CHINA CLASSIFICATION SOCIETY

RULES FOR CLASSIFICATION OF SMALL SEA-GOING BOATS

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Chapter 1 GENERAL

Section 1 General Provisions

1.1.1 General requirements

1.1.1.1 The Rules apply to sea-going boats of less than 20 m in length. Unless otherwise stated, the Rules do not apply to:
(1) boats of war;
(2) yachts;
(3) oil tankers carrying oil having a flash point not exceeding 60℃(closed cup test);
(4) boats carrying dangerous goods (including bulk chemical carriers and liquefied gas carriers);
(5) submerged and semi-submerged boats;
(6) small water-plane area twin-hull boats;
(7) sports boats; and
(8) fishing boats.
1.1.1.2 The service restriction for boats to which the Rules are applicable is specified as follows:
(1) **Greater coastal service restriction** means the service in the sea area within 200 n miles off the shore, and a passenger boat does not proceed in the course of its voyage more than 4 h, or a cargo boat 8 h, at operational speed from a place of refuge① when fully laden. Where the sea state of some service areas above-mentioned is heavier, more stringent requirements may be made by CCS to the distance above-mentioned, depending on the specific cases. When special provisions for the service area are stipulated by the Administration of the flag State or by the coastal Authority in charge of the service area, the provisions are to be observed.
(2) **Coastal service restriction** means the service in the sea area within 20 n miles off the shore, and a passenger boat does not proceed in the course of its voyage more than 4 h, or a cargo boat 8 h, at operational speed from a place of refuge when fully laden. Where the sea state of some service areas above-mentioned is heavier, more stringent requirements may be made by CCS to the distance above-mentioned, depending on the specific cases. When special provisions for the service area are stipulated by the Administration of the flag State or by the coastal Authority in charge of the service area, the provisions are to be observed.
(3) **Sheltered water service restriction** means the service in the sea area between the island and the shore and between islands with a distance of less than 10 n miles in between, which form a comparatively good sheltered condition with a little wave, or within 10 n miles off the shore, and a passenger boat does not proceed in the course of its voyage more than 2 h, or a cargo boat 4 h, at operational speed from a place of refuge when fully laden, Beaufort wind scale not more than 6 scale, and the visual wave height not more than 2 m in sea state.
(4) **Calm water service restriction** means the service in the sea area within 5 n miles off the shore and a boat does not proceed in the course of its voyage more than 2 h at operational speed when fully laden, Beaufort wind scale not more than 6 scale, and the visual wave height not more than 1 m in sea state.
1.1.1.3 Operation of open boat is generally to be limited in the condition of Beaufort wind scale not more than 6 scale, and visual wave height not more than 1 m in sea state, and the boat does not proceed in the course of its voyage more than 2 h. High speed open boat is not permitted to carry more than 12 passengers.
1.1.1.4 The materials for boats to which the Rules are applicable may be steel, aluminum alloy, fabric reinforced plastics or wood. The materials and construction technology of boats are to be in compliance with the relevant requirements of Rules for Materials and Welding released by China Classification Society (hereinafter referred to as CCS). Wood materials are to be in compliance with the recognized standards accepted by CCS.
1.1.1.5 The existing boats after repair, alteration or modification are at least to be in compliance with the applicable requirements of the original corresponding rules. Where major repair, alternation or modification are made, the parts where major repair, alternation and modification

① Place of refuge is any naturally or artificially sheltered area which may be used as a shelter by a boat under conditions likely to endanger its safety.

are made and related parts are to comply with the requirements of the new rules in so far as reasonable and practicable.

1.1.1.6 Safety equipment and environmental protection including stability, fire safety, life-saving appliances, communication/navigation equipment and signal equipment etc. of boats are to comply with the requirements of the flag State Administration.

1.1.1.7 Except as provided in the Rules, certification of marine products are to be implemented in accordance with the requirements of Chapter 3, PART ONE of CCS Rules for Classification of Sea-Going Steel Ships.

1.1.2 Definitions

1.1.2.1 Unless expressly provided otherwise, for the purpose of the Rules:

(1) **Overall length L_{oa}** (m) means the horizontal distance from foremost end to the aftermost end of a boat. This length includes all structural and integral parts of the boat, such as stem or stern posts, bulwarks and hull/deck joints. This length excludes removable parts without affecting the structural integrity of the boat, e.g. spars, bowsprits, pulpits at either end of the boat, stemhead fittings, rudders, outdrives and their mounting brackets and plates, diving platforms, rubbing strakes, fenders and wave suppression plates. For multihull boat, the length of each hull is to be measured individually. The overall length L_{oa} is to be taken as the longest of the individual measurements.

