacitor elements, such as relief valves or overpressure disconnectors, in order to protect against damage from rupturing. This consideration is to take into account the type of capacitors used.

2.12.5 Shop Tests

1 Converters and their accessories are to be tested in accordance with the requirements in this **2.12.5**. 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 temperature rise for the interiors of converters is not to exceed manufacturer specified values and the temperature rise for the exteriors of converters (*e.g.*, the connecting parts of busbars and cables for switchboards as well as coils, contactors and resistors) is 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) = 1.5 EP_i + 1,000 (minimum 2,000 V)

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 100 V, minimum testing voltages may be 1,500 V. 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 1 *MΩ* when tested with *d.c.* voltages of at least 500 *V*.

2.13 Lighting Fittings (Including LED)

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 engine rooms 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 μF 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 15 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 thereto; furthermore, they are also to comply with the requirements given in this **2.16**.

2.16.2 Selection of Explosion-protected Construction

Constructions for explosion-protected electrical equipment used in hazardous areas on board ships are to be selected from the following explosion-protected types:

(1) Flameproof type
(2) Increased safety type
(3) Intrinsically safe type
    (a) Category '*ia*' intrinsically safe type
    (b) Category '*ib*' intrinsically safe type
(4) Pressurized protected type
(5) Encapsulation type
(6) Powder filling type
(7) Oil immersion type

2.16.3 Materials

1 Materials for explosion-protected constructions are to have adequate electrical, mechanical, thermal and chemical resistant properties against any environmental conditions as well as flammable gases or vapours (hereinafter referred to as "gases") at the installation locations of such electrical equipment.

2 Enclosures and outer fittings of portable appliances are to be made of materials which minimize the risk of sparks by friction, or are to have non-metallic strong covers with hanging straps.

3 Insulating compounds and sealing compounds used for integral parts of explosion-protected constructions are to be such that no harmful expansion, contraction, softening or cracking occurs such constructions are in service. In addition, any insulating compounds applied to bare live-parts are to be flame-retardant.

2.16.4 Construction

1 Glazed ports of lighting fittings as well as any inspection windows of other electrical apparatus whose constructions are flameproof types, increased safety types and pressurized protected types are, as a rule, to be provided with robust metallic guards.

2 In cases where gaskets are used with views to give watertightness to explosion-protected electrical equipment installed on weather decks and in other similar spaces, such gaskets are to be fitted so that no explosion-proof characteristics are impaired due to any gasket deterioration or breakage.

3 Leading-in parts of cables are to be of constructions suitable for ship cables. Consideration is to be given so that cables can be surely fixed at their leading-in parts, except in cases where such cables are installed in steel conduits.

4 Electrical equipment associated with intrinsically safe circuits and located in hazardous areas are in principle to consist of totally enclosed constructions.

5 Types of explosion-protected electrical equipment, those kinds of gases for which such equipment is designed and any other items deemed necessary by the Society are to be clearly indicated on the surface of such equipment.

2.16.5 Special Requirement

Explosion-protected electrical equipment is to be in accordance with any requirements otherwise specified by the Society for each explosion-protected construction specified in **2.16.2**.

2.17 High Voltage Electrical Installations

2.17.1 General

1 The requirements given in this **2.17** are to be applied to those high voltage electrical installations with system voltages above *a.c.* 1,000 *V* up to *a.c.* 15,000 *V*.

2 The high voltage electrical installations are to meet the requirements given in this **2.17** and also those in other applicable chapters of this Part.

2.17.2 Distribution

1 The following distribution systems **(1)** or **(2)** are considered as standard:

(1) Three-phase, three-wire, insulated systems

(2) Three-phase, three-wire, neutral earthed systems

- (a) High-impedance earthing
- (b) Low-impedance earthing
- (c) Direct earthing

2 In the case of three-wire insulated systems, high voltage equipment is to be able to withstand

any transient over-voltages which may arise from earth-faults.
3 In the case of three-wire neutral earthed systems, high voltage equipment is to be able to withstand earth-fault currents. In cases where means are provided for limiting earth-fault currents, such means are not to influence selective tripping of fault circuits.
4 In the case of three-wire neutral earthed systems, it is to be assured that at least one source neutral to ground connection is available whenever such systems are in energized modes.
5 All earthing resistors are to be connected to the hull. Earthing methods are to be considered in order to eliminate any possible interference with radio, radar and communication circuits.

2.17.3 Construction and Location

1 High voltage electrical equipment is to be manufactured in accordance with standards deemed appropriate by the Society, whose ambient temperature may be subject to consideration by the **3.1.1, Part 1** when necessary, and to comply with the requirements in this **2.17.3**.
2 High voltage electrical equipment is to be protected so that the operators are not accidentally able to come in contact with the live parts of the equipment.
3 High voltage electrical equipment or entrances to key-locked spaces in which the equipment are installed are to be marked in an easily visible place so as to identify them as high voltage electrical installations.
4 High voltage electrical equipment is to be of construction to facilitate leading of cables, preparation of cable ends, and connection of cables, and also to prevent any accidental contact between high and low voltage circuits.
5 In the case of rotating machines, transformers and reactors, effective means are to be provided to prevent the accumulation of moisture and condensation within such machines especially in cases where they are idle for appreciable periods.
6 In cases where generators are run with neutrals interconnected, such generators are to be suitably designed to avoid any excessive circulating currents.
7 In the case of generators used in three-wire neutral earthed systems, means to disconnect are to be fitted in neutral earthing connections of each generator so that the generator may be disconnected for maintenance and for insulation resistance measurements.
8 To ensure safety of operation, a passageway that has a width of at least 1 *m* is to be arranged in front of each high voltage switchboard. Where access to the rear of a switchboard is needed for purposes of operation or maintenance, a passageway of sufficient width allowing such access is to be provided.
9 For generators with cooling systems that use auxiliary power, interlocks are to be provided. These interlocks are to disconnect the generator for all other systems in either of the following cases:
(1) In cases where the auxiliary power fails.
(2) In cases where temperature detectors, which sound an alarm when the generator stator windings reach their maximum rated temperature, indicate a temperature of 110 % of the maximum rated temperature.
10 Rotating machines are to be provided with temperature detectors in their stator windings to actuate visual and audible alarms in normally attended positions whenever temperatures exceed their permissible limits.
11 In cases where rotating machines are provided with water-air heat exchangers, they are to be double tube types. Visual and audible alarms in normally attended positions are to be given to monitor cooling water leakage.
12 Higher voltage terminals are never to be combined with lower voltage terminals in the same box, unless measures are taken to ensure that access to lower voltage terminals can be obtained without danger.
13 The degree of protection applying to enclosures of high voltage electrical equipment is to be

deemed appropriate by the Society.

14 High voltage switchboards and control boards are to be of an enclosed type and the high voltage sections are to be equipped with doors that are either locked by key or some other equivalent means.

15 Earthing conductors are to be provided for high voltage electrical equipment. These conductors are to be properly connected to the earthing system of the equipment and satisfy the following:

(1) be made of copper.

(2) the cross-section area is to be at least 35 mm^2.

(3) the current density does not exceed 150 A/mm^2 when an earth fault occurs.

16 High voltage switchboards are to comply with the requirements given in **2.5.3-1** and **2.5.3-2** of this chapter regardless of whether power is being fed to the propulsion system. In such cases, for neutral earthed systems, means of earthing are to be provided for each section. If two separate switchboards are provided and interconnected by cables, circuit breakers are to be provided at each end of such cables.

17 Each high voltage circuit in high voltage switch boards and control boards is to be fitted with means of earthing and short-circuiting for safe maintenance work. An adequate number of portable earthing and short-circuiting devices may be used as an alternative method.

18 In high voltage switchboards and control boards, an adequate separation is to be provided between lower voltage circuits and higher voltage circuits, in order to prevent the operators from touching the live parts of higher voltage circuits accidentally.

19 Circuit-breakers are to be withdrawable types or their equivalent provided with means or arrangements for permitting safe maintenance while the busbars are live.

20 Withdrawable circuit breakers and switches are to be provided with mechanical locking facilities at both in-service and withdrawn positions. For safe maintenance, withdrawable circuit breakers, switches and fixed disconnectors are to be capable of being locked by key or some other equivalent means.

21 Fixed contacts of withdrawable circuit breakers and switches are to be arranged so that live contacts are automatically covered at withdrawn positions by shutters. Shutters are to be clearly marked using colours or labels to indicate whether they are for incoming and outgoing circuits.

22 If electrical energy or physical energy is required for the operation of circuit breakers, switches and the like, a store supply of such energy is to be provided for at least two operations of all the components. If stored electrical energy sources are necessary for the tripping due to overload, short-circuit or under-voltage, alarms which activate upon any discontinuity in release circuits and power supply failures are to be provided.

23 The air clearances (phase-to-phase, pole-to-pole and phase-to-earth) of the non-insulated busbars of high voltage switchboards and control boards, and the air clearances of high voltage control equipment are not to be less than the values given in **Table 8.2.15**. When difficulty arises in meeting the above requirements, the measures deemed appropriate by the Society are to be adopted.

24 The air clearances of high voltage electrical equipment other than the equipment specified in **-23** and the creepage distances of all high voltage electrical equipment are not to be less than the values deemed appropriate by the Society.

25 Control circuits are to be separated from main circuits by partitions insulated with flame-retardant material.

26 The secondary winding of current and voltage transformers for control circuits is to be earthed. In this case, the earthing conductor is to be of copper and have a minimum cross-section area of 4 mm^2.

27 For forced-ventilated transformers, the running condition of the ventilators and the temperature of the cooling air are to be monitored.

28 For transformers using a heat exchanger equipped with a closed circuit cooling method, the temperature sensors are to be provided so as to monitor the cooling air temperature. Transformers, particularly those employing a water forced-cooled system, are also to be provided with leakage monitoring devices and fitted so that leakage-water and condensed moisture are kept away from the transformer windings.
29 High voltage switchboards and control boards are to be internal arc classified in accordance with *IEC* 62271-200. In cases where they are accessible by authorized personnel only, *Accessibility Type A* is sufficient. *Accessibility Type B* is required if they are accessible by non-authorized personnel.
30 The installation and location of high voltage switchboards and control boards, including their clearance to the ceiling (deckhead), are to correspond with its internal arc classification and classified sides (front, lateral and rear).

Table 8.2.15 Minimum Air Clearances

Rated voltage (*V*)	Non-insulated busbars (*mm*)	High voltage control equipment (*mm*)
above 1,000 and 3,600 or below	55	30
above 3,600 and 7,200 or below	90	60
above 7,200 and 12,000 or below	120	100
above 12,000	160	--

2.17.4 Protective Devices, etc.

1 Fuses are not to be used for overload protection.
2 In order to protect a generator from any internal malfunctions and from any electrical failures between the generator and its circuit breakers, differential protection relays are to be provided.
3 Excitation systems of generators are to be designed so that faulty generators can be de-excited automatically.
4 In order to prevent any problems of over voltage, protective devices are to be provided for the temperature sensor circuits of the windings that are fitted to rotating machines.
5 Circuit-breakers are generally to be used for short-circuit protection at primary sides of transformers.
6 In cases where transformers are arranged in parallel, any tripping of those protective devices at their primary sides is to be automatically followed by the tripping of those switches connected at their secondary sides.
7 Oil immersed transformers are to be provided with the following alarms and safety devices.
(1) Alarms for low oil level and high oil temperature
(2) Stopping or load reducing devices for low oil level and high oil temperature
(3) Stopping devices for high gas pressure
8 In cases where single consumers, such as bow thrusters or others, are supplied directly at higher voltages via step-up transformers, transformers may be protected at their lower-voltage sides.
9 Protective measures are to be taken to prevent any problems of short circuit in both the primary and secondary sides of voltage-transformers used for control circuits. However, these protective measures may be omitted in cases where any power loss causes a critical condition in any related system.
10 Low voltage circuits fed through step-down transformers from high voltage circuits are to be protected so that there is no chance of any overlapping between the high voltage and low voltage circuits.
11 Devices capable of indicating any earth faults in systems by means of visual and audible alarms are to be provided.
12 In low impedance neutral earthed systems or direct neutral earthed systems, provisions are to

be made to automatically disconnect any faulty circuits. High impedance neutral earthed systems, in cases where outgoing feeders are not isolated in the case of earth faults, are to be capable of withstanding transitional over voltages caused by earth faults.

2.17.5 Cables

1 High voltage cables are to have metallic sheaths or metallic armour. In cases where high voltage cables having neither metallic sheaths nor metallic armour are used, they are to be protected by metallic ducts or pipes or electrically conductive non-metallic ones complying with the requirements specified in **2.9.14-3(4)** throughout their entire length. These ducts or pipes are to be ensured of their electrical continuity with earthings.

2 High voltage cables associated with different voltages are not to be run in the same ducts or pipes. These cables may be run on the same trays if they are fixed by individual clips and isolated from each other at distances of at least the air clearances of those non-insulated busbars (for the higher voltage cable) given in the **Table 8.2.15**.

3 High voltage cables are to be installed as far apart as possible from lower voltage cables and such cables are be laid in places not liable to suffer from mechanical damage. These cables are not to be run on or in the same trays, ducts or pipes.

4 In cases where practicable, high voltage cables are not to be run through accommodation spaces. In cases where it is necessary to run these accommodation spaces, they are to be installed for their entire length in enclosed cable pipes.

5 The terminal ends of high voltage cables and the connecting parts for high voltage cables are to be made of materials that will not negatively impact the overall integrity of the cable as well as be sufficiently protected by insulation in order to prevent, as much as is practically possible, any electrical accidents.

6 When the conductors inside of a terminal box are not insulated, sufficiently insulated shields are to be provided to ensure proper phase-to-phase and phase-to-earth separation.

7 High voltage cables are to be appropriately marked or color-coded to ensure easy identification.

2.17.6 Testing

1 High voltage electrical equipment and cables are to be tested in accordance with all applicable requirements of **Part 8**. High voltage test, however, is also to comply with the following requirements in this **2.17.6**.

2 Internal arc fault tests on high voltage switchboards and control boards, in accordance with the standards deemed appropriate by the Society, are to be carried out at the place of manufacturer, etc. However, the subsequent testing of identical units of the same series may be omitted subject to the approval of the Society.

3 The following high voltage tests on high voltage electrical equipment and cables are to be carried out at the place of manufacturer, etc.:

(1) Test voltages for high voltage switchboards and control boards of the following values.
Rated voltages above 1,000 *V* and 3,600 *V* or below: 10,000 *V*
Rated voltages above 3,600 *V* and 7,200 *V* or below: 20,000 *V*
Rated voltages above 7,200 *V* and 12,000 *V* or below: 28,000 *V*
Rated voltages above 12,000 *V*: 38,000 *V*

(2) Test voltages for high voltage transformers of the following values.
Maximum voltages above 1,000 *V* and 1,100 *V* or below: 3,000 *V*
Maximum voltages above 1,100 *V* and 3,600 *V* or below: 10,000 *V*
Maximum voltages above 3,600 *V* and 7,200 *V* or below: 20,000 *V*
Maximum voltages above 7,200 *V* and 12,000 *V* or below: 28,000 *V*
Maximum voltages above 12,000 *V*: 38,000 *V*

(3) At least five impulses are to be applied to the stator coils for high voltage rotating machines. The peak value of the test voltage is $\sqrt{6}$ *times* the rated voltage.
(4) Test voltages for high voltage cables of the following values.
Rated voltages above 1,000 *V* and 3,600 *V* or below: 6,500 *V*
Rated voltages above 3,600 *V* and 7,200 *V* or below: 12,500 *V*
Rated voltages above 7,200 *V* and 12,000 *V* or below: 21,000 *V*
Rated voltages above 12,000 *V*: 30,500 *V*

4 High voltage cables, after installation on board, are to be confirmed as having no abnormalities by testing them with the voltage in direct current (*d.c.*) equal to 4 *times* the rated voltage U_0 for a period of 15 *minutes*. However, in the case of cables with a rated voltage U_0/U above 1.8/3 *kV* (U_m=3.6 *kV*), alternative testing procedures, in lieu of that specified above, may be accepted by the Society.

In such cases, U_0, U and U_m means as follows:

U_0 : The rated power-frequency voltage between the phase conductor and the ground or metallic screen for which the cable is designed
U : The rated power-frequency voltage between phase conductors for which the cable is designed
U_m: The maximum value of the “highest system voltage” for which the equipment may be used

2.18 Tests after Installation On Board

2.18.1 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 8.2.16**.

2 Insulation resistance of internal communication circuits is to comply with the following **(1)** to **(3)**. In such cases, any or all appliances connected thereto may be disconnected.
(1) In the case of circuits of 100 *V* 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 *MΩ*.
(2) In the case of circuits below 100 *V*, insulation resistance is to be at least 1/ 3 *MΩ*.
(3) All electrical equipment in circuits may be removed in above tests (1) and (2).

3 The insulation resistance of generators and motors under working temperatures is to be those values specified in **Table 8.2.6**.

Table 8.2.16 Minimum Insulation Resistance

Rated voltage *Un* (*V*)	Minimum test voltage (*V*)	Minimum insulation resistance (*MΩ*)
$Un \leq 250$	2 × *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

Note:
During the above tests, any or all electric heaters, small appliances and the like which are connected may be disconnected from any circuits.

2.18.2 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** and **2.4.13**:

(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 requirements **(1)** and **(2)**:

(1) 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.

(2) Emergency lighting circuits are to be tested in the same manner specified in **(1)** above.

5 Electric heaters, electric cooking ranges and the like are to be tested to demonstrate that their heating elements function satisfactorily.

6 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.

2.18.3 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, emergency 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 emergency 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 Main 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. Such main sources of electrical power are to consist of at least two generating sets.

2 The capacities of these generating sets specified in **-1** above are to be such that in the event of any one generating set being stopped it will still be possible to supply those services necessary to provide normal operational conditions of propulsion and safety. A minimum of comfortable conditions of habitability is also to be ensured which includes at least adequate services for cooking, heating, domestic refrigeration, mechanical ventilation, sanitary and fresh water.

3 In cases where main sources of electrical power are necessary for the propulsion and steering of ships, systems are to be arranged so that electrical supplies to equipment necessary for propulsion and steering and to ensure ship safety will be maintained or immediately restored in cases where there is the loss of any one of the generators in service.

4 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.

5 Generating sets are to be such as to ensure that with any one generator or its primary source of power out of operation, the remaining generating sets are to be capable of providing the electrical services necessary to start main propulsion plants from a dead ship condition. Emergency sources of electrical power may be used for the purpose of starting from a dead ship condition if its capability either alone or combined with that of any other sources of electrical power is sufficient to provide at the same time those services required to be supplied by the requirements given in **3.3.2-2(1)** to **(4)**.

3.2.2 Number and Ratings of Transformers

In cases where transformers constitute an essential part of those electrical supply systems required by **3.2.1**, such systems are to be arranged so as to ensure the same continuity of supply as is stated in **3.2.1**.

3.2.3 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 Main electric lighting systems is to be arranged so as not to be impaired in the event of fire or any other causality in those spaces containing emergency sources of electrical power, associated transforming equipment, emergency switchboards and emergency lighting switchboards.

3 Emergency lighting is to provide sufficient illumination necessary for safety in the following locations:

(1) At muster and embarkation stations as required by the Paragraph 4, Regulation 11, Chapter III, the Annex to the *SOLAS* Convention;

(2) In all service and accommodation alleyways, stairways and exits, personnel lift cars and personnel lift trunks;

(3) In machinery spaces and main generating stations including their control positions;

(4) In all control stations, machinery control rooms, and at main and emergency switchboards;

(5) It all stowage positions for firemen's outfit;

(6) At the steering gears;

(7) At those fire pumps referred to in **3.3.2-2(5)**, at sprinkler pumps, if any, and at emergency bilge pumps, if any, as well as at the starting positions of their motors; and

(8) In cargo pump rooms for ships carrying flammable liquids intended for carrying in bulk any liquid cargo having flash point not exceeding 60 °C.

4 Those emergency electric lighting systems specified in **-3** above, those emergency electric lighting systems required by Paragraph 7, Regulation 16, Chapter III, the Annex to the *SOLAS* Convention, as well as navigation lights and any other lights specified in **3.3.2-2(3)** are to be arranged so as not to be impaired in the event of fire or other causality in those spaces containing main sources of electrical power, associated transforming equipment, main switchboards and main lighting switchboards.

3.2.4 Location of Main Switchboards

Main switchboards and main generating stations are to be located in the same spaces. However, main switchboards may be separated from generators by environmental enclosures, such as may be provided by machinery control rooms situated within the main boundaries of such spaces.

3.3 Emergency Sources of Electrical Power

3.3.1 General

1 Self-contained emergency sources of electrical power are to be provided. In cases where multiple main sources of electrical power are separately arranged for avoiding simultaneous damage by fire or flooding provided these are permitted by the society to be the equivalent thereto and the higher to comply with this section requirements they comply with this section requirements, one main source of electrical power set may be used as emergency power source to other main source. Object main source of electrical power is to comply with this section requirement for emergency source of electrical power.

2 Emergency sources of electrical power, associated transforming equipment, transitional sources of emergency electrical power, emergency switchboards and emergency lighting switchboards are to be located above uppermost continuous decks and are to be readily accessible from open decks. In cases where areas are able to avoid simultaneous damage with main source of electrical power by fire or flooding, above requirement may be waived. They are not to be located forward of collision bulkheads, except, under exceptional circumstances, in cases where permitted by the Society.

3 Locations of emergency sources of electrical power, associated transforming equipment, transitional sources of emergency electrical power, emergency switchboards and emergency lighting switchboards are to be such as to ensure, to the satisfaction of the Society, that fire or other casualty in those spaces containing main sources of electrical power, associated transforming equipment, and main switchboards, or in any machinery spaces of category *A* will not interfere with the supply, control and distribution of emergency electrical power. As far as practicable, those spaces containing emergency sources of electrical power, associated transforming equipment, transitional sources of emergency electrical power and emergency switchboards are not to be contiguous to the boundaries of machinery spaces of category *A*, or to those spaces containing main sources of electrical power, associated transforming equipment and main switchboards.

4 Provided that suitable measures are taken for safeguarding independent emergency operations under all circumstances, emergency generators may be used in non-emergency cases for short periods of time to supply to non-emergency circuits.

3.3.2 Capacities of Emergency Sources of Power

1 Any available electrical power is to be sufficient to supply all those services that are essential for safety in emergencies, with due regard being paid to such services which may have to be operated simultaneously.

2 Emergency sources of electrical power are to be capable, having regard for starting currents and the transitory nature of certain loads, of supplying simultaneously at least the following services for those periods specified hereinafter, if they depend upon electrical sources for operation:

(1) For a period of 3 *hours*, the emergency lighting specified in **3.2.3-3(1)** and the emergency lighting required by the Paragraph 7, Regulation 16, Chapter III, the Annex to the *SOLAS* Convention.