(2) **Length L** (m) means the length between the forward stem post and after rudder post along the full load waterline of a boat, or the length between the forward stem post and the center line of the rudder stock for a boat without rudderpost (length between the forward stem post and stern transom plating for a boat without rudder stock). For high speed craft, the length L means the overall length of the underwater watertight envelope of the rigid hull, excluding appendages at or below the design waterline, when the craft is in rest floatation. In boats designed with a rake of keel the waterline on which this is measured is to be parallel to the designed waterline.

(3) **Full-load displacement** $\triangle$ (t) means the weight of sea water displaced by a boat under an immediate sailing condition with the required crew, equipment, cargo stores, accessories, fittings and rigging, etc., 100% of fuel oil, lubricating oil, fresh water, food, supplies and rated passengers onboard the boat.

(4) **Full load draft d** (m) means the vertical distance measured at the midpoint of length (L) from the top (or from the lower surface of keel for fabric reinforced plastics boat and wooden boat) of the plate keel (excluding ballast keel) to the full load waterline of a boat at full-load displacement in rest floatation.

(5) **Breadth B** (m) means the horizontal distance measured from the outside of the boat frame of one to that of other side; or the maximum breadth between two sides of external surfaces for fabric reinforced plastics boat and wooden boat, at the widest part of a boat, excluding protrusions, fenders, etc. For multihulls, B is the maximum breadth measured to the outer hulls.

(6) **Moulded depth D** (m) means the vertical distance measured at the middle of the length L from the top (for fabric reinforced plastics boat and wooden boat, measured from the lower surface) of the plate keel (excluding ballast keel) to deck sheer line/top line of the hull.

(7) **Deck sheer line /top line of hull** means the intersection of deck and hull. For rounded deck edge, it is the normal intersection. If deck is not fitted or the hull extends above the deck (bulwark), it means the top line of hull.

(8) **Block coefficient C_b** is the boat form coefficient calculated according to the following formula:

$$C_b = \frac{\Delta}{1.025 L B_{WL} d}$$

where: B_{WL} is the breadth at full load waterline, in m.

(9) **Freeboard deck** means a continuous weathertight deck from bow to stern on decked boat.

(10) **New boat** means a boat for which the building contract is placed on or after the date on which the Rules enters into force.

(11) **Existing boat** means a boat which is not a new boat.

(12) **High speed craft** means a craft capable of a maximum speed V meeting both the following formulae at its full-load displacement:

$$V \geqslant 7.19 \nabla^{0.1667} \quad \text{kn}$$

$$V \geqslant 10 \quad kn$$

where: ∇ – displacement corresponding to its full-load displacement, in m^3;

V – speed achieved at its maximum continuous propulsion power for which the boat is certified at its full-loaded displacement and in smooth water.

(13) **Decked boat** means a boat having a continuous weathertight deck from bow to stern.

(14) **Open boat** means a boat which is not a decked boat.

(15) **Passenger boat** means a boat carrying more than 12 passengers.

(16) **Cargo boat** means any boat other than passenger boat.

(17) **Sailing boat** is the boat for which the primary means of propulsion is by wind power. The sum of the projected area A_s (excluding overlapped parts) of all sails which may be opened at a time when navigating against the wind is to be as follows:

$$A_s \geqslant 7(\triangle)^{2/3} \quad m^2$$

where: $\triangle$– full load displacement, in *t*.

(18) **Self-propelled boat** means a boat mainly driven by mechanical means of propulsion for navigation.

(19) **Non-propulsion boat** means the boat other than self-propelled boat.

(20) **Passenger** is the person other than:

① the master and the members of the crew or other persons employed or engaged in any capacity on board a boat on the business of that boat; and

② a child under one year of age.

(21) **Crew** means personnel provided for the navigation of boat, maintenance of boat, machinery, system and propulsion and key devices for safety navigation and personnel providing services to other people onboard the boat.

(22) **Occupant** means all persons onboard the boat, including passengers and crew.

(23) **Major repairs, alterations or modifications** (hereinafter referred to as major conversions) means conversions which substantially change one or more of the following characteristics of existing boats: main dimensions of a boat; boat type; level of subdivision of a boat; carrying capacity of a boat; passenger accommodation spaces; increasing a boat's service life; other major conversions in the opinion of the Administration.

1.1.3 Equivalent and exemption

1.1.3.1 Any boat which embodies structure and features of a novel kind may be exempted from any requirement of the Rules if the application of which might seriously impede the incorporation of its features or its service, subject to agreement by the Headquarters of CCS.

1.1.3.2 Any fitting, material, appliance or apparatus, in substitution of that required in CCS Rules, may be allowed to be fitted in a boat, if it is satisfied by trial thereof or otherwise that such fitting, material, appliance or apparatus is at least as effective as that required in the Rules.

1.1.3.3 Equivalence or substitution to those methods of calculation, criteria of evaluation, manufacturing procedures, materials, survey and test requirements specified by the Rules may be accepted subject to agreement by the Headquarters of CCS, when relevant tests, theoretical basis or service experience are provided, or recognized effective standards are available.

1.1.4 Interpretations of the Rules

1.1.4.1 The right of interpretations on the Rules is to be left solely to the Headquarters of CCS.

1.1.4.2 In case of any different understanding to the English version of the Rules, the currently effective Chinese version of the Rules is to prevail.

1.1.5 Statutory surveys

1.1.5.1 CCS will undertake part or entire statutory surveys of boats under the authority of the Government of flag States and in accordance with the application or contracts/agreements from the boat owners or designers or boatyards.

1.1.5.2 For boats intended to be classed with CCS, CCS will carry out the classification survey in conjunction with the statutory survey when so authorized.

1.1.5.3 CCS will issue relevant statutory certificates, document of compliance and/or reports, upon completion of plan approval, surveys during construction and after construction, and after the classification part is confirmed complying with the CCS requirements relating to classification and satisfying the corresponding statutory requirements.

1.1.5.4 For boats of which the classification and statutory surveys are carried out by CCS, once the classification certificate is invalid, the corresponding statutory certificate will be invalid simultaneously.

Section 2 Characters of Classification and Class Notations

1.2.1 Characters of classification

1.2.1.1 Boats applied for classification survey and have classed with CCS is to be assigned with the following characters of classification as appropriate after approval:

★ CSA
★ CSM

or

★ CSA
★ CSM

or

★ CSA
★ CSM

The meanings of characters of classification are as follows:

★ CSA — indicating that the boat's hull structure and equipment have been constructed with plan approval by and under the supervision of CCS and comply with the Rules.

★ CSA — indicating that the boat's hull structure and equipment have been constructed not with plan approval by and not under the supervision of CCS, and that they have been found upon classification survey by CCS to be in compliance with the Rules;

★ CSM — indicating that the boat's propulsion and essential auxiliary machinery have been inspected by CCS, and that its machinery and electrical installations have been constructed with plan approval by and under the supervision of CCS and comply with the Rules.

★ CSM — indicating that the boat's propulsion and essential auxiliary machinery have not been inspected by CCS, and that its machinery and electrical installations have been constructed with plan approval by and under the supervision of CCS and comply with the Rules;

★ CSM — indicating that the boat's machinery and electrical installations have been constructed not with plan approval by and not under the supervision of CCS, and that they have been found upon classification survey by CCS to be in compliance with the Rules.

1.2.2 Class notations

1.2.2.1 Boats classed with CCS will be assigned type notations and service restriction notations to be affixed to the character of classification, depending on the specific cases. See Table A, Table B and Table C for different class notations.

1.2.2.2 At the request of the shipowner, class notation(s) may be added for small sea-going boats according to relevant CCS rules/guidelines.

1.2.2.3 General principles for identification of class notations are as follows:

(1) Class notations are marked after characters of classification, where the notations for type of boat and service restriction or limitation are marked after the characters ★CSA and the notations for special equipment and system are marked after the characters ★CSM.

(2) The class notations for type of boat, service restriction or limitation are necessary notations and are to be assigned together with characters of classification.

(3) Every two sets of class notations are to be separated by a semicolon ";".

(4) Unless specifically stated otherwise, class notations are generally given in the sequence A ~ C as shown in the table below:

For example, in respect to a high speed public affair boat constructed according to CCS rules, engaged in coastal service, propelled purely by battery and installed with solar power photovoltaic system, the following characters of classification and class notations are to be assigned:

★ CSA Public Affair Boat (HSC); Coastal Service Restriction

★ CSM Battery(power); SPV

Type Notations[①] **Table A**

<table>
<tr><th>Class notation</th><th colspan="3">Description</th></tr>
<tr><td>Passenger Boat</td><td>Passenger boat</td><td colspan="2">Boats carrying more than 12 passengers</td></tr>
<tr><td>Cargo Boat</td><td>Cargo boat</td><td colspan="2">Boats used for the carriage of cargoes</td></tr>
<tr><td>Non-propulsion Boat</td><td>Non-propulsion boat</td><td colspan="2">Small boats not provided with propulsion equipment for navigation purposes</td></tr>
<tr><td>Sailing Boat</td><td>Sailing boat</td><td>Boats for which the primary means of propulsion is by wind power.</td><td rowspan="9">For boats carrying more than 12 persons, in accordance with technical requirements for passenger boats, unless specially specified by the Administration, only class notation “passenger boat” is assigned.</td></tr>
<tr><td>Tourist Boat</td><td>Tourist boat</td><td>Boats with sightseeing area used for the purposes of tourism</td></tr>
<tr><td>Ferry</td><td>Ferry</td><td>Boats having a continuous deck and carrying passengers (without sleeping berths) and/or vehicles for regular voyages between two sides of straits or islands</td></tr>
<tr><td>Windfarm Service Boat</td><td>Windfarm service boat</td><td>Special boats for the operation and maintenance of windfarm service facilities at sea</td></tr>
<tr><td>Public Affair Boat</td><td>Public affair boat</td><td>Boats used by the Government for public administration purposes</td></tr>
<tr><td>Traffic Boat</td><td>Traffic boat</td><td>For transporting personnel, but not as passenger transport service</td></tr>
<tr><td>X Boat</td><td>X boat</td><td>Boats dedicated to specific services. “X” is to be substituted by a specific service, e.g.:
Pilot Boat: Boats dedicated to pilot service;
Anchor Boat: Boats dedicated to operations related to anchoring;
Light Boat: Boats dedicated to serving for navigatio marks;
Diving Boat: Work boats dedicated to diving operations</td></tr>
<tr><td>Wooden Boat</td><td>Wooden boat</td><td>Boats the main hull of which is made of wood material.</td></tr>
</table>

Service Restriction or Limitations Notations **Table B**

Class notation	Description	
Greater Coastal Service Restriction	Greater coastal service restriction	Boats complying with the requirements of 1.1.1.2(1) of Section 1 of this Chapter may be assigned this notation
Coastal Service Restriction	Coastal service restriction	Boats complying with the requirements of 1.1.1.2(2) of Section 1 of this Chapter may be assigned this notation
Sheltered Water Service Restriction	Sheltered water service restriction	Boats complying with the requirements of 1.1.1.2(3) of Section 1 of this Chapter may be assigned this notation
Calm Water Service Restriction	Calm water service restriction	Boats complying with the requirements of 1.1.1.2(4) of Section 1 of this Chapter may be assigned this notation

Special Equipment and System Notations **Table C**

Class notation	Description

① For high speed boat complying with the requirements of the Rules, suffix (HSC) will be added after the type notation.

LPG Fuel	Using liquefied petroleum gas as fuel	For boats using liquefied petroleum gas as fuel, this notation may be added
Battery(power)	Propelled purely by battery	For boats propelled purely by battery, this notation may be added.
SPV	Solar photovoltaic system	For boats fitted with solar photovoltaic system, this notation may be added
AMPS	Alternative maritime power supply	For boats fitted with alternative maritime power supply system, this notation may be added

Section 3 Type of Classification Surveys and Certificates

1.3.1 Types of survey

1.3.1.1 The types of survey are divided into:

(1) Initial classification survey, including:

① construction survey for newbuildings;

② initial classification survey for existing boats (including those constructed not under the design review and supervision of CCS in accordance with the Rules, however subsequent survey carried out and considered to comply with the provisions of the Rules by CCS).

(2) Surveys after construction, including:

① annual survey;

② surveys of the outside of the boat's bottom and related items;

③ special survey;

④ occasional survey.

1.3.1.2 An occasional survey is to be applied for in one of the following conditions:

(1) an accident to a boat which affects its seaworthiness;

(2) alteration of a boat's intended purpose or service area as restricted in its certificates;

(3) invalidity of a boat's statutory certificate;

(4) changes of a boat's owner or manager, and of a boat's name or port of registry;

(5) repairs or modification involved in the safety of a boat.

1.3.1.3 All surveys mentioned in this Section may be carried out as appropriate basing on each type of boat.

1.3.2 Interval of surveys after construction

1.3.2.1 The boat already having the classification certificate is to be subject to surveys after construction in accordance with the specified interval and the requirements of 1.4.3 to 1.4.5 of Section 4.