(2) For a period of 18 *hours*, the emergency lighting specified in **3.2.3-3(2)** to **(8)**.

(3) For a period of 18 *hours*, those navigation lights and other lights required by the International Regulations for Preventing Collisions at Sea in force as well as those lights required by the National Regulations of those countries to which ships are registered.

(4) For a period of 18 *hours*:

- (a) All internal communication equipment as required during emergencies;
- (b) *VHF* radio installations, *MF* radio installations, *INMARSAT* Ship Earth Stations and *MF*/*HF* radio installations as required by Chapter IV, the Annex to the *SOLAS* Convention and installed on ships. However, in cases where these radio installations are installed in duplicate, it is not necessary to consider duplicated installations are operated simultaneously in determining the capacities of emergency sources of electrical power;
- (c) Those navigational aids, which require electrical sources, as required by Regulation 19 and 20, Chapter V, the Annex to the *SOLAS* Convention;
  In cases where such provision is unreasonable or impracticable, this requirement may be waived for those ships of less than 5,000 *estimated gross tonnage*;
- (d) Fire detection and fire alarm systems; and
- (e) Intermittent operation of daylight signaling lamps, the ship whistles, manual fire alarms as well as all internal signals required during emergencies
  Unless such services have independent supplies for a period of 18 *hours* from accumulator batteries suitably located for use during emergencies.
- (f) All navigation equipment required by 9.3.2.2, Part I-A of *MSC*.385(94) *International Code for Ships Operating in Polar Waters (Polar Code)*, as amended.
- (g) Gyrocompass for INMARSAT direct-printing telegraphy and INMARSAT telephone, which is provided in addition to gyrocompass required by Regulation 19, Chapter V, the Annex to the *SOLAS* Convention.

(5) For a period of 18 *hours*, fire pumps designed so as to depend upon emergency generators by those requirements given in **10.2.2-3**, **Part R of the Rules for the Survey and Construction**

of Steel Ships.

(6) For the period of time required by **3.2.6**, **Part 6**, steering gears in cases where it is required to be so supplied.

(7) For a period of 30 *minutes*, indications showing whether closing means are opened or closed and audible alarms showing that such closing means are operating as required by **4.3.2**, **Part 6**.

(8) For a period of 3 *hours*, intermittent operation of means to bring stabilizer wings inboard and indicators to show their positions, as required by Paragraph 9, Regulation 16, Chapter III, the Annex to the *SOLAS* Convention.

(9) For a period of 3 *hours*, intermittent operation of secondary launching appliances of free-fall lifeboats as required by Paragraph 6.1.4.7, Chapter VI of the International Life-Saving Appliances (*LSA*) Code.

(10) In those ships engaged regularly in voyages of short durations, the Society, if satisfied that an adequate standard of safety would be attained, may accept a lesser period than those 18 *hours* period specified from **(2)** to **(5)** above, but not less than 12 *hours*.

3 In cases where electrical sources are necessary to restore propulsion, capacities of emergency sources of power shall be sufficient to restore propulsion to ships from dead ship conditions within a period of 30 *minutes* after a blackout.

3.3.3 Kind and Performance of Emergency Sources of Electrical Power

Emergency sources of electrical power are to be either generators or accumulator batteries or uninterruptible power systems, which are to comply with the following:

(1) In cases where emergency sources of electrical power are generators, they are to comply with the following:

(a) Emergency generators are to be driven by suitable primemovers with independent supplies of fuel, having a flashpoint (closed cup test) of not less than 43 °C;

(b) Emergency generators are to be automatically started upon the failure of any main sources of electrical power supplies unless transitional sources of emergency electrical power in accordance with the following **(c)** are provided; in cases where emergency generators are automatically started, they are to be automatically connected to emergency switchboards; those services referred to in the requirements given in **3.3.4** are then to be automatically connected to emergency generators; and

(c) Transitional sources of emergency electrical power as specified in **3.3.4** are to be provided unless emergency generators are provided capable both of supplying those services mentioned in **3.3.4** and of being automatically started and supplying any required loads as quickly as is safe and practicable for a maximum period of 45 *seconds*. In cases where emergency generator is driven by gas turbine and it is approved by the Society, this requirement may be excluded.

(2) In cases where emergency sources of electrical power are accumulator batteries, they are to be capable of:

(a) Carrying emergency electrical loads without recharging while maintaining battery voltages throughout discharge periods within 12 % above or below nominal voltages;

(b) Automatically connecting to emergency switchboards in the event of the failure of any main sources of electrical power; and

(c) Immediately supplying at least those services specified in paragraph **3.3.4**.

(3) In cases where emergency generators are uninterruptible power systems, refer to **3.3.3(3)**, **Part H of the Rules for the Survey and Construction of Steel Ships**.

3.3.4 Transitional Sources of Emergency Electrical Power

Transitional sources of emergency electrical power, in cases where required by **3.3.3(1) (c)**, are to consist of accumulator batteries suitably located for use in emergencies which are to conform to the following **(1)** and **(2)**:

(1) Operate without recharging while maintaining battery voltages throughout discharge periods within 12 % above or below nominal voltages; and

(2) Be of sufficient capacities and be arranged so as to automatically supply in the event of the failure of either main or emergency sources of electrical power, for a period of a half an hour, at least the following services if they depend upon electrical sources for their operation:

  (a) Lighting required by **3.3.2-2(1)** to **(3)**. For this transitional phase, the required emergency electric lighting, in respect of machinery spaces and accommodation and service spaces may be provided by permanently fixed, individual, automatically charged, relay operated accumulator lamps; and

  (b) All services required by **3.3.2-2(4) (a)**, **(d)** and **(e)**, unless such services have independent supplies for those periods specified from accumulator batteries suitably located for use during emergencies.

3.3.5 Location, etc. of Emergency Sources of Electrical Power

1 Emergency switchboards are to be installed as near as is practicable to emergency sources of electrical power.

2 In cases where emergency sources of electrical power are generators, emergency switchboards are to be located in the same spaces unless the operation of such emergency switchboards would thereby be impaired.

3 No accumulator batteries fitted in accordance with this **3.3** are to be installed in the same spaces as emergency switchboards.

4 Indicators are to be mounted in suitable places on main switchboards or in machinery control rooms to indicate when batteries constituting either those emergency sources of electrical power or those transitional sources of electrical power referred to in the requirements given in **3.3.3(2)** or **3.3.4** are being discharged.

5 Interconnector feeders connecting emergency switchboards and main switchboards are to conform to the following **(1)** to **(3)**:

(1) They are to be adequately protected at main switchboards against any overloads and short circuits;

(2) They are to disconnect automatically at emergency switchboards upon the failure of main sources of electrical power; and

(3) They are to be protected at emergency switchboards at least against short circuits in cases where systems are arranged for feedback operations. In addition, emergency switchboards are to be supplied during normal operation from main switchboards.

6 Arrangements are to be made in cases where necessary to automatically disconnect non-emergency circuits from emergency switchboards to ensure that electrical power shall be automatically available to emergency circuits.

3.3.6 Provisions for Testing

Emergency electrical systems are to be provided with measures for periodic testing. Such periodic testing is to include the testing of automatic starting arrangements.

3.4 Starting Arrangements for Emergency Generating Sets

3.4.1 General

1 Emergency generating sets are to be capable of being easily started from a cold condition at a temperature of 0 °C. If this is impracticable, or if lower temperatures are likely to be encountered, provisions acceptable to the Society are to be made for the maintenance of heating arrangements, to ensure easy starting of such generating sets.

2 Each emergency generating set arranged to be automatically started is to be equipped with starting devices approved by the Society which have a stored energy capability of at least three consecutive starts. Sources of such stored energy are to be protected to prevent any critical depletion by automatic starting systems, unless secondary independent means of starting are provided. In addition, secondary sources of energy are to be provided for an additional three starts within a period of 30 *minutes* unless manual starting can be demonstrated to be effective.

3 Stored energy is to be maintained at all times as follows:

(1) Electrical and hydraulic starting systems are to be maintained from emergency switchboards;

(2) Compressed air starting systems may be maintained by main or auxiliary compressed air reservoirs through suitable non-return valves or by emergency air compressors which, if electrically driven, are supplied from emergency switchboards; and

(3) All of these starting, charging and energy storing devices are to be located in emergency generator spaces; furthermore, these devices are not to be used for any purpose other than the operation of emergency generating sets. However, this does not preclude the supply of air to those air reservoirs of emergency generating sets from main or auxiliary compressed air systems through those non-return valves fitted in emergency generator spaces.

4 In cases where automatic starting is not required, manual starting, such as manual cranking, inertia starters, manually charged hydraulic accumulators, or powder charge cartridges, is permissible in cases where it can be demonstrated as being effective.

5 In cases where manual starting is not practicable, starting arrangements are to comply with requirements **-2** and **-3** above. However, starting may be manually initiated.

3.5 Steering Gear

3.5.1 General

See **Chapter 3**, **Part 6**.

3.6 Navigation Lights, Other Lights, Internal Signals, etc.

3.6.1 Navigation Lights

1 Navigation lights are to be connected separately to navigation light indicator panels.

2 Each navigation light is to be controlled and protected in each insulated pole by switches with fuses or circuit breakers fitted on navigation light indicator panels.

3 Navigation light indicator panels are to be supplied power by separate circuits from main switchboards or those secondary busbars of transformers connected to them and from emergency switchboards or those secondary busbars of transformers connected to them respectively. Such circuits are to be separated as far apart as practicable throughout their length.

4 Switches and fuses are not to be provided on feeder circuits of navigation lights, except for those of switchboards and indicator panels.

5 Navigation light indicator panels are to be placed in accessible positions on navigation bridges.

6 In cases where the event of failure of navigation lights due to bulb blown and short-circuit, etc., visual and audible alarms are to activate on navigation light indicator panels. That alarm devices are to be fed from the main sources or emergency sources (or reserve sources) of power and that their feeder circuits are to be independent of the feeder circuits from navigation light indicator panels to navigation lights.

3.6.2 Not under Command Lights and Anchor Lights

Not under command lights and anchor lights are to be supplied power from both main sources of electrical power and emergency sources of electrical power.

3.6.3 Signal Lights

Signal lights are to be supplied power from both main sources of electrical power and emergency sources of electrical power.

3.6.4 General Emergency Alarm Systems

Those general emergency alarm systems specified in Regulation 50 as well as public address systems or those other suitable means of communication specified in Paragraph 4.2, Regulation 6, Chapter III, the Annex to the *SOLAS* Convention are to be supplied power from both main sources of electrical power and emergency sources of electrical power.

3.6.5 On-board Communication Systems

Those on-board communication systems specified in Paragraph 4.1, Regulation 6, Chapter III, the Annex to the *SOLAS* Convention are to be supplied power from electrical source(s) suitably located for use during emergencies.

3.7 Lightning Conductors

3.7.1 General

Lightning conductors are to be fitted on each mast of ships having wooden masts or topmasts.

3.7.2 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 Ω.

3.8 Spare Parts, Tools and Instruments

3.8.1 Spare Parts

1 In the case of rotating machines and controlgears intended for electric propulsion plants, the types and quantities of spare parts specified in **Table 8.3.1**, **Table 8.3.3** and **Table 8.3.5** are to be provided.

2 In the case of ship service generators, motors of important use and their controlgears and switchboards, the types and quantities of spare parts specified in **Table 8.3.1** to **Table 8.3.5**, so far as applicable, are recommended, as a standard, to be provided.

3 The quantities required by **-1** and **-2** above are the number of spare parts for all totally identical installations per ship.

4 In the case of steering gear motors and motor-generators, if no stand-by machines are installed; those spare parts specified in **Table 8.3.2** are to be provided in addition to any spare parts for motors enumerated in **Table 8.3.1**.

5 In cases where voltages of emergency lighting circuits are different from those of general service, 1 spare for each 2 lamps are to be provided

Table 8.3.1 Spare Parts for Generators, Exciters and Motors

Spare parts	Number required
Bearing or bearing linings including oil ring	1 for each 4 or less
Brushholders	1 for each 10 or less
Brushholder springs	1 for each 4 or less
Brushes	1 for each 1
Field coils for *d.c.* machines except for uninsulated inter-pole coils	1 for each 10 or less
Resistors for field rheostat and discharge resistors for generators and exciters	*See* **Table 8.3.5**
Armatures of cargo winch *d.c.* motors	1 for each 6 or more motors
Stators of cargo winch *a.c.* cage-rotor motors	1 for each 6 or more motors
Rotors of cargo winch *a.c.* wound-rotor motors	1 for each 6 or more motors
Slip-rings for electric propulsion machines	1 for each kind and size

Table 8.3.2 Additional Spare Parts for Steering Gear Motors without Stand-by Motors or Motor-generators

Spare parts	Number required
Armatures of *d.c.* motors and motor-generators	1 for each size (complete with shafts and couplings)
Stators of *a.c.* cage-rotor motors	1 for each size
Rotors of *a.c.* wound-rotors motors	1 for each size (complete with shafts and couplings)

Table 8.3.3 Spare Parts for Control Gear

Spare parts	Number required
Contact pieces (arcing or wear parts)	1 set for each 2 sets of less
Springs	1 for each 4 or less
Operating and shunt coils	1 for each 10 or less
Resistors of each kind and size	1 for each 10 or less
Fuses and their elements	*See* **Table 8.3.5**
Lamp lenses and bulbs	*See* **Table 8.3.5**

Table 8.3.4 Spare Parts for Brakes

Spare parts	Number required
Shoe linings and rivets	1 set for each 4 or less
Springs	1 for each 4 or less
Coils	1 for each 10 or less

Table 8.3.5 Spare Parts for Switchboards, Section Boards and Distribution Boards

Spare parts	Number required
Fuses (non-renewable)	1 for each, but need not exceed 20 in total
Fuses (renewable)	1 for each 10, but need not exceed 10 in total
Fuse elements of renewable fuses	1 for each
Arcing contacts	1 for each, but need not exceed 10 in total
Springs	1 for each, but need not exceed 10 in total
Complete trip element assembly, where interchangeable tripelements are used for moulded case thermal type circuit-breakers	1 for each 10 identical trip elements or less
Complete moulded case thermal type circuit-breakers, where non-interchangeable trip elements are used	1 for each group of 10 identical breakers or less
Potential coils	1 for each rating and type
Resistors	1 for each rating and type
Lenses of pilot and signal lamps	1 for each 10 identical lenses or less
Lamps of pilot and signal lamps	1 for each

3.8.2 Testing Instruments

In the case of ships having electrical installations of 50 *kW* and above, 500 *V* insulation resistance meters are to be provided in order that such insulations may be tested at regular intervals. In addition, the following portable instruments are to be provided:

(1) One portable voltmeter, *a.c*. or *d.c*., or both as required.

(2) One portable ammeter, *a.c*. or *d.c*., or both as required. These are to have shunts or current transformers as required.

3.8.3 Disassembling Tools

In cases where special tools are required to adjust or disassemble equipment, one set such tools are to be provided.

3.8.4 Storage and Packing

All spare parts, instruments and tools are to be packed in suitable wooden boxes or corrosion-protected steel boxes. Such boxes are to be clearly marked on their surface regarding their contents and are to be placed in suitable places. In cases where lockers are provided to store these spare parts, individual boxes may be omitted.

Chapter 4 ELECTRICAL INSTALLATIONS FOR SHIPS CARRYING FLAMMABLE LIQUIDS

4.1 General

4.1.1 Scope

Electrical installations for those ships or cargo spaces carrying special cargoes as specified in the following **(1)** to **(3)** are to comply with the requirements in this Chapter, in addition to those requirements in any other relevant Chapters in this Part.

(1) Ships carrying flammable liquids having flash point not exceeding 60 °C
(2) Enclosed cargo holds for motor vehicles with fuel in their tanks for their own propulsion and enclosed compartments adjoining enclosed cargo holds
(3) Ships carrying dangerous goods

4.2 Ships carrying Flammable Liquids

4.2.1 General

Electrical equipment for Ships carrying Flammable Liquids is to comply with this chapter as well as the requirements in **Chapter 4**, **Part R of the Rules for the Survey and Construction of Steel Ships**.

4.2.2 Distribution Systems

1 Notwithstanding those requirements given in **2.2.1-1**, 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 those requirements given in **-1** above, hull return distribution systems may be used for those systems listed in **2.2.1-2(1)** to **(3)**.

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.

4.2.3 Hazardous Areas

1 Hazardous areas for Ships carrying Flammable Liquids are to be categorized in accordance with those requirements given in **4.3.1**, **4.4.1** and **4.5.1**.

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

4.2.4 Electrical Installations in Hazardous Areas

1 Electrical installations are not to be installed in hazardous areas unless such installations are essential 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 '*Exia*' 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 '*Exib*' 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 or cargo compressor room, 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 into Zone 0 are to be provided with the following measures:

(1) Circuits other than intrinsically-safe circuits are to be automatically disconnected or are to be prevented from being energized in the event of abnormally low levels of insulation resistance or 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 or cargo compressor 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.

4.2.5 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 for ships carrying flammable liquids 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.

4.2.6 Ventilation

1 Ventilators installed in cargo pump rooms or cargo compressor 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 and cargo compressor rooms.

2 The ventilators specified in **-1** above for ships carrying flammable liquids are to be ones that do not to produce any source of ignition in compliance with the requirements given in **2.5.4-1(1), Part 9**.

3 The ventilation air change ratios in cargo pump rooms for ships carrying flammable liquids are to comply with the requirements given in **2.5.4-1(1), Part 9**.

4 Ventilation ducts, air intakes and exhaust outlets serving artificial ventilation systems are to be positioned in accordance with standards deemed appropriate by the Society.

4.2.7 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.

4.3 Ships Carrying Flammable Liquids Having a Flashpoint Not Exceeding 60 °C

4.3.1 Classification of Hazardous Areas

The following areas or spaces in Ships carrying Flammable Liquids 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 ships) 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, 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 ships 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 ships 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

4.4 Ships Carrying Flammable Liquids having a Flashpoint Exceeding 60 °C and Cargoes which are Heated to Temperatures more than 15 °C lower than their Flashpoint

4.4.1 Classification of Hazardous Areas

Those areas or spaces in ships carrying flammable liquids having a flashpoint exceeding 60 °C and cargoes which are heated to temperatures more than 15 °C lower than their flashpoint are to be classified in accordance with those requirements specified in **4.3.1**.

4.5 Ships Carrying Flammable Liquids having a Flashpoints Exceeding 60 °C and Cargoes which are not Heated or Heated to Temperatures less than 15 °C lower than their Flashpoint

4.5.1 Classification of Hazardous Areas

The following areas or spaces in ships carrying flammable liquids having a flashpoint exceeding 60 °C and cargoes which are not heated or heated to temperatures less than 15 °C lower than their flashpoint are to be classified as Zone 2:

(1) Cargo tanks and slop tanks
(2) Interior of pipes for pressure-relief or venting systems for cargo and slop tanks
(3) Interior of cargo pipes

4.6 Enclosed Cargo Holds for Carrying Motor Vehicles with Fuel in their Tanks for their own Propulsion and Enclosed Compartments Adjoining the Cargo Holds, etc.

4.6.1 Electrical Installations in Enclosed Cargo Holds, etc.

Enclosed cargo holds for the carriage of motor vehicles with fuel in their tanks for their own propulsion, etc. are to comply with those requirements given in **20.3**, **Part R** of the Rules for the Survey and Construction of Steel Ships.

4.6.2 Electrical Installations in Cargo Holds for Carriage of Motor Vehicles with Compressed Natural Gas in their Tanks for their own Propulsion

Cargo holds of vehicle carriers defined in **3.2.54**, **Part R** of the Rules for the Survey and Construction of Steel Ships for carriage of motor vehicles with compressed natural gas in their tanks for their own propulsion are to comply with those requirements given in **20A.3**, **Part R of the Rules for the Survey and Construction of Steel Ships**.

4.6.3 Electrical Installations in Cargo Holds for Carriage of Motor Vehicles with Compressed Hydrogen in their Tanks for their own Propulsion

Cargo holds of vehicle carriers defined in **3.2.54**, **Part R of the Rules for the Survey and Construction of Steel Ships** for carriage of motor vehicles with compressed hydrogen in their tanks for their own propulsion are to comply with those requirements given in **20A.4**, **Part R of the Rules for the Survey and Construction of Steel Ships**.

4.7 Special Requirements for Ships Carrying Dangerous Goods

4.7.1 General

Electrical installations for ships carrying dangerous goods are to comply with those requirements given in **Chapter 10**, **Part 9** as well as any of the relevant requirements in this Part.

Chapter 5 ADDITIONAL REQUIREMENTS FOR ELECTRIC PROPULSION PLANTS

5.1 General

5.1.1 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.

5.1.2 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 **4.3.1-1** or **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.

5.2 Propulsion Electrical Equipment and Cables

5.2.1 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.
3 Propulsion electrical equipment and cables connected to circuits with propulsion semiconductor convertors are to be designed in consideration of the additional heating contribution caused by the harmonics generated by such circuits.

5.2.2 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 all 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 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.

3 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

4 In cases where the coolers of propulsion motors fail, but restricted service is to be possible.

5 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. In this case, the power output of the remaining shafts may be limited as long as manoeuvrability is maintained under all weather conditions.

6 In cases where the temperature rise for the windings of propulsion motors mentioned above in **5.2.3-3** exceed design allowance values, means of decreasing nominal propulsion power are to be provided.

5.2.3 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, air filters, water-cooled heat exchangers, 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-cooled heat exchangers are adopted, additional leakage monitoring systems are to be provided.

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*).

9 Regenerated power which may occur when reversing operation of ship from full ahead to full astern or from full astern to full ahead is carried out is to be limited by the control system in order to protect generators from overspeed or reverse power. However, the requirement does not apply in cases where external means such as a braking resistor is provided to absorb excess amounts of regenerated energy and to reduce the speed of the propulsion motor.

5.2.4 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.

5.2.5 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 **1.2.2**, **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 Failures of semiconductor elements and harmonic filter installed in propulsion semiconductor convertors are to be monitored at all times. Harmonic filter protection circuits are to be fail-safe.

5.2.6 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 primary and secondary sides. However, it is acceptable to only protect the primary side provided that overcurrent protection is arranged on the secondary side.

7 High voltage propulsion transformers are to be provided with differential protection relays to protect the primary side (high voltage busbar side), except in cases where other means deemed equivalent to such relays are provided instead.

5.2.7 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)

5.3 Composition of Electrical Equipment for Propulsion and Electrical Power Supply Circuits

5.3.1 Composition of Electrical Equipment for Propulsion and Auxiliary Machinery for Propulsion

1 Means are to be provided to ensure that the installations or equipment mentioned in the following **(1)** to **(5)** 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**.

5.3.2 Electrical Power Supply Circuits

1 Electrical equipment or installations, in duplicate, in accordance with the requirements given in **5.3.1-1** 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 through out 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 **1.2.2**, **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 500 kW, 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.

Part 9 FIRE SAFETY

Chapter 1 GENERAL

1.1 General

1.1.1 Application

1 Construction and arrangement for fire protection, means of escape and extinction are to be in accordance with those specified in this Part, except that, piping systems for fire-fighting and fire-fighting appliances for Helicopter Facilities are to comply with relevant place of the requirements of **Part 6**. In the application of **Part R of the Rules for the Survey and Construction of Steel Ships** in this Part, "*gross tonnage*" is read as "*estimated gross tonnage*" and "*tanker*" is read as "*ships carrying flammable liquids*".

2 Construction and arrangement for fire protection adopting the requirements of **6.1.1-1** are to apply the requirements of **Chapter 9**, **Part R of the Rules for the Survey and Construction of Steel Ships**. Regardless of the requirements of **Chapter 9**, **Part R of the Rules for the Survey and Construction of Steel Ships**, construction and arrangement for fire protection applied the requirements of **6.1.1-2** are to be deemed appropriate by the Society.

3 Ships for which registrations will be made with class notation "*EFS*" affixed in accordance with the provisions of **1.2.12-3**, **Part 1** are to be in accordance with the requirements in **6.1.2-3** and **6.1.2-4**.

4 Construction and arrangement for fire protection and means of escape for ships carrying liquefied gases in bulk applicable to **Part N of the Rules for the Survey and Construction of Steel Ships** and ships carrying dangerous chemicals in bulk applicable to **Part S of the Rules for the Survey and Construction of Steel Ships** are to be in accordance with the requirements in **Part N** and **Part S of the Rules for the Survey and Construction of Steel Ships**, except where specially required in this Part.

5 Where liquid cargoes other than liquid having a flashpoint not exceeding 60 ℃ (hereinafter referred to as "flammable liquids") and petroleum products having a flashpoint not exceeding 60 ℃ and a Reid vapour pressure which is below the atmospheric pressure or other liquid products having a similar fire hazard or liquefied gases are intended to be carried, additional safety measures are to be required, having due regard to the provisions of **Part N** and **Part S of the Rules for the Survey and Construction of Steel Ships**, as appropriate.

6 Flammable liquids for which a regular foam fire-fighting system complying with the requirements of **Chapter 34**, **Part R of the Rules for the Survey and Construction of Steel Ships** is not effective, is to be considered to be a cargo introducing additional fire hazards in this context. The following additional measures are required:

(1) the foam are to be of alcohol resistant type;

(2) the type of foam concentrates for use in chemical tankers are to be to the satisfaction of the Society;

(3) the capacity and application rates of the foam extinguishing system are to comply with the requirements of **Chapter 11**, **Part S of the Rules for the Survey and Construction of Steel Ships**, except that lower application rates may be accepted based on performance tests.

(4) for ships fitted with inert gas systems, a quantity of foam concentrate is to be sufficient for 20 *minutes* of foam generation.

7 Liquid cargoes with a vapour pressure greater than 0.1013 *MPa* (1.013 *bar*) absolute at 37.8 ℃ is to be considered to be a cargo introducing additional fire hazards. Ships carrying such substances are to comply with **15.14** of **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** of **Part S of the Rules for the Survey and Construction of Steel Ships**.

8 Liquid cargoes with a flashpoint above 60 °C other than oil products or liquid cargoes subject to the requirements of **Part S of the Rules for the Survey and Construction of Steel Ships** may be considered to constitute a low fire risk, not requiring the protection of a foam extinguishing system complying with the requirements of **Chapter 34**, **Part R of the Rules for the Survey and Construction of Steel Ships**.

9 Ships carrying liquid cargoes with a flashpoint above 60 °C are to comply with the requirements provided in **10.2.1-4(4)** and **10.10.2-2**, **Part R of the Rules for the Survey and Construction of Steel Ships** and the requirements for cargo ships other than ships carrying flammable liquids, except that, in lieu of the fixed fire extinguishing system required in **7.8**, they are to be fitted with a fixed deck foam system which is to comply with the provisions of **Chapter 34**, **Part R of the Rules for the Survey and Construction of Steel Ships**. In addition, for ships over 2,000 *estimated gross tonnage*, they are to comply with the requirements of **7.8.1**.

1.1.2 Equivalency

Alternative construction, equipment, arrangement and materials may be accepted by the Society, provided that the Society is satisfied with their equivalency to those required in this Part in accordance with the requirements of **Chapter 12**.

1.1.3 National Requirements

With respect to the construction and arrangement for fire protection, means of escape and extinction, attention is to be paid to compliance with the International Convention and the National Regulation of the country in which ships registered, in addition to the requirements in this Part. The Society may apply special requirements as instructed by the flag-government of ships or the government of sovereign nation in which ships navigate.

1.2 Basic principles

1.2.1 Fire Safety Objectives

The fire safety objectives of this Chapter are to:

(1) prevent the occurrence of fire and explosion;
(2) reduce the risk to life caused by fire;
(3) reduce the risk of damage caused by fire to the ship, its loaded goods on board, and the environment;
(4) contain, control and suppress fire and explosion in the compartment of origin; and
(5) provide adequate and readily accessible passages / stations on deck just below bulkhead deck and means of escape.

1.2.2 Functional Requirements

1 In order to achieve the fire safety objectives in **1.2.1**, the following functional requirements are stipulated in the regulations of this Part:

(1) division of the ship into main vertical zones and horizontal zones by thermal and structural boundaries;
(2) separation of accommodation spaces from the remainder of the ship by thermal and structural boundaries;
(3) restricted use of combustible materials;
(4) detection of any fire in the zone of origin;
(5) containment and extinction of any fire in the space of origin;

(6) protection of means of escape and passages / stations on deck just below bulkhead deck for fire-fighting ;
(7) ready availability of fire-extinguishing appliances; and
(8) minimization of possibility of ignition of flammable liquids vapour.

2 The fire safety objectives set out in **1.2.1** are to be achieved by ensuring compliance with the prescriptive requirements specified in **Chapters 2** to **11**, or by alternative design and arrangements which comply with **Chapter 12**. A ship is to be considered to meet the functional requirements in **-1** and to achieve the fire safety objectives set out in **1.2.1** when one of the following **(1)** to **(3)** In the case of any of **(1)** to **(3)**, class notation is affixed according to the provisions of **1.2.12-3**, **Part 1**:
(1) the ship's design and arrangements, as a whole, comply with the relevant prescriptive requirements in **Chapters 2** to **11**;
(2) the ship's design and arrangements, as a whole, have been reviewed and approved in accordance with **Chapter 12**; or
(3) part(s) of the ship's designs and arrangements have been reviewed and approved in accordance with **Chapter 12** of this Part and the remaining parts of the ship comply with the relevant prescriptive requirements in **Chapters 2** to **11**.

1.3 Definitions

1.3.1 General

For the purpose of this Part, unless expressly provided otherwise, the following definitions are to apply.

1.3.2 Fire Safety Systems Code

Fire Safety Systems Code (*FSS* Code) means the International Code for Fire Safety Systems as adopted by the Maritime Safety Committee (hereinafter referred to as "*MSC*") of the International Maritime Organization (hereinafter referred to as "*IMO*") by resolution *MSC*.98(73), 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.

1.3.3 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.

1.3.4 International Maritime Solid Bulk Cargoes Code

International Maritime Solid Bulk Cargoes Code (*IMSBC* Code) means the International Maritime Solid Bulk Cargoes Code as adopted by the *MSC* of the *IMO* by resolution *MSC*. 268(85), 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.

1.3.5 International Maritime Dangerous Goods Code

International Maritime Dangerous Goods Code (*IMSBC* Code) means the International Maritime Dangerous Goods as adopted by the *MSC* of the *IMO* by resolution *MSC*. 122(75), 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.

1.3.6 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 *FTP* Code.

1.3.7 "*A*" Class Divisions

"*A*" class divisions are those divisions formed by bulkheads and decks which comply with the following criteria. In addition, the materials, details and arrangements of "*A*" class divisions and the means of affixing the insulation used on board ships are to be consistent with the detail drawings referred to on the Certificate of Approval for Fire Protection Material:

(1) they are to be constructed of steel or other equivalent material;

(2) they are to be suitably stiffened;

(3) they are to be insulated with approved non-combustible materials such that the average temperature of the unexposed side will not rise more than 140 °C above the original temperature, nor will the temperature, at any one point, including any joint, rise more than 180 °C above the original temperature, within the time listed below:

class "*A* - 60" 60 *minutes*
class "*A* - 30" 30 *minutes*
class "*A* - 15" 15 *minutes*
class "*A* - 0" 0 *minute*

(4) they are to be constructed as to be capable of preventing the passage of smoke and flame to the end of the one-hour standard fire test; and

(5) they are to be ensured by a test of a prototype bulkhead or deck in accordance with the *FTP* Code to ensure that it meets the above requirements for integrity and temperature rise, and to be approved by the Society or organizations deemed appropriate by the Society.

1.3.8 "*B*" Class Divisions

"*B*" class divisions are those divisions formed by bulkheads, decks, ceilings or linings which comply with the following criteria:

(1) they are to be constructed of approved non-combustible materials and all materials used in the construction and erection of "*B*" class divisions are non-combustible, with the exception that combustible veneers may be permitted provided they meet other appropriate requirements of this chapter;

(2) they are to have an insulation value such that the average temperature of the unexposed side will not rise more than 140 °C above the original temperature, nor will the temperature at any one point, including any joint, rise more than 225 °C above the original temperature, within the time listed below:

class "*B* - 15" 15 *minutes*
class "*B* - 0" 0 *minute*

(3) they are to be constructed as to be capable of preventing the passage of flame to the end of the first half hour of the standard fire test; and

(4) they are to be ensured by a test of a prototype deck in accordance with the Fire Test Procedures Code to ensure that it meets the above requirements for integrity and temperature rise, and to be approved by the Society or organizations deemed appropriate by the Society.

1.3.9 "*C*" Class Divisions

"*C*" class divisions are divisions constructed of approved non-combustible materials. They need meet neither requirements relative to the passage of smoke and flame nor limitations relative to the temperature rise. Combustible veneers are permitted provided they meet other requirements of this Part.

1.3.10 Low Flame Spread

Low flame spread means that the surface thus described will adequately restrict the spread of flame, this being approved by the Society or organizations deemed appropriate by the Society in accordance with the Fire Test Procedures Code.

1.3.11 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).

1.3.12 Fire Damper

Fire damper is, for the purpose of **9.7**, **Part R of the Rules for the Survey and Construction of Steel Ships**, a device installed in a ventilation duct, which under normal conditions remains open allowing flow in the duct, and is closed during a fire, preventing the flow in the duct to restrict the passage of fire. Fire dampers are classified as follows:

(1) Automatic fire damper is a fire damper that closes independently in response to exposure to fire products;
(2) Manual fire damper is a fire damper that is intended to be opened or closed by the crew by hand at the damper itself; and
(3) Remotely operated fire damper is a fire damper that is closed by the crew through a control located at a distance away from the controlled damper.

1.3.13 Furniture and Furnishings of Restricted Fire Risk

Furniture and furnishings of restricted fire risk are furniture and furnishings of restricted fire risk in which:

(1) case furniture such as desks, wardrobes, dressing tables, bureaux, dressers, are constructed entirely of approved non-combustible materials, except that a combustible veneer not exceeding 2 *mm* may be used on the working surface of such articles;
(2) free-standing furniture such as chairs, sofas, tables, is constructed with frames of non-combustible materials;
(3) draperies, curtains and other suspended textile materials have qualities of resistance to the propagation of flame not inferior to those of wool of mass 0.8 kg/m^2, this being approved by the Society or organizations deemed appropriate by the Society in accordance with the *FTP* Code;
(4) floor coverings have low flame spread characteristics;
(5) exposed surfaces of bulkheads, linings and ceilings have low flame-spread characteristics;
(6) upholstered furniture has qualities of resistance to the ignition and propagation of flame, this being approved by the Society or organizations deemed appropriate by the Society in accordance with the *FTP* Code; and
(7) bedding components have qualities of resistance to the ignition and propagation of flame, this being approved by the Society or organizations deemed appropriate by the Society determined in accordance with the *FTP* Code.

1.3.14 Vehicle Spaces

Vehicle spaces are cargo spaces intended for carriage of motor vehicles etc. with fuel in their tanks for their own propulsion.

1.3.15 Ro-ro Spaces

Ro-ro spaces are spaces not normally subdivided in any way and normally extending to either a substantial length or the entire length of the ship in which motor vehicles with fuel in their tanks for their own propulsion and/or goods (in or on rail or road cars, vehicles (including road or rail tankers), trailers, containers, pallets, demountable tanks or in or on similar stowage units or other receptacles) can be loaded and unloaded normally in a horizontal direction.

1.3.16 Open Ro-ro Spaces

Open ro-ro spaces are those ro-ro spaces that are either open at both ends or have an opening at one end and are provided with adequate natural ventilation effective over their entire length through permanent openings distributed in the side plating or deck head or from above, having a total area of at least 10 % of the total area of the space sides.

1.3.17 Open Vehicle Spaces

Open vehicle spaces are those vehicle spaces either open at both ends, or have an opening at one end and are provided with adequate natural ventilation effective over their entire length through permanent openings distributed in the side plating or deckhead or from above, having a total area of at least 10% of the total area of the space sides.

1.3.18 Special Category Spaces

Special category spaces are those enclosed vehicle spaces above and below the bulkhead deck, into and from which vehicles can be driven and to which passengers have access. Special category spaces may be accommodated on more than one deck provided that the total overall clear height for vehicles does not exceed 10 m.

1.3.19 Control Stations

Control stations are those spaces in which the ship's radio or main navigational equipment (controls for steering gears, gyro compass, radar etc.), battery 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.

1.3.20 Main Vertical Zones

Main vertical zones are those sections into which the hull, superstructure and deckhouses are divided by "A" class divisions, the mean length and width of which on any deck does not in general exceed 40 m.

Chapter 2 PROBABILITY OF IGNITION

2.1 General

2.1.1 Functional Requirements

1 The purpose of this Chapter is to prevent the ignition of combustible materials or flammable liquids or goods loaded in hazardous areas. For this purpose, the following functional requirements are to be met:

(1) means are to be provided to control leaks of flammable liquids;
(2) means are to be provided to limit the accumulation of flammable vapours;
(3) the ignitability of combustible materials are to be restricted;
(4) means are to be provided to limit the retention of evolved gas in the hazardous area;
(5) ignition sources are to be restricted;
(6) ignition sources are to be separated from combustible materials, flammable liquids and hazardous areas; and
(7) the atmosphere in cargo tanks is to be maintained out of the explosive range.

2 With respect to the design and fabrication of pipes, valves and pipe fittings, the requirements of **Part 6** are to apply, in addition to the requirements in this Part.

2.2 Arrangements for Oil Fuel, Lubrication Oil and Other Flammable Oils

2.2.1 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;
    (e) filling pipes and sounding pipes of fuel oil tanks are to be of permanently fixed ones led above the weather deck;
    (f) sounding rod is to be of non-ferrous metal material;
    (g) sounding device is to be so located that tank sounding can readily be taken at a place near the filling connection;
    (h) the fuel oil is not to be heated to a temperature of 38 °C or more; and
    (i) 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.
(4) In ships, to which notation "*LFE*" are not affixed, the use of fuel having a lower flashpoint than otherwise specified in **(1)** above, 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) In ships, to which notation "*LFE*" are applicable, the use of oil fuel having a lower flashpoint than otherwise specified in **(1)** above is permitted.

(6) 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 fuel oil service tanks, settling tanks or other tanks provided in fuel oil supply systems which satisfy the following conditions:

(a) The length of the air vent pipes from such tanks and/or cooling devices are sufficient for cooling the vapours to below 60 °C, or the outlet of the air vent pipes to be located 3 *m* away from a source of ignition.

(b) The open-end device of air vent pipes are fitted with flame screens.

(c) There are no openings from the vapourspace of the fuel oil tanks into machinery spaces (bolted manholes with gaskets are acceptable).

(d) Enclosed spaces are not located right above the fuel oil tanks, except for well-ventilated cofferdams, unless the safety assessment is performed according to the provisions of **Chapter 12**.

2.2.2 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 of flammable liquids. In general, the use of free-standing oil fuel tanks are to be avoided. When such tanks are employed their use are to be prohibited in category *A* machinery spaces on passenger ships. 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 according to the following;

i) 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

ii) 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*.

(d) Oil fuel pipes, which, if a valve or a cock (with fuel oil tanks) that is normally open are 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) an oil-level gauge is provided meeting the requirements of **ii)** below;

2) 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

3) 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 the approved ones by the Society or to comply with the standard deemed approved by the Society.

1) The failure or damage of the gauges or overfilling of the tank is not to permit release of fuel into the space.

2) 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.

3) 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 vent 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 or into closed ro-ro 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 material approved by the Society, except that restricted use of flexible hoses is permissible in positions where the Society is satisfied that they are necessary. Such flexible hoses, end fittings and use of ordinary cast iron valves in piping systems are to comply with the requirements of **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 or damage. 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 or damage. However, when these pipes are deemed by the Society, to have appropriate designs, constructions and arrangements for minimizing the fire risk, the requirements may not apply.

(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 regards to their ability to prevent pressurized oil fuel leaks while in service and after maintenance.

(e) In multi-engine installations which are supplied from the same fuel source, means of isolating the fuel supply and spill piping to individual engines are to be provided. The means of isolation are not to affect the operation of the other engines and are to be operable from a position not rendered inaccessible by a fire on any of the engines.

(f) 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 or damage 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.

(8) The upper ends of sounding pipes for fuel overflow tanks which terminate in machinery spaces are to be fitted with self-closing blanking devices and with small-diameter self-closing control cocks located below the blanking devices for the purpose of ascertaining before the blanking devices are 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 cocks involves no ignition hazard.

2.2.3 Arrangements for Lubricating Oil

1 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 space of category *A*, and whenever practicable in other machinery spaces, are at least to comply with the provisions of **2.2.2(1)**, **2.2.2(2)**, **2.2.2(3)(c)**, **2.2.2(3)(d)**, **2.2.2(3)(e)**, **2.2.2(4)**, **2.2.2(5)(a)**, **2.2.2(5)(c)**, **2.2.2(6)** and **2.2.2(7)** 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 **1)** and **3)** of **2.2.2(3)(e)i)** need not be applied on condition that the sounding pipes are fitted with appropriate means of closure;

(3) the provisions of **2.2.2(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.

2 Air vent 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 electrical equipment or heated surface.

2.2.4 Arrangements for Other Combustible Oils

1 The arrangements for the storage, distribution and utilization of other combustible 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 **2.2.2** and with the provisions of **(4)** and **(5)(a)** of **2.2.2** in respect of strength and construction. With respect to thermal oil systems, such arrangements are to comply with the provisions of **2.2.2(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 which 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 Hydraulic units with working pressure above 1.5 *MPa* installed in machinery space 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.

2.2.5 Arrangements for Fuel Oil in Machinery Spaces of ships with class notation "M0" affixed for the main propulsion engines

In addition to the requirements of **2.2.1** to **2.2.4**, the oil fuel and lubricating oil systems in machinery spaces of ships with class notation "M0" affixed for the main propulsion engines 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 combustible 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 fuel oil 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, if the fuel oil is heated by steam, etc., and the fuel oil is not likely to be heated above the set heating temperature, the set temperature of the alarm device can be set to the flash point or higher, and if it may be heated to the flash point or higher, the alarm device may be not fitted.

2.3 Arrangements for Gases for Domestic Purpose

2.3.1 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.

2.3.2 Arrangements for Gas Welding Equipment

Gas welding equipments 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.

2.4 Miscellaneous Items of Ignition Sources and Ignitability

2.4.1 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.

2.4.2 Waste Receptacles

Waste receptacles are to be constructed of non-combustible materials with no openings in the sides or bottom. However, 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.

2.4.3 Insulation Surfaces Protected against Oil Penetration

Except the thermal insulation of pipes in machinery spaces ,in spaces where penetration of oil products (this spaces are located in the vicinity of all types of equipment (purifiers, pumps and tanks) and pipe fittings (valves, flanges, strainers, flow meters, etc.) handling oils (fuel oil, lubricating oil, hydraulic oil and thermal oil) with possible reach of oils or oil vapours leaked or splashed during operation or maintenance work to the thermal insulation is possible) , the surface of insulation is to be impervious to oil or oil vapours.

2.4.4 Primary Deck Coverings

If applied within accommodation and service spaces and control stations, primary deck coverings (this means the first layer of a floor construction which is applied directly on the top of deck plating and is inclusive of any primary coat, anti-corrosive compound or adhesive which is necessary to provide protection or adhesion to the deck plating) are to be of approved material by the Society or organizations deemed appropriate by the Society, which will not readily ignite, this being determined in accordance with the Fire Test Procedures Code.

2.4.5 Arrangements for Combustible Gases

One portable type combustible gases detector equipped in ships having a device for collecting oil spilled into sea and in ships engaging with oil fence expansion is to be of suitable type to the satisfaction of the Society.

2.5 Cargo Areas of Ships Carrying Flammable liquids

2.5.1 Separation of Cargo Tanks and Location of Fuel Tanks

1 Cargo pump-rooms, cargo tanks, slop tanks and cofferdams are to be positioned forward of machinery spaces. However, oil fuel banker tanks need not be forward of machinery spaces. Cargo tanks and slop tanks are to be isolated from machinery spaces by cofferdams, cargo pump-rooms, oil bunker tanks or ballast tanks. Pump-rooms containing pumps and their accessories for ballasting those spaces situated adjacent to cargo tanks and slop tanks and pumps for oil fuel transfer, are to be considered as equivalent to a cargo pump-room within the context of this paragraph provided that such pump-rooms have the same safety standard as that required for cargo pump-rooms. Pump-rooms intended solely for ballast or oil fuel transfer, however, need not comply with the requirements of **7.8**. The lower portion of the pump-room may be recessed into machinery spaces of category *A* to accommodate pumps, provided that the deck head of the recess is in general not more than one third of the moulded depth above the keel, except that in the case of ships of not more than 25,000 *tonnes* deadweight, where it can be demonstrated that for reasons of access and satisfactory piping arrangements this is impracticable, the Society may permit a recess in excess of such height, but not exceeding one half of the moulded depth above the keel.

2 Main cargo control stations, control stations, accommodation and service spaces (excluding isolated cargo handling gear lockers) are to be positioned aft of all cargo tanks, slop tanks, and spaces which isolate cargo or slop tanks from machinery spaces, but not necessarily aft of the fuel oil bunker tanks and ballast tanks, and are to be arranged in such a way that a single damage of a deck or bulkhead are not to permit the entry of gas or fumes from the cargo tanks into an accommodation space, main cargo control stations, control stations, or service spaces. A recess provided in accordance with **-1** above need not be taken into account when the position of these spaces is being determined.