1.3.2.2 Annual surveys are to be carried out within 3 months before or after each anniversary date[①] of the certificate. After a satisfactory survey, the Surveyor is to endorse the corresponding certificates to confirm the certificates are valid continuously within the specified period.

1.3.2.3 Surveys of the outside of the boat's bottom and related items are to be carried out once every two years for passenger boat, annually for high speed craft and a minimum of twice within a five-year period for cargo boat, the maximum interval between successive surveys is not to exceed 36 months, however one of the two surveys required in each five-year period is to coincide with the special survey. After a satisfactory survey, the Surveyor is to endorse the corresponding certificates to confirm the certificates are valid continuously within the specified period.

1.3.2.4 The interval of special surveys is not to exceed 2 years for passenger boat, 5 years for high speed craft (including high speed passenger boats and high speed cargo boats) and 5 years for cargo boat. Corresponding certificate is to be renewed after a satisfactory survey. Where it is not able to complete the special survey by its due date, the boat may be granted an extension not exceeding 3 months subject to agreement by CCS.

① Anniversary date means the day and the month of each year which will correspond to the date of expiry of the classification certificate.

1.3.3 Issue of certificates and validity

1.3.3.1 Where a boat is found in compliance with the relevant provisions of the Rules and other requirements after the initial classification survey, the character of classification and corresponding class notations will be assigned and the classification certificate will be issued.
1.3.3.2 A new classification certificate is to be issued once the special survey of the boat is completed according to the requirements of the rules.
1.3.3.3 The validity of classification certificates is not to exceed 2 years for passenger boat, 5 years for high speed craft (including high speed passenger boats and high speed cargo boats) and 5 years for cargo boat.

1.3.4 Invalidity of certificates

1.3.4.1 All the certificates will be invalid automatically where the boat is not operated in accordance with the service requirements stipulated by the certificates or surveys after construction are not carried out as required.

Section 4 Surveys

1.4.1 Submission and examination of plans

1.4.1.1 Before construction of a boat, plans and documents① as specified in this Section are to be submitted to CCS for approval.
1.4.1.2 The approved plans and documents are only effective for the designated numbers of boats to be constructed specified in the Application for plan approval. The validity of the approved plans and documents is 4 years.
1.4.1.3 The following plans and documents are to be submitted to CCS for approval as appropriate:
*(1) General arrangement;
*(2) Construction profile (including main transverse sections, bow and stern construction, bulkheads, decks, superstructure, details of hull typical structure, propeller shaft bracket etc.);
(3) Layout design;
(4) Shell expansion;
(5) Welding methods and specifications；
(6) Structure plan of main engine seating and gear box seating;
*(7) Structure, installation and arrangement of doors, windows (including viewports fitted below the waterline, if applicable) and covers;
(8) Calculations of equipment number and arrangement of anchoring, mooring, handrails and deck skid-proof facility;
(9) Construction of rudder (including rudder blades, rudder stocks, rudder bearings and connections);
*(10) Arrangement of machinery spaces;
*(11) Ventilation arrangement in machinery spaces;
*(12) Shafting arrangement and propeller plan;
(13) Calculations of shafting and propeller strength;
(14) Arrangement of Z-type propelling unit or stern machinery of inboard/outboard engine;
*(15) Steering system;
*(16) Arrangement of piping systems (including main/auxiliary exhaust piping system, fuel oil piping system, fire piping system and bilge piping system);
(17) Electric loading calculations (including calculations of storage battery capacity);
*(18) Electric power system, marking:
① primary rated parameters of motors, transformers, storage batteries and power electric equipment;
② all the feeder lines on switchboard;
③ types, sectional areas and primary rated parameters of cables;
④ types and primary rated parameters of circuit breakers and fuses.

① Plans and documents are to be submitted in triplicate.