3 However, where deemed necessary, the Society may permit main cargo control stations, control stations, accommodation and service spaces forward of the cargo tanks, slop tanks and spaces which isolate cargo and slop tanks from machinery spaces, but not necessarily forward of oil fuel bunker tanks or ballast tanks. Machinery spaces, other than those of category *A*, may be permitted forward of the cargo tanks and slop tanks provided they are isolated from the cargo tanks and slop tanks by cofferdams, cargo pump-rooms, oil fuel bunker tanks or ballast tanks, and have at least one portable fire extinguisher. In case where they contain internal combustion machinery, one approved foam-type extinguisher of at least 45 *l* capacity or equivalent is to be arranged in addition to portable fire extinguishers. If operation of a semi-portable fire extinguisher is impracticable, this fire extinguisher may be replaced by two additional portable fire extinguishers. Accommodation spaces, main cargo control spaces, control stations and service spaces are to be arranged in such a way that a single damage of a deck or bulkhead is not to permit the entry of gas or fumes from the cargo tanks into such spaces. In addition, where deemed necessary for the safety or navigation of the ship, the Society may permit machinery spaces containing internal combustion machinery not being main propulsion machinery having an output greater than 375 *kW* to be located forward of the cargo area provided the arrangements are in accordance with the provisions of this paragraph.

4 Where the fitting of a navigation position above the cargo area is shown to be necessary, it is to be for navigation purposes only and it is to be separated from the cargo tank deck by means of an open space with a height of at least 2 *m*. The fire protection requirements for such a navigation position are to be that required for control stations, as specified in **9.2.4**, **Part R of the Rules for the Survey and Construction of Steel Ships** and other provisions in **Chapters 2** and **3** for ships carrying flammable liquids, as applicable.

5 Means are to be provided to keep deck spills away from the accommodation and service areas. This may be accomplished by provision of a permanent continuous coaming of a height of at least 300 *mm*, extending from side to side. Special consideration is to be given to the arrangements associated with stern loading.

6 For the protection of cargo tanks carrying crude oil and petroleum products having a flashpoint not exceed 60 °C, materials readily rendered ineffective by heat and spread fire to the cargo are not to be used for the valves, fittings, tank opening covers, cargo vent pipings and cargo pipings.

7 In cases where fuel tanks are located in the cargo area of the oil tankers defined in **2.1.1(6), Part 1 of the Rules for Marine Pollution Prevention Systems**, the following **(1)** to **(5)** are to apply. The "cargo tank block" referred to in the following **(1)** and **(2)** means the part of the ship extending from the aft bulkhead of the aft most cargo or slop tank to the forward bulkhead of the forward most cargo or slop tank, extending to the full depth and beam of the ship, but not including the area above the deck of the cargo or slop tank.

(1) Fuel tanks located with a common boundary to cargo or slop tanks are not to be situated within nor extend partly into the cargo tank block.

(2) Fuel tanks specified in **(1)** above may be situated aft and/or forward of the cargo tank block.

(3) Fuel tanks may be accepted when located as independent tanks on open deck in the cargo area subject to spill and fire safety considerations.

(4) The arrangement of independent fuel tanks and associated fuel piping systems, including the pumps, can be as for fuel tanks and associated fuel piping systems located in the machinery spaces.

(5) For electrical equipment, the requirements to hazardous area classification specified in **Part 8** are to be met.

2.5.2 Restriction on Boundary Openings

1 Except as permitted in **-2** below, access doors, air inlets and openings to accommodation spaces, service spaces, control stations and machinery spaces are not to face the cargo area. They are to be located on the transverse bulkhead not facing the cargo area or on the outboard side of the superstructure or deckhouse at a distance of at least 4 % of the length of the ship but not less than 3*m* from the end of the superstructure or deckhouse facing the cargo area. This distance need not exceed 5 *m*.

2 The Society may permit access doors in boundary bulkheads facing the cargo area or within the 5 *m* limits specified in **-1** above, to main cargo control stations and to such service spaces as provision rooms, store-rooms and lockers, provided they do not give access directly or indirectly to any other space containing or provided for accommodation, control stations or service spaces such as galleys, pantries or workshops, or similar spaces containing sources of vapour ignition. The boundary of such a space is to be insulated to "*A*-60" standard, with the exception of the boundary facing the cargo area. Bolted plates for the removal of machinery may be fitted within the limits specified in **-1** above. Wheelhouse doors and wheelhouse windows may be located within the limits specified in **-1** above so long as they are designed to ensure that the wheelhouse can be made rapidly and efficiently gas and vapour tight.

3 Windows and side scuttles facing the cargo area and on the sides of the superstructures and deckhouses within the limits specified in **-1** above are to be of the fixed (non-opening) type. Such windows and side scuttles, except wheelhouse windows, are to be constructed to "*A*-60" class standard, except that "*A*-0" class standard is acceptable for windows and side scuttles outside the area insulated to "*A*-60" class standard as required in **9.2.4-3, Part R of the Rules for the Survey and Construction of Steel Ships**.

4 Where there is pipe tunnel in cargo area, the pipe tunnel is not to be open to engine rooms and is to be provided with at least two exits to open deck arranged at a maximum distance from each other. However, one of these exits may lead to the main pump room. Where there is permanent access from the pipe tunnel to the main pump-room, a watertight door is to be fitted complying with the requirements of **4.3.2, Part 6** and, in addition, with the following. For the application of **4.3.2, Part 6**, such doors are considered as those which are used at sea.

(1) In addition to the bridge operation, the watertight door is to be capable of being manually closed from outside the main pump-room entrance; and

(2) The watertight door is to be kept closed during normal operations of the ship except when

access to the pipe tunnel is required.

5 Permanent approved gas tight lighting enclosures for illuminating cargo pump-rooms may be permitted in bulkheads and decks separating cargo pump-rooms and other spaces provided they are of adequate strength and the fire integrity and gas-tightness of the bulkhead or deck are maintained.

6 The arrangement of ventilation inlets and outlets and other deckhouse and superstructure boundary space openings is to be such as to complement the provisions of **2.5.3** and **8.6**. Such vents, especially for machinery spaces, are to be situated as far aft as practicable. Due consideration in this regard is to be given when the ship is equipped to load or discharge at the stern. Sources of ignition such as electrical equipment are to be so arranged as to avoid an explosion hazard.

2.5.3 Cargo Tank Venting

1 The venting systems of cargo tanks (including slop tanks) are to be entirely distinct from the air vent pipes of the other compartments of the ship. 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 **-2** to **-5** below and **8.6** will apply.

2 Venting arrangements

(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 **8.6.1(1)**. Any isolation is to also continue to permit the passage of large volumes of vapour, air or inert gas mixtures during cargo loading and ballasting, or during discharging in accordance with **8.6.1(2)**.

(3) If cargo loading and ballasting or discharging of a cargo tank or cargo tank group is intended, which is isolated from a common venting system, that cargo tank or cargo tank group is to be fitted with a means for over-pressure or under-pressure protection as required in **8.6.3-2**.

(4) 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 ship. Where it may not be possible to provide self-draining lines, permanent arrangements are to be provided to drain the vent lines to a cargo tank.

3 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.

4 Vent outlets for cargo loading and ballasting

(1) Vent outlets for cargo loading, discharging and ballasting required by **8.6.1(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 **2.5.3** and **8.6** 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.

2.5.4 Ventilation

1 Ventilation systems in cargo pump rooms

(1) Cargo pump-rooms 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. 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 cofferdams adjacent to a cargo oil tank. Where air vent 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.

2.5.5 Inert Gas Systems

1 For ships carrying flammable liquids of 8,000 *tonnes* deadweight and upwards when carrying cargoes described in **1.1.1-3** or **1.1.1-4** And **1.1.1-5**, 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 the Society may accept other equivalent systems or arrangements, as described in **-6** through **-8**.

2 Ships carrying flammable liquids 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.

3 Ships carrying flammable liquids 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 in accordance with **(2)** and **(3)**;

(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 all gas carriers:

(1) when carrying cargoes described in regulation **1.1.1-3**, provided that they comply with the requirements for inert gas systems on chemical tankers established by the Society, based on the guidelines deemed appropriate by the Society; or

(2) when carrying flammable cargoes other than crude oil or petroleum products such as cargoes listed in **Chapters 17** and **18**, **Part R 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) Ships carrying flammable liquids fitted with a fixed inert gas system are to be provided with a closed ullage system.

6 The Society may, after having given consideration to the ship's arrangement and equipment, accept other fixed installations, in accordance with **1.1.2** and **-8**.

7 For ships carrying flammable liquids of 8,000 *tonnes* deadweight and upwards but less than 20,000 *tonnes* deadweight, in lieu of fixed installations as required by **-6** above, the Society may accept other equivalent arrangements or means of protection in accordance with **1.1.2** and **-8**.

8 Equivalent systems or arrangements are 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.

9 Inert gas systems, which are installed in ships that **-1** or **-2** above does not apply to, are to be the satisfaction of the Society.

2.5.6 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 **16.3.2**, **Part R of the Rules for the Survey and Construction of Steel Ships**.

3 The arrangements for inerting, purging or gas-freeing of empty tanks as required in **2.5.5-5(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 **2.5.3** and **8.6**. 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.

2.5.7 Gas Measurement

The following measures are to be provided for gas measurement:

(1) Ships carrying flammable liquids are to be equipped with at least one portable instrument for measuring flammable vapour concentrations and at least one portable instrument for measuring oxygen concentrations, together with a sufficient set of spares. Suitable means are to be provided for the calibration of such instruments. These measuring instruments 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)** through **(c)**.

(a) 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 ships carrying flammable liquids

(a) Ships carrying flammable liquids 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) Ships carrying flammable liquids provided with constant operative inerting systems for such spaces complying with the **Chapter 36**, **Part R of the Rules for the Survey and Construction of Steel Ships** need not be equipped with fixed hydrocarbon gas detection equipment.

(c) Notwithstanding **(a)** and **(b)** above, cargo pump-rooms subject to the provisions of **2.5.10** need not comply with the requirements of this paragraph.

2.5.8 Air Supply to Double Hull and Double Bottom Spaces

1 Double hull and double bottom spaces are to be fitted with suitable connections for the supply of air.

2 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.

2.5.9 Protection of Cargo Area

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.

2.5.10 Protection of Cargo Pump-rooms

In ships carrying flammable liquids:

(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 or damage 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, engine control room, cargo control room and navigation bridge 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.

2.6 Arrangements for Hazardous Areas

2.6.1 Arrangement and structure of hazardous areas

1 In principle, hazardous areas are not to be located adjacent to the following spaces and compartments:

(1) machinery spaces of category *A*

(2) tanks containing liquid cargoes less than a flashpoint 60 °C or over 32 °C

(3) compartments containing liquid oxygen

(4) pump-rooms for fuel, gasoline or lubricating oil

(5) control stations, switchboard or electrical control stations

(6) service spaces (galleys, pantries, etc.)

(7) accommodation spaces

(8) important spaces equipped important electronic equipment necessary for operation of ships

2 Arrangements that access from spaces defined in **-1** above to hazardous areas are to be avoided.

3 If arrangement defined in requirements of **-1** above is not applicable due to ship arrangement restrictions, Measures such as providing a cofferdam of an appropriate wide must be taken. However, cofferdams are not to be designed or used for stowage purposes.

4 In hazardous areas, provisions are to be suitable electromagnetic screening and earthing arrangements for type of stored dangerous substances.

5 Within hazardous areas, arrangements are to ensure that all stored dangerous substances are safely stowed and suitably restrained in their stowage for motions of rolling and pitching etc. and environmental conditions.

6 Structure of hazardous areas are to be of watertight or airtight and steel type construction.

7 In order to retard heat transfer from the adjacent compartment, "*A*-30" class heat insulation is to be installed on the boundary wall in the hazardous area.

2.6.2 Protection of hazardous areas

1 The temperature within hazardous areas is to be maintained at the required conditions specified by the stowed dangerous substances. In general, due to property required by the stored dangerous substances dangerous areas are to be maintained at temperatures greater than 7 ℃ and less than 35 ℃ with a relative humidity between 30 and 70 %.

2 Openings in hazardous areas, such as doors, hatches and escape hatches, are to be of equivalent strength and fire protection as the surrounding structure.

3 Security measures, such as locking, etc., are to be taken in openings of doors, hatches and escape hatches etc. to hazardous areas to prevent accidental access, and structure of doors, hatches and escape hatches etc., are not to be such that the hinge pin is removed to prevent access. The escape hatches are to be designed so that it can be opened inside areas only.

4 Ventilation and air conditioning system for hazardous areas are to comply with the requirements of **Chapter 10**, **Part 6**.

5 High temperature alarm devices, which is alarmed at the control stations of navigation bridge etc. are to be provided in hazardous areas and temperature at hazardous areas are to be monitored in related locations such as control stations.

6 Pipes, ducts and wires penetrating through the boundaries of the hazardous areas are to be limited to those used for the equipment required in the hazardous areas.

7 Hazardous areas are to be fitted with a spray system with manual or automatic activation and a suitable drainage system, and these systems are to comply with the requirements of **Chapter 11**, **Part 6**.

Chapter 3 FIRE GROWTH POTENTIAL AND SMOKE GENERATION POTENTIAL AND TOXICITY

3.1 General

3.1.1 Purpose

1 The purpose of the following **3.1** to **3.3** is to limit the fire growth potential in every space of the ship. For this purpose, the following functional requirements are to be met:

(1) means of control for the air supply to the space are to be provided;
(2) means of control for f combustible liquids in the space are to be provided; and
(3) the use of combustible materials is to be restricted.

2 In the event of a fire in the compartments that generally people work and/or accommodate, the risk of life due to smoke and toxicity gases is to needs to be reduced. For the purpose of this risk reduction, amount of smoke and toxicity gases due to combustible materials including face materials, in the event of a fire, when fire occurred, are to be restricted.

3.2 Control of Air Supply and Combustible Liquid to the Space

3.2.1 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.

3.2.2 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 **2.2.2(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.

3.2.3 Additional Requirements for Means of Control in Machinery Spaces of ships with class notation "M0" affixed for the main propulsion engines

For machinery spaces of ships with class notation "M0" affixed for the main propulsion engines, 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.

3.3 Fire Protection Materials

3.3.1 Use of Non-combustible Materials

1 Insulating materials are to be non-combustible, except in cargo spaces, mail rooms, baggage rooms and refrigerated compartments of service spaces. Vapour barriers and adhesives used in conjunction with insulation, as well as the insulation of pipe fittings for cold service systems, need not be of non-combustible materials, but they are to be kept to the minimum quantity practicable and their exposed surfaces are to have low flame spread characteristics.

2 All linings, ceilings, draught stops and their associated grounds are to be of non-combustible materials in the following spaces:

(1) in accommodation and service spaces and control stations for ships where Method I*C* is specified as referred to in **6.1.2**; and

(2) in corridors and stairway enclosures serving accommodation and service spaces and control stations for ships where Method II*C* or III*C* are specified as referred to in **6.1.2**.

3.3.2 Use of Combustible Materials

1 Non-combustible bulkheads, ceilings and linings fitted in accommodation and service spaces may be faced with combustible materials, facings, mouldings, decorations and veneers provided such spaces are bounded by non-combustible bulkheads, ceilings and linings in accordance with the provisions of **-2** to **-4** and **3.4** below.

2 Combustible materials used on the surfaces and linings specified in **-1** above are to have a calorific value not exceeding 45 MJ/m^2 of the area for the thickness used , measured in accordance with *ISO* 1716:2010 "*Reaction to fire tests for building products - Determination of the heat of combustion*". The requirements of this paragraph are not applicable to the surfaces of furniture fixed to linings or bulkheads.

3 Where combustible materials are used in accordance with **-1** above, they are to comply with the following requirements:

(1) The total volume of combustible facings, mouldings, decorations and veneers in any accommodation and service spaces is not to exceed a volume equivalent to 2.5 *mm* veneer on the combined area of the walls and ceiling linings. Furniture fixed to linings, bulkheads or decks need not be included in the calculation of the total volume of combustible materials; and

(2) In the case of ships fitted with an automatic sprinkler system complying with the provisions of **Chapter 28**, **Part R of the Rules for the Survey and Construction of Steel Ships**, the above volume may include some combustible material used for erection of "*C*" class divisions.

4 The following surfaces are to have low flame spread characteristics:

(1) exposed surfaces in corridors and stairway enclosures and of ceilings in accommodation and service spaces (except saunas) and control stations; and

(2) surfaces and grounds in concealed or inaccessible spaces in accommodation and service spaces and control stations.

3.4 Smoke Generation Potential and Toxicity

3.4.1 Finishes

Paints, varnishes and other finishes used on exposed interior surfaces are not to be capable of producing excessive quantities of smoke and toxic products; this being approved by the Society or organizations deemed appropriate by the Society in accordance with the Fire Test Procedures Code.

3.4.2 Primary Deck Coverings

Primary deck coverings, if applied within accommodation and service spaces and control stations, are to be of approved material which will not give rise to smoke or toxic or explosive hazards at elevated temperatures; this being approved by the Society or organizations deemed appropriate by the Society in accordance with the Fire Test Procedures Code.

Chapter 4 DETECTION AND ALARM

4.1 General

4.1.1 Purpose

The purpose of this Chapter is to detect a fire in the space of origin and to provide for alarm for safe escape and fire-fighting activity. For this purpose, the following functional requirements are to be met:

(1) fire detection and alarm system installations are to be suitable for the nature of the space, fire growth potential and potential generation of smoke and gases;
(2) manually operated call points are to be placed effectively to ensure a readily accessible means of notification.

4.2 General Requirements

4.2.1 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 and a sample extraction smoke detection system required in this Part is to be of an approved type and comply with **Chapters 29** or **30**, **Part R of the Rules for the Survey and Construction of Steel Ships**.

3 Where a fixed fire detection and fire alarm system is required for the protection of spaces other than those specified in **4.4**, at least one detector which is of an approved type and complying with **Chapter 29**, **Part R of the Rules for the Survey and Construction of Steel Ships** is to be installed in each such space.

4.2.2 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.

4.3 Protection of Machinery Spaces

4.3.1 Installation

1 A fixed fire detection and fire alarm system is to be installed in:

(1) machinery spaces of ships with class notation “M0” affixed for the main propulsion engines;
(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;
(3) machinery spaces where the main propulsion and associated machinery including sources of main sources of electrical power are provided with various degrees of automatic or remote control and are under continuous manned supervision from a control room; and
(4) enclosed spaces containing incinerators.

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 defined in **Chapter 1 of the Rules for Automatic and Remote Control Systems**; and

(c) centralized control stations for main propulsion defined in **Chapter 1 of the Rules for Automatic and Remote Control Systems**, including the stations placed in machinery spaces where main propulsion is installed.

(2) Where a switch to open temporarily a specific 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.

4.3.2 Design

1 The fixed fire detection and fire alarm system required in **4.3.1** 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.

2 The fixed fire detection and fire alarm 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.

4.4 Protection of Accommodation and Service Spaces and Control Stations

4.4.1 Fire Detection and Fire Alarm Systems

Accommodation and service spaces, control stations of ships and other important spaces specified by the society are to be protected by a fixed fire detection and fire alarm system and/or an automatic sprinkler, fire detection and fire alarm system as follows depending on a protection method adopted in accordance with **6.1.2**. Where deemed necessary by the Society, additional smoke detectors in ventilation ducts may be required.

(1) Method I*C*

A fixed fire detection and fire alarm system is to be so installed and arranged as to provide smoke detection in all corridors, stairways and escape routes within accommodation spaces.

(2) Method II*C*

An automatic sprinkler, fire detection and fire alarm system of a type deemed appropriate by the Society and complying with the relevant requirements of **Chapter 28**, **Part R of the Rules for the Survey and Construction of Steel Ships** is to be so installed and arranged as to protect accommodation spaces, galleys and other service spaces, except spaces which afford no substantial fire risk such as void spaces, sanitary spaces, etc. In addition, a fixed detection and fire alarm system is to be so installed and arranged as to provide smoke detection in all corridors, stairways and escape routes within accommodation spaces.

(3) Method III*C*

A fixed fire detection and fire alarm system is to be so installed and arranged as to detect the presence of fire in all accommodation spaces and service spaces, except spaces which afford no substantial fire risk such as void spaces, sanitary spaces, etc. In addition, a fixed fire detection and fire alarm system is to be so installed and arranged as to provide smoke detection in all corridors, stairways and escape routes within accommodation spaces.

4.4.2 Manually Operated Call Points

Manually operated call points complying with **Chapter 29**, **Part R of the Rules for the Survey and Construction of Steel Ships** are to be installed throughout the accommodation spaces, service spaces and control stations. One manually operated call point is to be located at each exit. Manually operated call points are to be readily accessible in the corridors of each deck such that no part of the corridor is more than 20 *m* from a manually operated call point.

4.5 General Emergency Alarm System and Public Address Systems

4.5.1 Purpose

The purpose of this Chapter is to notify crew and passengers of a fire for safe evacuation. For this purpose, a general emergency alarm system and a public address system are to be provided.

4.5.2 General Emergency Alarm System

A general emergency alarm system required by regulation III/6.4.2 of *SOLAS*, as may be amended, is to be used for notifying crew and passengers of a fire.

4.5.3 Public Address Systems

A public address system or other effective means of communication is to be available throughout the accommodation and service spaces and control stations and open decks.

Chapter 5 CONTROL OF SMOKE SPREAD

5.1 General

5.1.1 Purpose

The purpose of this Chapter is to control the spread of smoke in order to minimize the hazards from smoke. For this purpose, means for controlling smoke in atriums, control stations, machinery spaces and concealed spaces are to be provided.

5.2 Protection of Control Stations

5.2.1 Protection of Control Stations Outside Machinery Spaces

1 Mechanical ventilation system are to be taken for control stations outside machinery spaces in order to ensure that ventilation, visibility and freedom from smoke are maintained so that, in the event of fire, the machinery and equipment contained therein may be supervised and continue to function effectively. Alternative and separate means of air supply are to be provided and air inlets of the two sources of supply are to be so disposed that the risk of both inlets drawing in smoke simultaneously is minimized. Portable ventilators may be used with a heat-resistant flexible duct.

2 The requirements of **-1** above need not apply to control stations situated on, and opening on to, an open deck, or where local closing arrangements would be applied in the followings **(1)** and **(2)**.

(1) fire dampers which are easily closed within the control stations are to be provided in the ventilation system so that smoke would not be drawn into such a control station in case of fire; and

(2) any openings, where provided, can be easily and securely are to closed.

5.3 Release of Smoke

5.3.1 Release of Smoke from Machinery Spaces

1 The provisions of **5.3.1** 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 **9.5.2-1**, **Part R of the Rules for the Survey and Construction of Steel Ships**. 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.

5.4 Draught Stops

5.4.1 General

Air spaces enclosed behind ceilings, paneling or linings are to be divided by close-fitting draught stops spaced not more than 14 *m* apart. In the vertical direction, such enclosed air spaces, including those behind linings of stairways, trunks, etc., are to be closed at each deck.

Chapter 6 CONTAINMENT OF FIRE

6.1 General

6.1.1 Purpose

1 The purpose of this Chapter is to contain a fire in the space of origin. For this purpose, the following functional requirements are to be met:

(1) the ship is to be subdivided by thermal and structural boundaries;

(2) thermal insulation of boundaries is to have due regard to the fire risk of the space and adjacent spaces; and

(3) the fire integrity of the divisions is to be maintained at openings and penetrations.

2 As an alternative to the measures listed in **-1.(1)** to **(3)** above, the powerful fire extinguishing systems that can be used in any situation and that can contain a fire in the space of origin may be provided,

6.1.2 Application

1 One of the following methods of protection is to be adopted in accommodation and service spaces and control stations:

(1) Method I*C*

The construction of internal divisional bulkheads of non-combustible "*B*" or "*C*" class divisions generally without the installation of an automatic sprinkler, fire detection and fire alarm system in the accommodation and service spaces;

(2) Method II*C*

The fitting of an automatic sprinkler, fire detection and fire alarm system as required by **4.4.1(2)** for the detection and extinction of fire in all spaces in which fire might be expected to originate, generally with no restriction on the type of internal divisional bulkheads; or

(3) Method III*C*

The fitting of a fixed fire detection and fire alarm system as required by **4.4.1(3)**, in spaces in which a fire might be expected to originate, generally with no restriction on the type of internal divisional bulkheads, except that in no case must the area of any accommodation space or spaces bounded by an "*A*" or "*B*" class division exceed 50 m^2. Consideration may be given by the Society to increasing this area for public spaces.

2 The requirements for the use of non-combustible materials in the construction and insulation of boundary bulkheads of machinery spaces, control stations, service spaces, etc., and the protection of the above stairway enclosures and corridors will be common to all three methods outlined in **-1** above.

3 For ships other than high-speed ships that adopt the measures required by **6.1.1-1**, the provisions of **Chapter 9**, **Part R of the Rules for the Survey and Construction of Steel Ships** are to be applied.

4 For construction and arrangement for fire protection for ships other than high-speed ships that adopt the measures required by **6.1.1-2**, they are to be deemed appropriate by the Society regardless of the provisions of **Chapter 9**, **Part R of the Rules for the Survey and Construction of Steel Ships**.

5 For high-speed ships that adopt the measures required by **6.1.1-1**, the provisions of **Chapter 2**, **Part 11 of the Rules for High Speed Craft** are to be applied.

Chapter 7 FIRE FIGHTING

7.1 General

7.1.1 Purpose

1 The purpose of this Chapter is to suppress and swiftly extinguish a fire in the space of origin, except for **-2** below. For this purpose, the following functional requirements are to be met:

(1) Fixed fire extinguishing systems are to be installed having due regard to the fire growth potential of the protected spaces; and

(2) Fire extinguishing appliances are to be readily available.

2 For open-top container holds and on deck container stowage areas on ships designed to carry containers on or above the weather deck, fire protection arrangements are to be provided for the purpose of containing a fire in the space or area of origin and cooling adjacent areas to prevent fire spread and structural damage.

7.1.2 Application

1 Ships to which this rule applies are to be provided with fire pumps, fire main, fire hydrants and fire hoses that comply with the relevant requirements of **Chapter 11**, **Part 6**.

2 Ships with helicopter facilities are to be provided with fire extinguishing equipment that comply with the relevant requirements of **Chapter 9**, **Part 6**.

3 High-speed ships to which the provisions of **Chapter 2**, **Part 11 of the Rules for High Speed Craft** are applied in accordance with the provisions of **6.1.2-5**, are to be provided with fire pumps, fire main, hydrants and fire hoses that comply with the relevant requirements of **Chapter 3**, **Part 11 of the Rules for High Speed Craft**.

4 If a fire extinguishing system that does not comply with this provision is required in the requirements etc., specified by the owners, the record is to be kept and submitted to the Society.

7.2 Portable Fire Extinguishers

7.2.1 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**.

7.2.2 Arrangement of Fire Extinguishers

1 Accommodation spaces, service spaces, important spaces and control stations are to be provided with portable fire extinguishers of appropriate types and in sufficient number to the satisfaction of the Society. Ships of 1,000 *estimated gross tonnage* and upwards are to carry at least five portable fire extinguishers. Ships of less than 1,000 *estimated gross tonnage* are to carry at least four portable fire extinguishers.

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 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.

5 Two portable fire extinguishers which are to be as deemed appropriate by the Society are to be provided on weather deck within the cargo area for ships carrying flammable liquids.

7.2.3 Spare Charges

1 Spare charges are to be provided for 100 % of the first 10 extinguishers and 50 % of the remaining fire extinguishers capable of being recharged on board. Not more than 60 % total spare charges are required. Instructions for recharging are to be carried on board.

2 For fire extinguishers which cannot be recharged on board, 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.

7.3 Fixed Fire-extinguishing Systems

7.3.1 General

1 Unless otherwise specified, the requirements of **7.3** apply to fixed fire-extinguishing systems required by the provisions of **7.4**, **7.6** and **7.8**.

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 **Part R of the Rules for the Survey and Construction of Steel Ships**, as appropriate.

3 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**.

4 When a pump system is commonly served for fixed water-based fire-extinguishing systems (including those required in **7.5**) 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 damage or a failure of function of other fire-extinguishing systems.

7.3.2 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.

7.3.3 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.

(7) For the purpose of the application of the integrity in **Tables R9.1** to **R9.4** of **Part R of the**

Rules for the Survey and Construction of Steel Ships, such storage rooms are to be treated as fire control stations.

7.3.4 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.

7.4 Fire-extinguishing Arrangements in Machinery Spaces

7.4.1 Machinery Spaces Containing Oil-fired Boilers or Oil Fuel Units

1 Fixed fire-extinguishing systems

Machinery spaces of category *A* containing oil-fired boilers or oil fuel units are to be provided with any one of the following fixed fire-extinguishing systems. 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**;

(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**; 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**.

2 Additional fire-extinguishing arrangements

(1) There is to be in each boiler room or at an entrance outside of the boiler room at least one portable foam applicator unit complying with the provisions of **Chapter 24, Part R of the Rules for the Survey and Construction of Steel Ships**.

(2) There are to be at least two portable foam extinguishers 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. There is to be not less than one approved foam-type extinguisher of at least 135 *l* capacity or equivalent in each boiler room. These extinguishers are to be provided with hoses on reels suitable for reaching any part of the boiler room. In the case of domestic boilers of less than 175 *kW*, or boilers protected by fixed water-based local application fire-extinguishing systems as required by **7.4.5** where deemed appropriate by the Society, an approved foam-type extinguisher of at least 135 *l* capacity is not required.

(3) In each firing space there is to be a receptacle containing at least 0.1 m^3 sand, sawdust impregnated with soda, or other approved dry material, along with a suitable shovel for spreading the material. An approved portable extinguisher may be substituted as an alternative.

7.4.2 Machinery Spaces of Category *A* Containing Internal Combustion Machinery

1 Fixed fire-extinguishing systems

Machinery spaces of category *A* containing internal combustion machinery are to be provided with one of the fixed fire-extinguishing systems in **7.4.1**.

2 Additional fire-extinguishing arrangements

(1) There is to be at least one portable foam applicator unit complying with the provisions of **Chapter 24**, **Part R of the Rules for the Survey and Construction of Steel Ships**.

(2) There are to be in each such space approved foam-type 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 fuel and lubricating oil pressure systems, gearing and other fire hazards. In

addition, there is to be provided 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.

7.4.3 Other Machinery Spaces

Where a fire hazard exists in any machinery space for which no specific provisions for fire-extinguishing appliances are prescribed in **7.4.1** and **7.4.2**, there are to be provided in, or adjacent to, that space such a number of approved portable fire extinguishers or other means of fire extinction as the Society may deem sufficient.

7.4.4 Fixed Local Application Fire-fighting Systems

1 The requirements of the provisions in **-2** to **-4** below are to apply to ships of 2,000 *estimated gross tonnage* and above.

2 Machinery spaces of category *A* above 500 m^3 in volume are to, in addition to the fixed fire-extinguishing system required in **7.4.1-1**, be protected by an approved type of fixed water-based or equivalent local application fire-fighting system. In the case of machinery spaces f ships with class notation "M0" affixed for the main propulsion engines, the fire fighting system is to have both automatic and manual release capabilities. In the case of continuously manned machinery spaces, the fire-fighting system is only required to have a manual release capability.

3 Fixed local application fire-fighting systems are to protect areas such as the following without the necessity of engine shutdown, personnel evacuation, or sealing of the spaces:

(1) The fire hazard portions of internal combustion machinery;

(2) Boiler fronts;

(3) The fire hazard portions of incinerators; and

(4) Purifiers for heated fuel oil.

4 Activation of any local application system is to give a visual and distinct audible alarm in the protected space, the engine control room and the wheelhouse. The alarm is to indicate the specific system activated. The system alarm requirements are to be in addition to, and not a substitute for, the detection and fire alarm system required elsewhere in this Part.

7.5 Fire-extinguishing Arrangements in Control Stations, Accommodation and Service Spaces

7.5.1 Sprinkler Systems

In ships in which method II*C* specified in **6.1.2** is adopted, an automatic sprinkler, fire detection and fire alarm system is to be fitted in accordance with the requirements in **4.4.1(2)**.

7.5.2 Spaces Containing Combustible 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 Combustible 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.

7.5.3 Deep-fat Cooking Equipment

Deep-fat cooking equipment is to be fitted with the following:

(1) An automatic or manual extinguishing system tested to an international standard acceptable to the Society;
(2) A primary and backup thermostat with an alarm to alert the operator in the event of failure of either thermostat;
(3) Arrangements for automatically shutting off the electrical power upon activation of the extinguishing system;
(4) An alarm for indicating operation of the extinguishing system in the galley where the equipment is installed; and
(5) Controls for manual operation of the extinguishing system which are clearly labelled for ready use by the crew.

7.6 Fire-extinguishing Arrangements in Cargo Spaces

7.6.1 Fixed Fire-extinguishing Systems for General Cargo

1 Except for ro-ro and vehicle spaces, cargo spaces of ships of 2,000 *estimated gross tonnage* and upwards are to be protected by a fixed carbon dioxide or inert gas fire-extinguishing system complying with the provisions of **Chapter 25**, **Part R of the Rules for the Survey and Construction of Steel Ships**, or by a fire-extinguishing system which gives equivalent protection.

2 The Society may exempt from the requirements of **-1** above and **7.6.2** provided that cargo spaces of any ship if constructed and solely intended for the carriage of ore, coal, grain, unseasoned timber, non-combustible cargoes or cargoes which constitute a low fire risk. Such exemptions may be granted only if the ship is fitted with steel hatch covers and effective means of closing all ventilators and other openings leading to the cargo spaces. In this case, a list of cargoes intended to be carried is to be submitted to the Society.

7.6.2 Fixed Fire-extinguishing Systems for Dangerous Goods

A ship engaged in the carriage of dangerous goods in any cargo spaces is to be provided with a fixed carbon dioxide or inert gas fire-extinguishing system complying with the provisions of **Chapter 25**, **Part R of the Rules for the Survey and Construction of Steel Ships** or with a fire-extinguishing system which gives equivalent protection for the cargoes carried.

7.6.3 Firefighting for Ships Designed to Carry Containers on or above the Weather Deck

1 Ships designed to carry containers on or above the weather deck are to comply with the following **(1)** and **(2)**:

(1) Ships are to carry, in addition to the equipment and arrangements required by **7.1** and **11.2**, **Part 6** at least one water mist lance; and
(2) The water mist lance is to consist of a tube with a piercing nozzle which is capable of penetrating a container wall and producing water mist inside a confined space (container, etc.) when connected to the fire main.

2 Ships designed to carry five or more tiers of containers on or above the weather deck are to be provided with, in addition to **-1** above, mobile water monitors complying with the provisions of

10.7.3-2, **Part R of the Rules for the Survey and Construction of Steel Ships**:

7.7 Cargo Tank Protection

7.7.1 Fixed Deck Foam Systems

1 For Ships carrying flammable liquids of 20,000 *tonnes deadweight* and upwards a fixed deck foam system is to be provided in accordance with the requirements of **Chapter 34**, **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 ship's arrangement and equipment, may accept other fixed installations if they afford protection equivalent to the above. The requirements for alternative fixed installations are to comply with the requirements in **-2** below.

2 In accordance with **-1** above, where the Society accepts an equivalent fixed installation in lieu of the fixed deck foam system, the installation is to:

(1) be capable of extinguishing spill fires and also preclude ignition of spilled oil not yet ignited; and

(2) be capable of combating fires in ruptured tanks.

3 Ships carrying flammable liquids of less than 20,000 *tonnes deadweight* are to be provided with a deck foam system complying with the requirements of **Chapter 34**, **Part R of the Rules for the Survey and Construction of Steel Ships**.

4 The foam concentrate is to be limited to only one type which is effective in fire of any cargoes intended to be carried.

7.8 Protection of Cargo Pump Rooms

7.8.1 Fixed Fire-extinguishing Systems

Each cargo pump-room of ships carrying flammable liquids is to be provided with one of the following fixed fire-extinguishing systems operated from a readily accessible position outside the pump-room. Cargo pump-rooms are to be provided with a system suitable for machinery spaces of category *A*.

(1) A carbon dioxide system complying with the provisions of **Chapter 25**, **Part R of the Rules for the Survey and Construction of Steel Ships** and with the following:

  (a) the alarms giving audible warning of the release of fire-extinguishing medium are to be safe for use in a flammable cargo vapour/air mixture; and

  (b) a notice is to be exhibited at the controls stating that due to the electrostatic ignition hazard, the system is to be used only for fire extinguishing and not for inerting purposes.

(2) A high-expansion foam system complying with the provisions of **Chapter 26**, **Part R of the Rules for the Survey and Construction of Steel Ships**, provided that the foam concentrate supply is suitable for extinguishing fires involving the cargoes carried.

(3) A fixed pressure water-spraying system complying with the provisions of **Chapter 27**, **Part R of the Rules for the Survey and Construction of Steel Ships**.

7.8.2 Quantity of Fire-extinguishing Medium

Where the extinguishing medium used in the cargo pump-room system is also used in systems serving other spaces, the quantity of medium provided or its delivery rate need not be more than the maximum required for the largest compartment.

7.8.3 Portable Fire Extinguishers

Each cargo pump room is to be provided with at least two portable foam extinguishers or equivalent, one at the position the pumps are installed and one at the pump room entrance.

7.9 Fire-fighter's Outfits

7.9.1 Types of Fire-fighter's Outfits

Fire-fighter's outfits are to comply with the requirements of **Chapter 23**, **Part R of the Rules for the Survey and Construction of Steel Ships**.

7.9.2 Number of Fire-fighter's Outfits

1 Ships are to carry at least two fire-fighter's outfits.

2 In addition, in ships carrying flammable liquids, two fire-fighter's outfits are to be provided.

3 The Society may require additional sets of personal equipment and breathing apparatus, having due regard to the size and type of the ship.

4 Two spare charges are to be provided for each required breathing apparatus. Ships that are equipped with suitably located means for fully recharging the air cylinders free from contamination, need carry only one spare charge for each required apparatus.

7.9.3 Storage of Fire-fighter's Outfits

The fire-fighter's outfits or sets of personal equipment are to be kept ready for use in an easily accessible location that is permanently and clearly marked and, where more than one fire-fighter's outfit or more than one set of personal equipment is carried, they are to be stored in widely separated positions.

7.9.4 Fire-fighter's Communication

A minimum of two two-way portable radiotelephone apparatus for each fire party for fire-fighter's communication is to be carried on board. Those two-way portable radiotelephone apparatus are to be of an explosion-proof type or intrinsically safe.

Chapter 8 STRUCTURAL INTEGRITY

8.1 General

8.1.1 Purpose

The purpose of this Chapter is to maintain structural integrity of the ship preventing partial or whole collapse of the ship structures due to strength deterioration by heat. For this purpose, materials used in the ships' structure are to ensure that the structural integrity is not degraded due to fire.

8.2 Material

8.2.1 Material of Hull, Superstructures, Structural Bulkheads, Decks and Deckhouses

1 The hull, superstructures, structural bulkheads, decks and deckhouses are to be constructed of steel or other equivalent material. For the purpose of applying the definition of steel or other equivalent material, time during the applicable fire exposure is to be one hour for fire exposure for "*A*" class divisions and half an hour for "*B*" class divisions.

2 For ships applying with the provisions of **11.2.2-19**, **Part 6**, if it has the ability to extinguish a fire at the location within the time specified in **-1** above, the materials used for the location are to be considered steel or other equivalent material.

8.3 Structure

8.3.1 Structure of Aluminum Alloy

Unless otherwise specified in **8.2.1**, in cases where the structure is of aluminum alloy, the following is to apply:

(1) the insulation of aluminum alloy components of "*A*" or "*B*" class divisions, except structure which, in the opinion of the Society, is non-load-bearing, is to be such that the temperature of the structural core does not rise more than 200 °C above the ambient temperature at any time during the applicable fire exposure to the standard fire test; and

(2) special attention is to be given to the insulation of aluminum alloy components of columns, stanchions and other structural members required to support lifeboat and life raft stowage, launching and embarkation areas, and "*A*" and "*B*" class divisions to ensure:

  (a) that for such members supporting lifeboat and life raft areas and "*A*" class divisions, the temperature rise limitation specified in **(1)** above is to apply at the end of one hour; and

  (b) that for such members required to support "*B*" class divisions, the temperature rise limitation specified in **(1)** above is to apply at the end of half an hour.

8.4 Machinery Spaces of Category *A*

8.4.1 General

The provisions of **8.4** are to apply to the structure of machinery spaces of category *A* applying the provisions of **6.1.2-3** or **6.1.2-5**.

8.4.2 Crowns and Casings

Crowns and casings of machinery spaces of category *A* are to be of steel construction and are to be insulated as required by **Tables R9.1** to **R9.4** of **Chapter 9**, **Part R of the Rules for the Survey and Construction of Steel Ships**, as appropriate.

8.4.3 Floor Plating

The floor plating of normal passageways in machinery spaces of category *A* is to be made of steel or other equivalent material.

8.5 Overboard Fittings

8.5.1 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 damage of the material in the event of fire would give rise to danger of flooding.

8.6 Protection of Cargo Tank Structure against Pressure or Vacuum

8.6.1 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 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.

8.6.2 Openings for Small Flow by Thermal Variations

Openings for pressure release required by **8.6.1(1)** are to comply with the following **(1)** and **(2)**, and are to be arranged in accordance with regulation **2.5.3-4(1)**.

(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.

8.6.3 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 **Chapter 11**, **Part 6** and cargo tank filling procedures. For the purposes of this paragraph, spill valves are not considered equivalent to an overflow system.

2 Secondary means for pressure/vacuum relief

A secondary means of allowing full flow relief of vapour, air or inert gas mixtures are to be provided to prevent over-pressure or under-pressure in the event of failure of the arrangements in **8.6.1(2)**. In addition, the secondary means are to be capable of preventing over-pressure or under-pressure in the event of damage to, or inadvertent closing of, the means of isolation required in **2.5.3-2(2)**. Alternatively, pressure sensors may be fitted in each tank protected by the arrangement required in **8.6.1(2)**, with a monitoring system in the ship's cargo control room or the position from which cargo operations are normally carried out. Such monitoring equipment is also to provide an alarm facility which is activated by detection of over-pressure or under-pressure conditions within a tank.

3 Bypasses in vent mains

Pressure/vacuum valves required by **8.6.1(1)** 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.

4 Pressure/vacuum breaking devices

One or more pressure/vacuum breaking devices are to be provided to prevent the cargo tanks from being subject to **(1)** and **(2)** below. Such devices are to be installed on the inert gas main unless they are installed in the venting system required by **2.5.3-1** or on individual cargo tanks. The location and design of the devices are to be in accordance with **2.5.3** and **8.6**.

(1) 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

(2) A negative pressure in excess of 700 *mm* water gauge if cargo were to be discharged at the maximum rated capacity of the cargo pumps and the inert gas blowers were to fail.

8.6.4 Size of Vent Outlets

Vent outlets for cargo loading, discharging and ballasting required by **8.6.1(2)** 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 9 PROTECTION OF VEHICLE AND RO-RO SPACES

9.1 General

9.1.1 Purpose

The purpose of this Chapter is to provide additional safety measures in order to address the fire safety objectives of this Part for ships fitted with vehicle and ro-ro spaces. For this purpose, the following functional requirements are to be met:

(1) Fire protection systems are to be provided to adequately protect the ship from the fire hazards associated with vehicle and ro-ro spaces;

(2) Ignition sources are to be separated from vehicle and ro-ro spaces; and

(3) Vehicle and ro-ro spaces are to be adequately ventilated.

9.1.2 Application

1 In addition to complying with the requirements of **Chapters 2** to **11**, as appropriate, vehicle and ro-ro spaces are to comply with the requirements of this Chapter.

2 In addition to complying with the requirements of **Chapters 2** to **11**, as appropriate, vehicle and ro-ro spaces of ships stowing vehicle with compressed hydrogen or compressed natural gas in their tanks for their own propulsion are to comply with the requirements in **Chapter 20A**, **Part R of the Rules for the Survey and Construction of Steel Ships**.

9.2 Precaution against Ignition of Combustible Vapours in Closed Vehicle Spaces and Closed Ro-ro Spaces

9.2.1 Ventilation Systems

1 Capacity of ventilation systems

There is to be provided an effective power ventilation system sufficient to give at least 6 *air changes per hour* basing upon an empty spaces. The Society may require an increased number of air changes when vehicles are being loaded and unloaded.

2 Performance of ventilation systems

(1) Ventilation fans are normally to be run continuously and give at least the number of air changes required in **-1** above whenever vehicles are on board, except where an air quality control system in accordance with **(3)** below is provided. Where this is impracticable, they are to be operated for a limited period daily as weather permits and in any case for a reasonable period prior to discharge, after which period the ro-ro or vehicle space is to be proved gas-free. One or more portable combustible gas detecting instruments deemed as appropriate by the Society are to be carried for this purpose. The system is to be entirely separate from other ventilating systems. Ventilation ducts serving ro-ro or vehicle spaces are to be capable of being effectively sealed for each cargo space. The system is to be capable of being controlled from a position outside such spaces.

(2) The ventilation system is to be such as to prevent air stratification and the formation of air pockets.

(3) For all ships, where an air quality control system deemed appropriate by the Society is provided, the ventilation system may be operated at a decreased number of air changes and/or a decreased amount of ventilation. This relaxation does not apply to spaces to which at least 10 *air changes per hour* is required by **9.2.2-2** and spaces subject to **10.2.4-1**.

3 Indication of ventilation systems

Means are to be provided on the navigation bridge to indicate any loss of the required ventilating capacity.

4 Closing appliances and ducts

(1) Arrangements are to be provided to permit a rapid shutdown and effective closure of the ventilation system from outside of the space in case of fire, taking into account the weather and sea conditions.

(2) Ventilation ducts, including dampers are to be made of steel. Ventilation ducts that pass through machinery spaces are to be "*A*-60" class steel ducts constructed in accordance with **(1)** and **(2)** of **9.7.2-4**, **Part R of the Rules for the Survey and Construction of Steel Ships**.

5 Permanent openings

Permanent openings in the side plating, the ends or deck head of the space are to be so situated that a fire in the cargo space does not endanger stowage areas and embarkation stations for survival craft and accommodation spaces, service spaces and control stations in superstructures and deckhouses above the cargo spaces.

9.2.2 Electrical Equipment and Wiring

1 Except as provided in **-2** above, electrical equipment and wiring installed in vehicle spaces are to be of a type suitable for use in an explosive petrol and air mixture.

2 Notwithstanding the provisions in **-1** above, above a height of 450 *mm* from the deck and from each platform for vehicle, if fitted, except platforms with openings of sufficient size permitting penetration of petrol gases downwards, electrical equipment of a type so enclosed and protected as to prevent the escape of sparks is to be permitted as an alternative on condition that the ventilation system is so designed and operated as to provide continuous ventilation of the cargo spaces at the rate of at least ten air changes per hour whenever vehicles are on board.

9.2.3 Electrical Equipment and Wiring in Exhaust Ventilation Ducts

Electrical equipment and wiring, if installed in an exhaust ventilation duct for vehicle spaces, are to be of a type approved for use in explosive petrol and air mixtures and the outlet from any exhaust duct is to be sited in a safe position, having regard to other possible sources of ignition.

9.2.4 Other Ignition Sources

1 Other equipment which may constitute a source of ignition of combustible vapours in vehicle spaces is not to be permitted.

2 Notices of "No Smoking" are to be posted in way of all access to vehicle and ro-ro spaces.

9.2.5 Scuppers and Discharges

Scuppers for vehicle spaces are not to be led to machinery or other spaces where sources of ignition may be present.

9.3 Detection and Alarm

9.3.1 Fixed Fire Detection and Fire Alarm Systems

There is to be provided a fixed fire detection and fire alarm system complying with the requirements of **Chapter 29**, **Part R of the Rules for the Survey and Construction of Steel Ships**. The fixed fire detection system is to be capable of rapidly detecting the onset of fire. The type of detectors and their spacing and location are to be determined taking into account the effects of ventilation and other relevant factors. After being installed the system is to be tested under normal ventilation conditions and is to give an overall response time to the satisfaction of the Society.

9.3.2 Sample Extraction Smoke Detection Systems

Except open ro-ro spaces and open vehicle spaces, a sample extraction smoke detection system complying with the requirements of **Chapter 30**, **Part R of the Rules for the Survey and Construction of Steel Ships** may be used as an alternative of the fixed fire detection and fire alarm system required in **9.3.1**.

9.4 Fire-extinction

9.4.1 Fixed Fire-extinguishing Systems

1 Vehicle spaces and ro-ro spaces which are capable of being sealed from a location outside of the cargo spaces are to be fitted with one of the following fixed fire-extinguishing systems:

(1) a fixed gas fire-extinguishing system complying with the provisions of **Chapter 25**, **Part R of the Rules for the Survey and Construction of Steel Ships**;

(2) a fixed high-expansion foam fire-extinguishing system complying with the provisions of **Chapter 26**, **Part R of the Rules for the Survey and Construction of Steel Ships**; or

(3) a fixed water-based fire-fighting system for ro-ro spaces complying with the provisions of **Chapter 27**, **Part R of the Rules for the Survey and Construction of Steel Ships**, and sub-paragraphs **-2(1)** to **(4)**.

2 Vehicle spaces and ro-ro spaces not capable of being sealed are to be fitted with a fixed water-based fire-fighting system for ro-ro spaces complying with the provisions of **Chapter 27**, **Part R of the Rules for the Survey and Construction of Steel Ships** which is to protect all parts of any deck and vehicle platform in such spaces. Such a water-based fire-fighting system is to have:

(1) a pressure gauge on the valve manifold;

(2) clear marking on each manifold valve indicating the spaces served;

(3) instructions for maintenance and operation located in the valve room; and

(4) a sufficient number of drainage valves to ensure complete drainage of the system.

3 The Society may permit the use of any other fixed fire-extinguishing system that has been shown that it is not less effective by full-scale test in conditions simulating a flowing petrol fire in a vehicle space or a ro-ro space in controlling fires likely to occur in such a space.

4 When fixed water pressure spraying systems are provided, in view of the serious loss of stability which could arise due to large quantities of water accumulating on the deck or decks during the operation of the fixed pressure water-spraying system, drainage and pumping arrangements are to be provided. The drainage and pumping arrangements are to be such as to prevent the build-up of free surfaces. In such case, the drainage system is to be sized to remove no less than 125 % of the combined capacity of both the water spraying system pumps and the required number of fire hose nozzles. The drainage system valves are to be operable from outside the protected space at a position in the vicinity of the extinguishing system controls. Bilge wells are to be of sufficient holding capacity and are to be arranged at the side shell of the ship at a distance from each other of not more than 40 *m* in each watertight compartment. If this is not possible, suitable measures as deemed appropriate by the Society are to be taken to limit the adverse effect upon stability of the added weight and free surface of water in its approval of the stability information. Such information is to be included in the stability information.

5 In the case of closed vehicle and ro-ro spaces, in cases where fixed water pressure spraying systems are fitted, Society approved means are to be provided to prevent the blockage of the drainage arrangements of such spaces.

9.4.2 Portable Fire Extinguishers

1 Portable extinguishers are to be provided at each deck level in each hold or compartment where vehicles are carried, spaced not more than 20 *m* apart on both sides of the space. At least one portable extinguisher is to be located at each access to such a cargo space.

2 In addition to the provision of **-1** above, the following fire extinguishing appliances are to be provided in vehicle and ro-ro spaces intended for carriage of motor vehicles with fuel in their tanks for their own propulsion:

(1) At least three water fog applicators deemed as appropriate by the Society; and
(2) One portable foam applicator unit complying with the provisions of **Chapter 24**, **Part R of the Rules for the Survey and Construction of Steel Ships** provided that at least two such units are available in the ship for use in such spaces.

Chapter 10 CARRIAGE OF DANGEROUS GOODS

10.1 General

10.1.1 Purpose

The purpose of this Chapter is to provide additional safety measures in order to address the fire safety objectives of this Part for ships carrying dangerous goods. For this purpose, the following functional requirements are to be met:

(1) fire protection systems are to be provided to protect the ship from the added fire hazards associated with carriage of dangerous goods;
(2) dangerous goods are to be adequately separated from ignition sources; and
(3) appropriate personnel protective equipment is to be provided for the hazards associated with the carriage of dangerous goods.

10.1.2 Application

1 In addition to complying with the requirements of regulations in **Chapters 2** to **9**, and **11** as appropriate, cargo spaces referred to in **10.1.3**, intended for the carriage of dangerous goods are to comply with the requirements of this Chapter, as appropriate, except when carrying dangerous goods in limited quantities and excepted quantities unless such requirements have already been met by compliance with the requirements elsewhere in this Part.
2 Facilities and conditions for carriage which are needed for carrying the dangerous goods specified in **10.1.4**, are to be in accordance with the relevant requirements of the *IMSBC* Code, as defined in Chapter VI, Regulation 1.1 of *SOLAS* (hereinafter referred to as *IMSBC* Code) and the relevant requirements of the *IMDG* Code, as defined in Chapter VII, Regulation 1.1 of the *SOLAS* (hereinafter referred to as *IMDG* Code).

10.1.3 Application for Categories of Cargo Spaces

The following cargo spaces are to govern the application of **Table 9.10.1** and **9.10.2**:

(1) Weather deck cargo spaces;
(2) Cargo spaces not specifically designed : cargo spaces not specially designed for the carriage of freight containers, but intended for the carriage of dangerous goods in packaged form including goods in freight containers and portable tanks;
(3) Container cargo spaces: cargo spaces intended for the carriage of dangerous goods in freight containers and portable tanks;
(4) Closed ro-ro spaces: ro-ro spaces which are neither open ro-ro spaces nor weather decks, intended for the carriage of dangerous goods;
(5) Open ro-ro spaces: open ro-ro spaces, defined in **1.3.15**, intended for the carriage of dangerous goods;
(6) Shipborne barge cargo spaces: cargo spaces intended for carriage of dangerous goods other than liquids and gases in bulk in shipborne barges; and
(7) Bulk cargo spaces: cargo spaces intended for the carriage of solid dangerous goods in bulk.

10.1.4 Classes of Dangerous Goods

Dangerous Goods, to which the requirements in this Chapter are applied, are classified into 23 classes as follows:

(1) Explosives in *Class* 1.1 to 1.6 as defined in the *IMDG* Code except goods in division 1.4, compatibility group S (hereinafter, referred to as goods in *Class* 1.4*S*).
(2) Explosives in *Class* 1.4*S* as defined in the *IMDG* Code.
(3) Flammable high-pressure gases in *Class* 2.1 as defined in the *IMDG* Code.
(4) Non-flammable non-poisonous (non-toxic) high-pressure gases in *Class* 2.2 as defined in the *IMDG* Code.
(5) Flammable poisonous (toxic) high-pressure gases in *Class* 2.3 as defined in the *IMDG* Code.
(6) Non-flammable poisonous (toxic) high-pressure gases in *Class* 2.3 as defined in the *IMDG*

Code.

(7) Flammable liquid substances having a flashpoint of less than 23 °C and in *Class* 3 as defined in the *IMDG* Code.

(8) Flammable liquid substances having a flashpoint of 23 °C or above and less than or equal to 60 °C and in *Class* 3 as defined in the *IMDG* Code.

(9) Flammable solid substances in *Class* 4.1 as defined in the *IMDG* Code.

(10) Substances liable to spontaneous combustion in *Class* 4.2 as defined in the *IMDG* Code.

(11) Liquid substances which, in contact with water, emit flammable gases in *Class* 4.3 as defined in the *IMDG* Code.

(12) Solid substances which, in contact with water, emit flammable gases in *Class* 4.3 as defined in the *IMDG* Code.

(13) Oxidizing substances in *Class* 5.1 as defined in the *IMDG* Code.

(14) Organic peroxides in *Class* 5.2 as defined in *IMDG* Code.

(15) Poisonous (toxic) liquid substances having a flashpoint of less than 23 °C and in *Class* 6.1 as defined in the *IMDG* Code.

(16) Poisonous (toxic) liquid substances having a flashpoint of 23 °C or above and less than or equal to 60 °C and in *Class* 6.1 as defined in the *IMDG* Code.

(17) Poisonous (toxic) liquid substances having a flashpoint of greater than 60 °C and in *Class* 6.1 as defined in the *IMDG* Code.

(18) Poisonous (toxic) solid substances in *Class* 6.1 as defined in the *IMDG* Code.

(19) Corrosives liquid substances having a flashpoint of less than 23 °C and in *Class* 8 as defined in the *IMDG* Code.

(20) Corrosives liquid substances having a flashpoint of 23 °C or above and less than or equal to 60 °C and in the *Class* 8 as defined in the *IMDG* Code.

(21) Corrosives liquid substances having a flashpoint of greater than 60 °C and in *Class* 8 as defined in the *IMDG* Code.

(22) Corrosive solid substances in *Class* 8 as defined in the *IMDG* Code.

(23) Miscellaneous dangerous substances in *Class* 9 as defined in the *IMDG* Code.

10.1.5 Application of Special Requirements

Unless otherwise specified, the following requirements are to govern the application of **Table 9.10.1**, **9.10.2** and **9.10.3** to both “on-deck” and “under-deck” stowage of dangerous goods where the numbers of the following requirements are indicated in the first column of the tables.

Table 9.10.1 Application of the Requirements to Different Modes of Carriage of Dangerous Goods in Ships

Special Requirements (**10.2**)		Categories of Cargo Spaces (**10.1.3**)					
		(1)	(2)	(3)	(4)	(5)	(6)
10.2.1-1	Remote arrangements for fire pumps	X	X	X	X	X	X
10.2.1-2	Quantity of water delivery	X	X	X	X	X	-
10.2.1-3	Cooling arrangements (water spraying or flooding)	-	X	X	X	X	X
10.2.1-4	Cooling arrangements (using media other than water)	-	X	X	X	X	X
10.2.1-5	Total capacity of water supply	X	X	X	X	X	-
10.2.2	Sources of ignition	-	X	X	X	X	X[d]
10.2.3	Detection system	-	X	X	X	-	X[d]
10.2.4-1	Power ventilation	-	X	X[a]	X	-	X[d]
10.2.4-2	Ventilation fans (ignition-free)	-	X	X[a]	X	-	X[d]
10.2.5	Bilge pumping	-	X	X	X	-	-
10.2.6-1	Personnel protection	X	X	X	X	X	-
10.2.6-2	Self-contained breathing apparatus	X	X	X	X	X	-
10.2.7	Portable fire extinguishers	X	X	-	-	X	-
10.2.8	Insulation of machinery space boundaries	X	X	X[b]	X	X	-
10.2.9	Water spray system	-	-	-	X[c]	X	-
10.2.10-1	Separation of ro-ro spaces	-	-	-	X	-	-
10.2.10-2	Separation of weather decks	-	-	-	X	-	-

Notes:

1. The categories of cargo spaces in **Table 9.10.1** in accordance with the provisions of **10.1.3** are as follows.
   (1) weather deck cargo spaces (including **(2)** to **(6)** below)
   (2) cargo spaces not specially designed
   (3) container cargo spaces
   (4) closed ro-ro spaces
   (5) open ro-ro spaces
   (6) shipborne barge cargo spaces
2. Where "X" appears in **Table 9.10.1**, it means that such requirements are to be applied to all categories of dangerous goods as given in the corresponding line of **Table 9.10.3**, except as indicated in the notes below.
3. Subscripts in **Table 9.10.1** are as follows.
   a : For *Classes* 4 and 5.1 solids (**10.1.4(9), (10), (12)** and **(13)**) not applicable to closed freight containers.
   For *Classes* 2, 3, 6.1 and 8 (**10.1.4(3)** to **(8)** and **(15)** to **(22)**) when carried in closed freight containers the ventilation rate may be reduced to not less than two air changes per hour. For *Classes* 4 and 5.1 liquids (**10.1.4(9)** to **(11)** and **(13)**) when carried in closed freight containers, the ventilation rate may be reduced to not less than two air changes per hour. For the purpose of this requirement a portable tank is a closed freight container.
   b : Applicable to decks only.
   c : Applies only to closed ro-ro spaces, not capable of being sealed.
   d : In the special case where the barges are capable of containing flammable vapours or alternatively if they are capable of discharging flammable vapours to a safe space outside the barge carrier compartment by means of ventilation ducts connected to the barges, these requirements may be reduced or waived to the satisfaction of the Society.

Table 9.10.2 Application of the Requirements to Different Classes of Dangerous Goods for Carrying Solid Dangerous Goods in Bulk

Special Requirements (**10.2**)		Classification of Dangerous Goods (**10.1.4**)						
		4.1	4.2	4.3[a]	5.1	6.1	8	9
10.2.1-1	Remote arrangements for fire pumps	X	X	-	X	-	-	X
10.2.1-2	Quantity of water delivery	X	X	-	X	-	-	X
10.2.1-5	Total capacity of water supply	X	X	-	X	-	-	X
10.2.2	Sources of ignition	X	X[b]	X	X[c]	-	-	X[c]
10.2.4-1	Power ventilation	-	X[b]	X	-	-	-	-
10.2.4-2	Ventilation fans (ignition-free)	X[d]	X[b]	X	X[b,d]	-	-	X[b,d]
10.2.4-3	Natural ventilation	X	X	X	X	X	X	X
10.2.6	Personnel protection	X	X	X	X	X	X	X
10.2.8	Insulation of machinery space boundaries	X	X	X	X[b]	-	-	X[e]

Notes:

1. *Classes* of dangerous goods in **Table 9.10.2** in accordance with the provisions of **10.1.4** are as follows.
   - 4.1 : Flammable solids in *Class* 4.1 (**10.1.4(9)**)
   - 4.2 : Substances liable to spontaneous combustion in *Class* 4.2 (**10.1.4 (10)**)
   - 4.3 : Substances which, in contact with water, emit flammable gases in *Class* 4.3 (**10.1.4(11)** and **(12)**)
   - 5.1 : Oxidizing substances in *Class* 5.1 (**10.1.4(13)**)
   - 6.1 : Solid poisonous (toxic) substances in *Class* 6.1 (**10.1.4(18)**)
   - 8 : Solid corrosives in *Class* 8 (**10.1.4(22)**)
   - 9 : Miscellaneous dangerous substances in *Class* 9 (**10.1.4(23)**)
2. Whenever "X" appears in **Table 9.10.2**, it means that this special requirement for the dangerous goods is applicable.
3. Subscripts in **Table 9.10.2** are as follows.
   - a : The hazards of substances in this class which may be carried in bulk are such that special consideration must be given by the Society to the construction and equipment of the ship involved in addition to meeting the requirements enumerated in this table.
   - b : Only applicable to Seedcake containing solvent extractions, to Ammonium nitrate and Ammonium nitrate fertilizers.
   - c : Only applicable to Ammonium nitrate and Ammonium nitrate fertilizers. However, a degree of protection in accordance with standards contained in the International Electrotechnical Commission, publication 60079, Electrical Apparatus for Explosive Gas Atmospheres, is sufficient.
   - d : Only suitable wire mesh guards are required.
   - e : The requirements of *IMSBC* Code are sufficient.

Table 9.10.3 Application of the Requirements to Different Classes of Dangerous Goods except Solid Dangerous Goods in Bulk

Special Requirements (**10.2**)	Classification of Dangerous Goods (**10.1.4**)																						
	1	1.4*S*	2.1	2.2	2.3 *F*[i]	2.3 *NF*	3*L*	3*M*	4.1	4.2	4.3 *liquids*[j]	4.3	5.1	5.2[e]	6.1*L* *liquids*	6.1*M* *liquids*	6.1*H* *liquids*	6.1	8*L* *liquids*	8*M* *liquids*	8*H* *liquids*	8	9
10.2.1-1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
10.2.1-2	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	-
10.2.1-3	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10.2.1-4	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10.2.1-5	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	-
10.2.2	X	-	X	-	X	-	X	-	-	-	X[g]	-	-	-	X	-	-	-	X	-	-	-	X[f]
10.2.3	X	X	X	X	-	X	X	X	X	X	X	X	X	-	X	X	X	X	X	X	X	X	-
10.2.4-1	-	-	X	-	-	X	X	-	X[a]	X[a]	X	X	X[a]	-	X	X	-	X[a]	X	X	-	-	X[a]
10.2.4-2	-	-	X	-	-	-	X	-	-	-	-	-	-	-	X	-	-	-	X	-	-	-	X[f]
10.2.5	-	-	-	-	-	-	X	-	-	-	-	-	-	-	X	X	X	-	X	X[h]	X[h]	-	-
10.2.6	-	-	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X[d]
10.2.7	-	-	-	-	-	-	X	X	X	X	X	X	X	-	X	X	-	-	X	X	-	-	-
10.2.8	X[b]	-	X	X	X	X	X	X	X	X	X	X	X[c]	X	X	X	-	-	X	X	-	-	-
10.2.9	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
10.2.10-1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
10.2.10-2	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Notes:

1. *Classes* of dangerous goods in **Table 9.10.3** in accordance with the provisions of **10.1.4** are as follows.

1 : Explosives in *Class* 1.1 to 1.6 except *Class* 1.4*S* (**10.1.4(1)**)

1.4*S* : Explosives in *Class* 1.4*S* (**10.1.4(2)**)

2.1 : Flammable high-pressure gases in *Class* 2.1 (**10.1.4(3)**)

2.2 : Non-flammable non-poisonous (non-toxic) high-pressure gases in *Class* 2.2 (**10.1.4(4)**)

2.3*F* : Flammable poisonous (toxic) high-pressure gases in *Class* 2.3 (**10.1.4(5)**)

2.3*NF*: Non-flammable poisonous (toxic) high-pressure gases in *Class* 2.3 (**10.1.4(6)**)

3*L* : Flammable liquid substances having a flashpoint of less than 23°C in *Class* 3 (**10.1.4(7)**)

3*M* : Flammable liquid substances having a flashpoint of 23°C or above and less than or equal to 60°C in *Class* 3 (**10.1.4(8)**)

4.1 : Flammable solid substances in *Class* 4.1 (**10.1.4(9)**)

4.2 : Substances liable to spontaneous combustion in *Class* 4.2 (**10.1.4(10)**)

4.3 *liquids* : Liquid substances which, in contact with water, emit flammable gases in *Class* 4.3 (**10.1.4(11)**)

4.3 : Solid substances which, in contact with water, emit flammable gases in *Class* 4.3 (**10.1.4(12)**)

5.1 : Oxidizing substances in *Class* 5.1 (**10.1.4(13)**)

5.2 : Organic peroxides in *Class* 5.2 (**10.1.4(14)**)

6.1*L liquids* : Poisonous (toxic) liquid substances having a flashpoint of less than 23 ℃ in *Class* 6.1 Code. (**10.1.4(15)**)

6.1*M liquids* : Poisonous (toxic) liquid substances having a flashpoint of 23 ℃ or above and less than or equal 60 ℃ in *Class* 6.1 Code. (**10.1.4(16)**)

6.1*H liquids* : Poisonous (toxic) liquid substances having a flashpoint of greater than 60 ℃ in *Class* 6.1 Code. (**10.1.4(17)**)

6.1 : Poisonous (toxic) solid substances in *Class* 6.1 (**10.1.4(18)**)

8*L liquids* : Corrosive liquid substances having a flashpoint of less than 23 ℃ in *Class* 8 Code. (**10.1.4(19)**)

8*M liquids* : Corrosive liquid substances having a flashpoint of 23 ℃ or above and less than or equal 60 ℃ in *Class* 8 Code. (**10.1.4(20)**)

8*H liquids* : Corrosive liquid substances having a flashpoint of greater than 60 ℃ in *Class* 8 Code. (**10.1.4(21)**)

8 : Corrosive solid substances in *Class* 8 (**10.1.4(22)**)

9 : Miscellaneous dangerous substances in *Class* 9 (**10.1.4(23)**)

2. Whenever “X” appears in **Table R19.2**, it means that this special requirement for the dangerous goods is applicable.
3. Subscripts in **Table 9.10.3** are as follows.

a : When “mechanically - ventilated spaces” are required by *IMDG* Code.

b : Stow 3 *m* horizontally away from the machinery space boundaries in all cases.

c : Refer to *IMDG* Code.

d : As appropriate to the goods to be carried.

e : Under the provisions of the *IMDG* Code Code, as amended, storage of *Class* 5.2 dangerous goods below deck or in enclosed ro-ro spaces is prohibited.

f : Only applicable to dangerous goods evolving flammable vapour listed in the *IMDG* Code.

g : Only applicable to dangerous goods having a flashpoint less than 23 ℃ listed in the *IMDG* Code.

h : Only applicable to dangerous goods having a subsidiary risk *Class* 6.1.

i : Under the provisions of the *IMDG* Code, stowage of *Class* 2.3 having subsidiary risk *Class* 2.1 under deck or in enclosed ro-ro space is prohibited.

j : Under the provisions of the *IMDG* Code, storage of *Class* 4.3 liquids having a flashpoint less than 23 ℃ under deck or in enclosed ro-ro spaces is prohibited.

10.2 Special Requirements

10.2.1 Water Supplies

1 Arrangements are to be made to ensure immediate availability of a supply of water from the fire main at the required pressure either by permanent pressurization or by suitably placed remote arrangements for the fire pumps.

2 The quantity of water delivered is to be capable of supplying nozzles as specified in **11.2.4, Part 6**, capable of being trained on any part of the cargo space when empty. This amount of water may be applied by equivalent means to the satisfaction of the Society.

3 Means are to be provided for effectively cooling the designated underdeck cargo space by at least 5 l/m^2 *per minute* of the horizontal area of cargo spaces, either by a fixed arrangement of spraying nozzles or flooding the cargo space with water. Hoses may be used for this purpose in small cargo spaces and in small areas of larger cargo spaces at the discretion of the Society. However, the drainage and pumping arrangements are to be such as to prevent the build-up of free surfaces. The drainage system is to be sized to remove no less than 125 % of the combined capacity of both the water spraying system pumps and the required number of fire hose nozzles. The drainage system valves are to be operable from outside the protected space at a position in the vicinity of the extinguishing system controls. Bilge wells are to be of sufficient holding capacity and are to be arranged at the side shell of the ship at a distance from each other of not more than 40*m* in each watertight compartment. If this is not possible, suitable measures as deemed appropriate by the Society are to be taken to limit the adverse effect upon stability of the added weight and free surface of water in its approval of the stability information.

4 Provision to flood a designated under-deck cargo space with suitable specified media may be substituted for the requirements in **-3** above.

5 The total required capacity of the water supply is to satisfy the provisions of **-2** and **-3** above, if applicable, simultaneously calculated for the largest designated cargo space. The capacity requirements of **-2** above are to be met by the total capacity of the main fire pump(s) not including the capacity of the emergency fire pump, if fitted. If a drencher system is used to satisfy the provisions of **-3** above, the drencher pump is also to be taken into account in this total capacity calculation.

10.2.2 Sources of Ignition

Electrical equipment and wiring is not to be fitted in enclosed cargo spaces or vehicle spaces unless it is essential for operational purposes in the opinion of the Society. However, if electrical equipment is fitted in such spaces, it is to be of a certified safe type for use in the dangerous environments to which it may be exposed unless it is possible to completely isolate the electrical system (*e.g.* by removal of links in the system, other than fuses). Cable penetrations of the decks and bulkheads are to be sealed against the passage of gas or vapour. Through runs of cables and cables within the cargo spaces are to be protected against damage from impact. Any other equipment which may constitute a source of ignition of flammable vapour is not to be permitted.

10.2.3 Detection System

Ro-ro spaces are to be fitted with a fixed fire detection and fire alarm system complying with the requirements of **Chapter 29, Part R of the Rules for the Survey and Construction of Steel Ships**. All other types of cargo spaces are to be fitted with either a fixed fire detection and fire alarm system or a sample extraction smoke detection system complying with the requirements of **Chapters 29** or **30, Part R of the Rules for the Survey and Construction of Steel Ships**, respectively. If a sample extraction smoke detection system is fitted, particular attention is to be made to the provisions of **30.2.1-3, Part R of the Rules for the Survey and Construction of Steel**

Ships in order to prevent the leakage of toxic fumes into occupied areas.

10.2.4 Ventilation Arrangement

1 Adequate power ventilation is to be provided in enclosed cargo spaces. The arrangement is to be such as to provide for at least six air changes per hour in the cargo space based on an empty cargo space and for removal of vapours from the upper or lower parts of the cargo space, as appropriate.

2 The fans are to be such as to avoid the possibility of ignition of combustible combustible gas air mixtures. Suitable wire mesh guards are to be fitted over inlet and outlet ventilation openings.

3 Natural ventilation is to be provided in enclosed cargo spaces intended for the carriage of solid dangerous goods in bulk, where there is no provision for mechanical ventilation.

10.2.5 Bilge Pumping

1 Where it is intended to carry combustible or toxic liquids in enclosed cargo spaces, the bilge pumping system is to be designed to ensure against inadvertent pumping of such liquids through machinery space piping or pumps. Where large quantities of such liquids are carried, consideration is to be given to the provision of additional means of draining those cargo spaces.

2 If the bilge drainage system is additional to the system served by pumps in the machinery space, the capacity of the system is to be not less than 10 m^3/h per cargo space served. If the additional system is common, the capacity need not exceed 25 m^3/h. The additional bilge system need not be arranged with redundancy.

3 Whenever combustible or toxic liquids are carried, the bilge line into the machinery space is to be isolated either by a stop valve and a blank flange or by a closed lockable valve fitted in the machinery space.

4 Cargo spaces intended for carriage of combustible or toxic liquids and enclosed spaces outside machinery spaces containing bilge pumps serving such cargo spaces are to be fitted with separate mechanical ventilation of exhaust type giving at least 6 *air changes per hour*. If the space has access from another enclosed space, the door is to be of reasonably gas-tight and self-closing.

5 If bilge drainage of cargo spaces is arranged by gravity drainage, the drainage is to be either lead directly overboard or to a closed drain tank located outside the machinery spaces. The tank is to be provided with a vent pipe to a safe location on the open deck. Drainage from a cargo space into bilge wells in a lower space is only permitted if that space satisfies the same requirements as the cargo space above.

10.2.6 Personnel Protection

1 Four sets of full protective clothing resistant to chemical attack are to be provided in addition to the fire-fighter's outfits required by the provisions of **7.9**. The protective clothing is to cover all skin, so that no part of the body is unprotected. Protective clothing is to be selected taking into account the hazards associated with the chemicals being transported.

2 At least two self-contained breathing apparatuses additional to those required by **7.9** are to be provided. Two spare charges suitable for use with the breathing apparatus are to be provided for each required apparatus. Ships that are equipped with suitably located means for fully recharging the air cylinders free from contamination, need carry only one spare charge for each required apparatus.

10.2.7 Portable Fire Extinguishers

Portable fire extinguishers with a total capacity of at least 12 *kg* of dry powder or equivalent are to be provided for the cargo spaces. These extinguishers are to be in addition to any portable fire extinguishers required elsewhere in this Part.

10.2.8 Insulation of Machinery Space Boundaries

Bulkheads forming boundaries between cargo spaces and machinery spaces of category *A* are to be insulated to "*A*-60" class standard, unless the dangerous goods are stowed at least 3 *m* horizontally away from such bulkheads. Other boundaries between such spaces are to be insulated to "*A*-60" class standard.

10.2.9 Water Spray System

Each open ro-ro space having a deck above it and each space deemed to be a closed ro-ro space not capable of being sealed is to be fitted with an approved fixed pressure water-spraying system for manual operation which is to protect all parts of any deck and vehicle platform in such space, except that the Society may permit the use of any other fixed fire-extinguishing system that has been shown by full-scale test to be no less effective. In any event, the drainage and pumping arrangements are to be such as to prevent the build-up of free surfaces. The drainage system is to be sized to remove no less than 125 % of the combined capacity of both the water spraying system pumps and the required number of fire hose nozzles. The drainage system valves are to be operable from outside the protected space at a position in the vicinity of the extinguishing system controls. Bilge wells are to be of sufficient holding capacity and are to be arranged at the side shell of the ship at a distance from each other of not more than 40 *m* in each watertight compartment. If this is not possible, suitable measures as deemed appropriate by the Society are to be taken to limit the adverse effect upon stability of the added weight and free surface of water in its approval of the stability information.

10.2.10 Separation of Ro-ro Spaces

1 In ships having ro-ro spaces, a separation is to be provided between a closed ro-ro space and an adjacent open ro-ro space. The separation is to be such as to minimize the passage of dangerous vapours and liquids between such spaces. Alternatively, such separation need not be provided if the ro-ro space is considered to be a closed cargo space over its entire length and is to fully comply with the relevant special requirements of this Chapter.

2 In ships having ro-ro spaces, a separation is to be provided between a closed ro-ro space and the adjacent weather deck. The separation is to be such as to minimize the passage of dangerous vapours and liquids between such spaces. Alternatively, a separation need not be provided if the arrangements of the closed ro-ro spaces are in accordance with those required for the dangerous goods carried on adjacent weather deck.

Chapter 11 MEANS OF ESCAPE

11.1 General

11.1.1 Purpose

The purpose of this Chapter is to provide means of escape so that persons on board can safely and swiftly escape to the life boat and life raft embarkation deck. For this purpose, the following functional requirements are to be met:

(1) safe escape routes are to be provided;
(2) escape routes are to be maintained in a safe condition, clear of obstacles; and
(3) additional aids for escape are to be provided as necessary to ensure accessibility, clear marking, and adequate design for emergency situations.

11.2 General Requirements

11.2.1 Application

1 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.

2 Lifts are not considered as forming one of the required means of escape as required by this Chapter.

11.3 Means of Escape from Control Stations, Accommodation, Service and Important Spaces

11.3.1 General Requirements

1 Stairways and ladders are to be so arranged as to provide ready means of escape to the lifeboat and liferaft embarkation 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, service and important 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 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 compartment doors may open into the compartments in order to avoid injury to persons in the corridor when the door is opened; and
(2) doors in vertical emergency escape trunks may open out of the trunk in order to permit the trunk to be used both for escape and for access.

11.3.2 Details of Means of Escape

1 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 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 Above the lowest open deck the means of escape are to be stairways or doors to an open deck or a combination thereof.

4 No dead-end corridors having a length of more than 7 *m* is to be accepted.

5 The width, number and continuity of escape routes are to be in accordance with the requirements in the following means of escape.

(1) Stairways and corridors used as means of escape from control stations, accommodation and service spaces are to be not less than 700 *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. The angle of inclination of stairways from vertical line 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*. Doorways which give access to a stairway are to be of the same size as the stairway.

(2) For ladders equipped with hatches at the top means of escape, such as ships intended to navigate in threat sea area, they may apply the width and inclination of the ladder specified in **4.4.1**, **Part 6**.

6 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.

11.3.3 Emergency Escape Breathing Devices

1 Emergency escape breathing devices are to comply with the requirements in **Chapter 23**, **Part R of the Rules for the Survey and Construction of Steel Ships**. Spare emergency escape breathing devices are to be kept on board.

2 All ships are to carry at least two emergency escape breathing devices within accommodation spaces.

11.4 Means of Escape from Machinery Spaces

11.4.1 Escape from Machinery Spaces of Category *A*

Except as provided in **11.4.2**, two means of escape are to be provided from each machinery space of category *A*. In particular, one of the following provisions is to be complied with:

(1) two sets of steel ladders as widely separated as possible leading to doors in the upper part of the space similarly separated and from which access is provided to the open deck. One of these ladders is to be located within a protected enclosure that satisfies the provisions of **9.2.3-2** or **9.2.4-2**, **Part R of the Rules for the Survey and Construction of Steel Ships**, as applicable, as a space with stairways from the lower part of the space it serves to a safe position outside the space. Self-closing fire doors of the same fire integrity standards are to be fitted in the protected enclosure. The ladder is to be fixed in such a way that heat is not transferred into the protected enclosure through non-insulated fixing points. The protected enclosure is to have minimum internal dimensions of at least 800 *mm* x 800 *mm*, and is to have emergency lighting provisions; or

(2) one steel ladder leading to a door in the upper part of the space from which access is provided to the open deck and additionally, in the lower part of the space and in a position well separated from the ladder referred to, a steel door capable of being operated from each side and which provides access to a safe escape route from the lower part of the space to the open deck.

11.4.2 Dispensation from Two Means of Escape

In a ship of less than 1,000 *estimated gross tonnage*, the Society may dispense with one of the means of escape required by **11.4.1**, due regard being paid to the dimension and disposition of the upper part of the space. In addition, the means of escape from machinery spaces of category *A* need not comply with the requirement for a protected enclosure listed in **11.4.1(1)**. 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.

11.4.3 Escape from Machinery Spaces other than Those of Category *A*

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.

11.4.4 Inclined Ladders and Stairways

All inclined ladders/stairways fitted to comply with **11.4.1** with open treads in machinery spaces being part of or providing access to escape routes but not located within a protected enclosure are to be made of steel. Such ladders/stairways are to be fitted with steel shields attached to their undersides, such as to provide escaping personnel protection against heat and flame from beneath.

11.4.5 Escape from Machinery Control Rooms in Machinery Spaces of Category *A*

Two means of escape are to be provided from the machinery control room located within a machinery space. At least one of these escape routes are to provide a continuous fire shelter to a safe position outside the machinery space.

11.4.6 Escape from Main Workshops in Machinery Spaces of Category *A*

Two means of escape are to be provided from the main workshop within a machinery space. At least one of these escape routes are to provide a continuous fire shelter to a safe position outside the machinery space.

11.4.7 Emergency Escape Breathing Devices

1 On all ships, within the machinery spaces, emergency escape breathing devices 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 fire. The location of emergency escape breathing devices is to take into account the layout of the machinery space and the number of persons normally working in the spaces.

2 Emergency escape breathing devices are to comply with the requirements in **Chapter 23, Part R of the Rules for the Survey and Construction of Steel Ships**.

11.5 Means of Escape from Ro-ro Spaces

11.5.1 Arrangement of Means of Escape

At least two means of escape are to be provided in ro-ro spaces where the crews are normally employed. The escape routes are to provide a safe escape to the lifeboat and liferaft embarkation deck and are to be located at the fore and aft ends of the space.

Chapter 12 ALTERNATIVE DESIGN AND ARRANGEMENTS

12.1 General

12.1.1 Purpose

The purpose of this Chapter is to provide the methodology for alternative design and arrangements for fire safety.

12.1.2 Application

1 Fire safety design and arrangements may deviate from prescriptive requirements set out in **Chapters 2** to **11** except this Chapter, provided that the design and arrangements meet the fire safety objectives and the functional requirements of this Part.

2 When fire safety design or arrangements deviate from the prescriptive requirements of this Part, engineering analysis, evaluation and approval of the alternative design and arrangements are to be carried out in accordance with this Chapter.

12.1.3 Engineering Analysis

The engineering analysis is to be prepared based on the Guidelines on Alternative Design and Arrangements for Fire Safety (*MSC/Circ*.1002 (including amendments approved as *MSC/Circ*.1552), hereinafter referred to as "the Alternative Design Guidelines".) developed by the *IMO* and is to include, as a minimum, the following elements:

(1) Determination of the ship type and space(s) concerned;
(2) Identification of prescriptive requirement(s) with which the ship or the space(s) will not comply;
(3) Identification of the fire and explosion hazards of the ship or the space(s) concerned;
   (a) identification of the possible ignition sources;
   (b) identification of the fire growth potential of each space concerned;
   (c) identification of the smoke and toxic effluent generation potential for each space concerned;
   (d) identification of the potential for the spread of fire, smoke or of toxic effluents from the space(s) concerned to other spaces;
(4) Determination of the required fire safety performance criteria for the ships or the space(s) concerned addressed by the prescriptive requirement(s);
   (a) performance criteria are to be based on the fire safety objectives and on the functional requirements of this chapter;
   (b) performance criteria are to provide a degree of safety level not less than that achieved by using the prescriptive requirements; and
   (c) performance criteria are to be quantifiable and measurable;
(5) Detailed description of the alternative design and arrangements, including the list of the assumptions used in the design and any proposed operational restrictions or conditions; and
(6) Technical justification demonstrating that the alternative design and arrangements meet the required fire safety performance criteria.

12.1.4 Evaluation of the Alternative Design and Arrangements

1 The engineering analysis required in **12.1.2-2** is to be evaluated and approved by the Administration and the Society taking into account the Alternative Design Guidelines.

2 A copy of the documentation, as approved by the Administration and the Society, indicating that the alternative design and arrangements comply with this Chapter is to be carried on board the ship.

12.1.5 Re-evaluation due to Change of Conditions

If the assumptions, and operational restrictions that were stipulated in the alternative design and arrangements are changed, the engineering analysis is to be carried out under the changed condition and is to be approved by the Administration and the Society.

Part 10 SAFETY EQUIPMENT, NAVIGATIONAL EQUIPMENT, RADIO INSTALLATIONS AND ACCOMMODATION FACILITIES, ETC.

Chapter 1 GENERAL

1.1 General

1.1.1 Application

1 The requirements in this Part apply to safety equipment, navigational equipment, radio installations and accommodation facilities, etc. which are installed on ships for which an application for classification with class notations related to the equipment specified in **Part 1** is submitted.

2 In applying the requirements specified in international conventions such as *SOLAS* in this Part, the term "*gross tonnage*" is changed to the term "*estimated gross tonnage*".

1.1.2 Terminology

1 *SOLAS* Convention means the International Convention for the *Safety of Life at Sea* (1974), as amended and the Protocol of 1988 relating to the said convention, as amended.

2 *LSA Code* means the International Life-Saving Appliance Code adopted by the Maritime Safety Committee (*MSC*) of the International Maritime Organization (*IMO*) as resolution *MSC*.48 (66), as amended.

3 *COLREG* Convention means the Convention on the International Regulation for Preventing Collision at Sea (1972), as amended.

4 *MLC* Convention means the Maritime Labour Convention (2006), adopted by International Labour Organization (*ILO*).

1.1.3 National Requirements of Flag States, etc.

In addition to the application of the requirements in this Part, attention is to be paid to the national requirements of the countries in which governmental and naval ships are registered with respect to safety equipment, navigational equipment, radio installations and accommodation facilities.

Chapter 2 SAFETY EQUIPMENT

2.1 General

2.1.1 Application

The requirements in this Chapter apply to safety equipment such as life-saving appliances installed on the ships to which the class notation "*Life Saving Appliances*" is affixed to their Classification Characters.

2.1.2 General

1 Life buoys, personal life-saving appliances (*e.g.* lifejackets, immersion suits and anti-exposure suits), lifeboats, liferafts and their launching appliances and other life-saving appliances are to comply with relevant requirements of the *LSA* Code and are to be provided on board in accordance with the requirements in Chapter 3 of the *SOLAS* Convention. However, the personnel capacity for lifeboats and liferafts as well as the number of lifejackets and immersion suits provided are to be as deemed appropriate by the Administration.

2 Rescue boats complying with relevant requirements of the *LSA* Code or the boats such as launches or fire boats, work boats or other craft deemed appropriate by the Society are to be provided on board in accordance with relevant requirements of Chapter 3 of the *SOLAS* Convention.

3 In applying the requirement of **-1** above, the marking on the life buoy and lifejackets may be accepted to be marked with the ship's name only.

4 *GMDSS* life-saving appliances are to be provided on board in accordance with regulation 6 of Chapter 3 of the *SOLAS* Convention.

5 Life-saving appliances such as lifeboats, liferafts, life buoys, lifejackets, immersion suits, etc. are to be fitted with the retro-reflective materials using procedures deemed to be appropriate by the Society.

2.1.2 Testing at the Manufacturing Firms

1 Prior to providing any life-saving appliances on board, it is to be confirmed by third parties deemed appropriate by the Society that said appliances comply with the *LSA* Code or equivalent regulations recognized by the Society.

2 When the carrying out of surveys for life-saving appliances by third parties deemed appropriate by the Society is considered to be difficult, the Society may carry out said surveys instead.

Chapter 3 NAVIGATIONAL EQUIPMENT

3.1 General

3.1.1 Application

The requirements in this Chapter apply to navigational equipment installed on ships to which the class notation "*Safety Navigation*" is affixed to their Classification Characters.

3.1.2 Terminology

For the purpose of this Chapter, the following definitions are to apply.

(1) Nautical charts and nautical publications are special-purpose books (or specially compiled databases from which such maps or books are derived) that are issued officially by or on the authority of a government, an authorised hydrographic office or other relevant government instructions and is designed to meet the requirements of marine navigation.

(2) Integrated bridge systems are systems mutually connected to the units of relevant navigational equipment arranged in navigation bridges so as to integrate various information or orders to permit control of such from the navigation bridge.

3.1.3 General Requirements on the Design of Navigation Bridges

The aims of any design and arrangement of navigational systems and equipment on the bridge and bridge procedures are to be as follows:

(1) Facilitating the tasks to be performed by the bridge team and the pilot in making full appraisal of the situation and in navigating the ship safety under all operational conditions;

(2) Promoting effective and safe bridge resource management;

(3) Enabling the bridge team and the pilot to have convenient and continuous access to essential information, which is presented in a clear and unambiguous manner, using standardized symbols and coding systems for controls and displays;

(4) Indicating the operational status of automated functions and integrated components, systems and/or sub-systems;

(5) Allowing for expeditious, continuous and effective information processing and decision making by the bridge team and the pilot;

(6) Preventing or minimizing excessive or unnecessary work and any conditions or distractions on the bridge which may cause fatigue or interfere with the vigilance of the bridge team and the pilot; and

(7) Minimizing the risk of human error and detecting such error if it occurs, through monitoring and alarm systems, in time for the bridge team and the pilot to take appropriate action.

3.1.4 Electromagnetic Compatibility

1 Electrical and electronic equipment are to be so installed that electromagnetic interference does not affect the proper function of navigational systems and equipment.

2 Portable electrical and electronic equipment are not to be operated on the bridge when doing so may affect the proper function of navigational systems and equipment.

3 Where it is confirmed that the navigational equipment, and electrical and electronic equipment installed in a space arranged for navigational equipment comply with this **3.1.4**, the class notation "Electro-Magnetic Compatibility" is affixed to the Classification Characters in accordance with the requirement in **1.2.12-6 of Part 1**.

3.1.5 Navigational Equipment and Systems Offering Alternative Modes

Navigational equipment and systems offering alternative modes of operation are to indicate the actual mode of use.

3.1.6 Integrated Bridge Systems

The following measures with respect to the failure of one sub-system or one part of an integrated bridge system are to be taken.

(1) Visible and audible alarms are to be activated at the bridge.

(2) The failure of one sub-system or one part is not to lead the failures of other equipment and systems.

(3) Other sub-systems or parts of an integrated system are to be able to continuously operate either independently of each other or together as a system separately from the failed sub-system or part.

3.2 Navigational Equipment

3.2.1 Navigational Equipment

1 The following navigational equipment, navigation lights, signalling apparatuses and other communication systems are to comply with the requirements of Chapters II-1, II-2, III and V of the *SOLAS* Convention and the *COLREG* Convention.

(1) Navigational equipment
- (a) Magnetic compasses
- (b) Gyro compasses
- (c) Echo sounding devices
- (d) Speed and distance measuring devices
- (e) Rudder angle indicators
- (f) Propeller revolution rate indicators
- (g) Pitch and operational mode indicators for variable pitch propellers or lateral thrust propellers
- (h) Rate-of-turn indicators
- (i) Radars
- (j) Automatic radar plotting aids
- (k) Auto-pilots
- (l) Heading control systems or track control systems
- (m) Sound reception systems
- (n) Global positioning system receivers
- (o) Electronic plotting aids
- (p) Radar reflectors
- (q) Automatic tracking aids
- (r) Transmitting heading devices
- (s) Automatic identification systems
- (t) Voyage data recorders
- (u) Electronic chart display and information systems
- (v) Long-range identification and tracking systems
- (w) Bridge navigational watch alarm systems

(2) Navigation lights
- (a) Masthead lights
- (b) Sidelights
- (c) Sternlights
- (d) Towing lights
- (e) All-round white lights
- (f) All-round red lights

(3) Signalling apparatus and communication systems

(a) Daylight signalling lamps
(b) Forecastle bells
(c) Ship whistles
(d) Gongs
(e) Shapes
(f) International Code of Signal and International maritime signal flags
(g) *NAVTEX* receivers, enhanced group call equipment, *VHF* digital selective calling systems, *VHF* digital selective calling watch systems, digital selective calling systems, digital selective calling watch systems

(4) Nautical charts and nautical publications

(5) Two-way radio telephone apparatuses

2 For ships having a standard magnet compass, communication systems are to be provided between the locations installed with compasses and navigation bridges.

3 High speed ships are also to comply with relevant requirements of the *IMO* "*International Code of Safety for High Speed Craft*", as amended.

4 For ships carrying dangerous goods, air-cushion vehicles, ships engaged in towing operations, ships of restricted manouevering ability, pilot boats, emergency vessels, route support vessels, etc., additional navigation lights or shapes deemed appropriate by the Society are to be provided on board.

5 Ships operating in polar waters are to comply with the relevant requirements of the *International Code for Ships Operating in Polar Waters*, as amended.

Chapter 4 RADIO INSTALLATIONS

4.1 General

4.1.1 Application

The requirements in this Chapter apply to ships and radio installations installed on ships to which the class notation "*Safety Radio*" is affixed to their Classification Characters.

4.2 Radio Installations

4.2.1 Arrangements and Performance

1 The arrangements of radio equipment and installations are to comply with the requirements specified in the following **(1)** to **(5)**.

(1) Radio installations are to be so located that no harmful interference of mechanical, electrical or of any other type affects their proper use as well as to ensure electromagnetic compatibility and avoidance of harmful interaction with other equipment and systems.

(2) Radio installations are to be so located as to ensure the greatest possible degree of safety and operational availability.

(3) Radio installations are to be protected against harmful effects of water, extremes temperature and other adverse environmental conditions.

(4) Radio installations are to be provided with reliable and permanently arranged electrical lighting (independent of main and emergency sources of electrical power) for the adequate illumination of the radio controls required for operation.

(5) Radio installations are to be clearly marked with the call sign, the ship station identity and other codes applicable to their use.

2 The following radio installations provided on board are to comply with relevant requirements of the *SOLAS* Convention.

(1) *VHF* radio installations
(2) *MF* radio installations
(3) *MF*/*HF* radio installations
(4) *INMARSAT* communication installations
(5) Ship radar transponders and *AIS-SART*
(6) International *NAVTEX* receivers
(7) Satellite emergency position indicating radio beacons
(8) Two-way *VHF* radiotelephone apparatuses
(9) Survival craft radar transponders and *AIS-SART*

4.3 Communication Systems

4.3.1 General

1 Ships at sea are to have the communication systems which are capable of the following:

(1) Transmitting ship-to-shore distress alerts by at least two separate and independent means, each using a different radio communication service;
(2) Receiving shore-to-ship distress alerts;
(3) Transmitting and receiving ship-to-ship distress alerts;
(4) Transmitting and receiving search and rescue coordinating communications;
(5) Transmitting and receiving on-scene communications;
(6) Transmitting and receiving signals for locating by means of radars operated in the 9 *GHz*

band;

(7) Transmitting and receiving maritime safety information;

(8) Transmitting and receiving general radio-communications to and from shore-based radio systems or networks; and

(9) Transmitting and receiving bridge-to-bridge communications

2 Communication systems and telephone systems for ship operation are to be as deemed appropriate by the Society.

Chapter 5 ACCOMMODATION AND SANITARY FACILITIES

5.1 General

5.1.1 Application

The requirements in this Chapter apply to the accommodation and sanitary facilities of ships to which the class notation "*Adequate Accommodation Facilities*" is affixed to their Classification Characters.

5.2 Accommodation Facilities, Sanitary Facilities, etc.

5.2.1 General

1 Accommodation facilities, recreational facilities, sanitary facilities and conning spaces are to comply with regulation 3.1 of Chapter 3 of the *MLC* Convention, except for the requirements for passenger ships and special purpose ships.

2 Regardless of compliance with the requirement in **-1** above, the Society may approve such facilities in consideration of ship size, type or intended service when it deems such a thing to be unavoidable. Where facilities, their arrangements and other items related to crew safety are not in compliance with the requirement in **-1** above, safety assessments for such items are to be carried out in accordance with the requirements in **Part 12**, and it is to be confirmed that risk levels are appropriately reduced to acceptable levels.

3 Lighting equipment is to be provided in crew accommodation rooms, on the navigation bridge and in machinery control rooms.

5.2.2 Prevention of Noise, etc.

1 Ships of an estimated gross tonnage of 1,600 *tons* and over for which an application for classification with the class notation "*Noise Code*" in accordance with the requirement in **1.2.9-1 of Part 1** is submitted are to comply with the preventive measures for noise in accordance with the following **(1)** to **(3)**, except in cases deemed unnecessary by the Society.

(1) The noise level in each compartment does not exceed the sound level deemed appropriate by the Society. The measurement of noise levels is to be carried out using procedures deemed appropriate by the Society.

(2) The bulkheads and decks in the accommodation spaces are to have airborne sound insulation deemed appropriate by the Society.

(3) Ships having spaces whose noise levels exceed 85 *dB*(*A*) are to be provided with ear protectors and alert indicators as deemed appropriate by to the Society.

2 Ships for which an application for classification with the class notation "*Noise and Vibration Comfort*" in accordance with the requirement in **1.2.9-2 of Part 1** is submitted are to comply with relevant requirements in the NK "*Noise and Vibration Guideline*" specified separately by the Society.

Part 11 MARINE POLLUTION PREVENTION SYSTEMS, ETC.

Chapter 1 GENERAL

1.1 General

1.1.1 Application

The requirements in this Part apply to ships for which an application for classification with class notations related to the marine and air pollution prevention systems specified in **1.2.8**, **Part 1** is submitted.

1.1.2 National Requirements of Flag States, etc.

In addition to the requirements in this Part, attention is to be paid to the national requirements of the countries in which ships are registered as well as the national requirements of any coastal states whose waters ships are intended to navigate or whose ports ships are intended to call, with respect to any structures and equipment related to the prevention of marine pollution.

1.1.3 Terminology

In applying this Part, where the terminology used in **Chapter 2**, **Part 1** is defined in **the Rules for Marine Pollution Prevention Systems**, the definitions given in **the Rules for Marine Pollution Prevention Systems** are to take precedence over those given in **Chapter 2**, **Part 1**.

1.1.4 Surveys

Ships applying the requirements in this Part are to be subject to surveys in accordance with the requirements in **Part 2**.

1.1.5 Application of the Rules for Marine Pollution Prevention Systems

In applying the **Rules for Marine Pollution Prevention Systems**, the term "gross tonnage" is changed to the term "estimated gross tonnage".

1.2 Construction and Equipment for the Prevention of Pollution by Oil

1.2.1 Construction and Equipment for the Prevention of Pollution by Oil

Ships with the class notation "*MARPOL ANNEX I*" affixed to their Classification Characters in accordance with the requirements in **1.2.8(1)**, **Part 1**, are to comply with relevant requirements in **Part 3 of the Rules for Marine Pollution Prevention Systems**.

1.3 Construction and Equipment for the Prevention of Pollution by Discharges of Noxious Liquid Substances in Bulk

1.3.1 Construction and Equipment for the Prevention of Pollution by Discharges of Noxious Liquid Substances in Bulk

Ships with the class notation "*MARPOL ANNEX II*" affixed to their Classification Characters in accordance with the requirements in **1.2.8(2)**, **Part 1**, are to comply with relevant requirements in **Part 4 of the Rules for Marine Pollution Prevention Systems**.

1.4 Equipment for the Prevention of Pollution by Sewage from Ships

1.4.1 Equipment for the Prevention of Pollution by Sewage from Ships

Ships with the class notation "*MARPOL ANNEX IV*" affixed to their Classification Characters in accordance with the requirements in **1.2.8(3)**, **Part 1**, are to comply with relevant requirements in **Part 7 of the Rules for Marine Pollution Prevention Systems**.

1.5 Equipment for the Prevention of Pollution by Garbage from Ships

1.5.1 Equipment for the Prevention of Pollution by Garbage from Ships

Ships with the class notation "*MARPOL ANNEX V*" affixed to their Classification Characters in accordance with the requirements in **1.2.8(4)**, **Part 1**, are to comply with relevant requirements in Annex V of the International Convention for the Prevention of Pollution form Ships, 1973, as modified by the Protocol of 1978 and as amended (Hereinafter referred to as "*MARPOL* Convention".).

1.6 Equipment for the Prevention of Air Pollution from Ships

1.6.1 Equipment for the Prevention of Air Pollution from Ships

Ships with the class notation "*MARPOL ANNEX VI*" affixed to their Classification Characters in accordance with the requirements in **1.2.8(5)**, **Part 1**, are to comply with relevant requirements in **Part 8 of the Rules for Marine Pollution Prevention Systems**.

1.7 Anti-Fouling Systems

1.7.1 Anti-Fouling Systems

Ships with the class notation "*Anti-Fouling System*" affixed to their Classification Characters in accordance with the requirements in **1.2.8(6)**, **Part 1**, are to comply with relevant requirements in **Chapter 3 of the Rules for Anti-Fouling Systems on Ships**.

1.8 Equipment for the Ballast Water Management

1.8.1 Equipment for the Ballast Water Management

Ships with the class notation "*Ballast Water Management System*" affixed to their Classification Characters in accordance with the requirements in **1.2.8(7)**, **Part 1**, are to comply with relevant requirements in **Part 3 of the Rules for Ballast Water Management Installations**.

1.9 Inventory of Hazardous Materials on Ships

1.9.1 Inventory of Hazardous Materials on Ships

Ships with the class notation "*Inventory of Hazardous Material*" affixed to their Classification Characters in accordance with the requirements in **1.2.8(8)**, **Part 1**, are to inventory and make a list of hazardous materials used in ship construction and in equipment in accordance with the "Guidelines for the Inventory of Hazardous Materials" based on Hong Kong International Convention for the Safe and Environmentally Sound Recycling of Ships, 2009, and the inventory is to be confirmed by the Society.

1.10 Environmental Measures

1.10.1 Environmental Measures

In addition to environmental measures required by international conventions which are mandated internationally, ships with the class notation "*Environmental Awareness*" affixed to their Classification Characters in accordance with the requirements in **1.2.8(9)**, **Part 1**, are to take additional measures complying with requirements in the NK "**Environmental Guideline**" specified separately by the Society.

Part 12 SAFETY ASSESSMENTS

Chapter 1 GENERAL

1.1 General

1.1.1 Application

1 This Part describes procedures for assessing and demonstrating the equivalency or degree of improvement of the performance of items which do not come under or are not applicable to the provisions in each Part of the Rules. However, where only a single item or system is assessed, a simplified assessment procedure may be accepted.

2 Safety assessments are to be carried out for the structural integrity of a ship with respect to the effects of collisions, grounding, flooding, fire, etc. on the operation of the ship due to the failure of equipment or loss of function of equipment, or due to a malfunction or an operational error of the equipment for automatic or remote control systems. In cases where a safety assessment is carried out, the class notation "*Risk Assessment*" is affixed to the Classification Characters in accordance with the requirements specified in **1.2.12-11** of **Part 1**.

3 A safety assessment means a risk assessment, in general, and is carried out to mainly assess the following items.

(1) Risks to human life
(2) Risks to survivability of the ship
(3) Risks to the return ability of the ship
(4) Risks to the restorability of the functioning of equipment

1.1.2 Terminology

1 "Harm" refers to bodily injury or health threats and includes loss of life, or damage to property or the environment. It also includes loss and other unanticipated results.

2 "Accident" refers to a unanticipated event leading to harm or loss of normal function.

3 "Hazard" is a factor leading to harm to life, health, property or the environment. It is also referred to as a "hazard factor".

4 "Risk" refers to the potential for some harm to occur because of some hazard in a system, multiplying the magnitude of the harm by the probability of the occurrence of such harm.

5 "Magnitude of Risk" means the value obtained by multiplying the degree of harm (or magnitude of damage) by the occurrence frequency of harm (the occurrence probability of harm).

6 "Accident scenario" means the scenario when a series of stages up to harm is assumed from the initial condition in which the potential for hazard exists.

7 "Hazard identification" refers to identifying a hazard or its process from the systematic use of information such as statistical data or by brainstorming about the system to be subjected to risk assessment.

8 "Risk analysis" refers to the process of creating an accident scenario from the identified hazard, constructing a risk model, analyzing the occurrence frequency and severity, and estimating the risk. Sometimes it is also called the process for identifying a hazard in a system to be subjected to risk assessment and calculating the quantitative risk from the occurrence frequency of harm and severity of harm.

9 "Assessment of magnitude of risk" means the process for assessing whether the magnitude of risk (level of risk or risk level) obtained from the results of risk assessment is allowable.

10 "Risk control option" refers to measures implemented for reducing risk. The risk control option includes avoiding hazards, reducing the magnitude of harm, and restricting the ease of

occurrence of harm.
11 “Risk assessment” refers to a series of processes consisting of hazard identification and risk analysis, assessing the magnitude of risk, and risk control option.
12 “Residual risk” is the risk remaining even after adopting risk control measures.
13 “Acceptable risk” refers to a risk that can be accepted under assigned conditions based on the value system of the society at that particular time.
14 “*ALARP* (As Low As Reasonably Practicable） region” is a region of an intermediate level of risk, when the risk may be categorized into three levels: unacceptable level, widely acceptable level and intermediate level between these two levels, depending upon the magnitude of the risk. Risk in the *ALARP* region is considered acceptable if it is in the “as low as reasonably practicable” condition in the rational and executable range. Here, “reasonable (rational)” is judged by considering the cost benefits of risk control option, the convenience, and the existing technical level.
15 “*HAZID* (Hazard Identification) Conference is a meeting of experts to obtain information required for risk assessment (hazard, accident scenario, etc.) from the findings of knowledgeable persons.

1.2 Risk Assessment

1.2.1 Preparation for Executing a Risk Assessment

The event or system (items) to be risk assessed are first to be determined, and then the selection of the experts, the period and costs for the risk assessment are to be determined.

1.2.2 Hazard Identification

1 The hazards considered for a system (all matters with the possibility of causing harm) are to be listed as the first step of hazard identification.
2 The risk is to be estimated for each hazard.
3 In hazard identification, as much as possible relevant information is to be collected either by holding meetings with multiple experts who have wide-ranging professional knowledge related to the relevant system or by asking said experts to complete a questionnaire.
4 Hazard identification methods include the Structured What IF Technique (*SWIFT*), the Failure Mode Effective Analysis (*FMEA*), the Failure Mode, Effects and Criticality Analysis (*FMECA*), the Hazard and Operability Study (*HAZOP*), the Delphi method, in addition to the methods specified in **-2**.
5 In order to judge whether detailed analysis for an identified hazard is necessary or to select a hazard for which detailed analysis is necessary, the approximate risk from each hazard is to be estimated. Generally, qualitative methods may be used for estimation purposes by substituting and expressing severity in terms of a Severity Index (*SI*) value and frequency in terms of a Frequency Index (*FI*) value. (Example *SI* value and *FI* value are shown in **Table 12.1.1** and **Table 12.1.2**, respectively.)
6 The risk index is to be estimated qualitatively by plotting the occurrence of harm on the vertical axis and the magnitude of harm on the horizontal axis. (As example is shown in **Table 12.1.3**)
7 The obtained hazard is to be ranked from the qualitative risk index for each hazard, and based upon such information it is to be judged whether a detailed analysis is necessary.

Table 12.1.1 Examples of Severity Index (*SI*)

SI Value	Qualitative expression	Effect on human beings	Conversion to death toll
1	Minor effect	Single casualty or multiple persons with slight injuries	0.01
2	Large effect	Multiple casualties or severely wounded persons	0.1
3	Severe effect	Single fatality or many severely wounded persons	1
4	Catastrophic effect	Multiple fatalities	10

Table 12.1.2 Examples of Frequency Index (*FI*)

FI Value	Qualitative expression	Definition	One-system, per year
7	Frequent	Occurs about once a month in one system	10
5	Sometimes	Occurs about once a year in ten systems. Or several times in the course of operation over a period of 20 to 30 years of one system	0.1
3	Rarely	About once a year in one thousand systems; about once in several similar systems over a period of operation of 20 to 30 years	0.001
1	Extremely rare	Assuming 5,000 systems, occurs about once over a period of operation of 20 to 30 years for all the systems	0.00001

Table 12.1.3 Example of Risk Matrix

		Severity Index (*SI*)			
		1	2	3	4
Frequency Index (*FI*)	7	8	9	10	11
	6	7	8	9	10
	5	6	7	8	9
	4	5	6	7	8
	3	4	5	6	7
	2	3	4	5	6
	1	2	3	4	5

1.2.3 Estimation of Risk

1 Each simplified accident scenario obtained by hazard identification is to be assessed in detail, and a refined accident scenario is to be obtained. The risk value is to be estimated from each refined accident scenario.

2 In order to obtain the risk value, the accident scenario is to be expressed as a risk model.

3 Typical models used for expressing risk models are the Fault Tree (*FT*), the Event Tree (*ET*), with the corresponding methods of analysis called Fault Tree Analysis (*FTA*) and Event Tree Analysis (*ETA*), respectively.

(1) Fault Tree Analysis (*FTA*) is a method in which the ultimate harm that could occur is taken as the top event, and its causes are expressed top down and prepared until the bottom event. The probability of occurrence of each event is then estimated, and finally the probability of arriving at the top event is estimated. A list of every event together with its probability is can be based upon the experience of many knowledgeable persons or upon data obtained for similar systems.

(2) Event Tree Analysis (*ETA*) is a method in which the stages from the initial event that becomes the origin of an accident to the final event after passing through several intermediate events are expressed as a time series. The problems of each intermediate event and probability of divergence are estimated based upon the experience of many knowledgeable persons or upon data obtained for similar systems.

1.2.4 Assessment of the Magnitude of Risk and the Acceptability of Risk

1 The risk value of a system under study is to reference risk assessment standards, and is to be judged as to whether the risk is acceptable. A decision is to then be made on whether a risk control option is to be taken.

2 A risk assessment standard is to be established for each system. In such cases, the risk assessment standard needs to be selected in reference to the judgment criteria for other systems, the existing technical level, the social safety target and the value system of the society at that particular time.

3 A risk is to be categorized as falling within either the "unacceptable region", "widely acceptable region", or "*ALARP* region".

4 Where there are prescriptive rule requirements applicable to a system being evaluated and system equivalency is required, a system complying with these prescriptive requirements is to be evaluated, and the boundary between the "unacceptable region" and "*ALARP* region", or the boundary between "*ALARP* region" and "widely acceptable region" is to be determined. These boundaries are then to be referenced when evaluating. Generally, systems complying with the prescriptive rule requirements are judged as falling within the "*ALARP* region".

1.2.5 Risk Control Option

1 Any risk judged as falling within the "unacceptable region" is to be avoided.

2 Risk control options are considered unnecessary for risk judged as falling within the "widely acceptable region".

3 Risks judged as being intermediate, i.e. falling within the "*ALARP* region", are to have rational and executable risk control options implemented in consideration of the cost benefits and convenience as well as the existing technical level.

4 In principle, risk control options for which the effects of risk reduction are clearly verified and for which demonstrable safety techniques are used are to be implemented.

5 Risk control options are categorised into three types or steps: intrinsic safety design measures, safeguards and additional protective measures, and usage information measures. Risk control options are to generally be considered in the order of intrinsic safety design measures, safeguards and additional protective measures, and usage information measures.

(1) Intrinsic safety design measures include eliminating the hazards related to the risk, reducing the ease with which harm occurs, reducing the magnitude of the harm, etc. and are taken at the design stage. For example, the use of redundant equipment and the arranging such equipment is independently of each other.

(2) Safeguards and additional protective measures are taken for reducing residual risk where such risk still remains after taking the measures specified in **(1)** above. For example, risk is able to be reduced by keeping out any residual hazard or by isolating through safeguards or stopping any moving equipment which might create a dangerous situation.

(3) After implementing the measures specified in **(1)** and **(2)**, usage information measures are to be taken which provide information of how much and what form of any residual acceptable risk remains is given to the user, including the use of warning signs, and alarms, etc. However, it must be carefully noted that risk cannot be reduced by only providing such usage information and that attention is also to be paid to other organizational measures for managing at the risk even at the site level such as ensuring wide notice, education and training, safety work procedures, supervisors etc.

6 The residual risk remaining after all risk control options are taken is to be assessed in accordance with the provisions in **1.2.2** to **1.2.4**.

7 Where a new hazard is identified after the results of the assessment specified in **-6**, or the effects of any risk reduction is judged to be small, additional risk control options are to be considered.

1.3 Results of Risk Assessments

1.3.1 General

The results of the risk assessments as well as the data and materials used for the risk assessments are to be submitted to the Society for reference.