*(19) Arrangement of electric power equipment (including installation position of motors, storage batteries, switchboards, etc.);
(20) Schematic diagrams and arrangement of lighting;
*(21) Schematic diagrams of onboard alternative maritime power supply devices (may be incorporated into the schematic diagram of electric power system);
*(22) Arrangement of onboard alternative maritime power supply devices (may be incorporated into the arrangement of electric power system);
*(23) Speed limit curves for boat navigating in waves, evacuation time calculation and evacuation analysis (only for high speed craft).
1.4.1.4 The following plans and documents are to be submitted to CCS for information as appropriate:
*(1) General specification;
(2) Lines;
(3) Calculations of weight and gravity center;
(4) Hydrostatic curves;
*(5) Scantling calculations according to the Rules;
(6) Tonnage calculations;
*(7) Thickness calculations of window glass;
*(8) Particulars of all boat equipment;
(9) Technology specifications of hull construction;
(10) Calculations of rudder strength;
(11) Calculations and procedures for hydrostatic pressure test and leakage test (if applicable) of viewports fitted below waterline;
*(12) Boat's operation manual (only for high speed craft).
1.4.1.5 Additional requirements for purely battery propelled boats:
*(1) Single line of electrical propulsion system, marking:
① primary rated parameters of motors, storage batteries and power electric equipment;
② types, section areas and load current of cables;
③ types and primary rated parameters of circuit breakers and fuses;
④ schematic diagrams of BMS system (if applicable) and all boat control circuits;
⑤ location of switchboard.
(2) electrical propulsion monitoring and list of alarm items;
* (3) arrangement of semi-conductor converter of electrical propulsion system, if fitted;
* (4) arrangement of accumulator batteries and accumulator batteries compartment;
* (5) ventilation and calculations of accumulator batteries compartment, if applicable;
* (6) fireproof structure plan of accumulator batteries compartment;
* (7) schematic diagrams and arrangement of temperature detection and alarms of accumulator batteries compartment;
* (8) arrangement of fire-extinguishing appliances and quantity calculations of accumulator batteries compartment.
1.4.1.6 Additional requirements for LPG fueled boats:
*(1) arrangement of LPG machinery space and gas tank storage space;
*(2) LPG gas supply system plan;
*(3) ventilation of LPG machinery space and gas tank storage space;
*(4) LPG detection and alarm system;
*(5) LPG power system operational manual.
1.4.1.7 Additional requirements for sailing boats:
*(1) arrangement of sails, rigging and masts;
*(2) ballast keel (including shape, material, structure, connection with hull, etc.);
*(3) arrangement of chainplates (including specifications and breaking loads of all rigging associated with the chainplates);
*(4) connection between mast and hull structure.
1.4.1.8 Additional requirements for windfarm service boats
*(1) The following plans and information are to be submitted for approval:
① technical specification of redundant propulsion system, including all design plans for achieving functional goals;

② FMEA report;
③ test plan.
(2) The operation manual of redundant propulsion system is to be submitted for information and the manual is at least to include:
① boat name and CCS class identity No.;
② simplified configuration diagram and descriptions of propulsion system under normal operation condition;
③ simplified diagram and descriptions of propulsion system redundant configuration;
④ descriptions of operation steps of redundant propulsion system;
⑤ descriptions of internal communication system;
⑥ detailed descriptions of local control of propulsion machinery;
⑦ full scale test report;
⑧ descriptions of propulsion capability in severe sea conditions.
1.4.1.9 Additional requirements for solar powered boats
*(1) single line of solar photovoltaic system, marking:
① primary rated parameters of solar cell module, photo-voltaic controller and photovoltaic inverter;
② type, sectional area and load current of cables.
*(2) arrangement of solar cell module, photo-voltaic controller and photovoltaic inverter;
*(3) photovoltaic system display and list of alarm items.
1.4.1.10 Additional requirements for wooden boats
(1) The following plans are to be submitted for approval:
*① wood drying, mothproof, anticorrosion, fire retardant treatment processes;
*② test programme of mechanical properties of wood structural connections and nodes;
③ wood structure processing and installation technology.
(2) The following plans are to be submitted for information:
① reference standard, evaluation method and implementation programme for wood physical and mechanical property tests;
② test report of mechanical properties of wood used for hull;
③ strength test report of typical structural connections.
1.4.1.11 The titles of plans and documents to be submitted may not be all the same, however at least the contents of the above-mentioned plans and documents are to be included. In addition to 1.4.1.3 to 1.4.1.10, other plans and documents may be required to submit by CCS according to the practical cases.
1.4.1.12 The plans and documents of the existing boats for initial survey may be in accordance with the requirements marked with * in 1.4.1.3 to 1.4.1.10.

1.4.2 Initial classification survey
1.4.2.1 Hull surveys of newbuildings are as follows:
(1) to confirm material, technology, equipment and fittings used for hull structure complying with the rules requirements and holding the relevant marine product certificates;
(2) to examine hull forming die;
(3) to check test report of mechanical properties of hull plating specimens (including single plate and sandwich plate);
(4) to check correctness, completeness and welds quality of hull assembly;
(5) to examine after hull is formed;
(6) to examine installation quality of the windows of the first layer of superstructure and the front wall of bridge room (including connections between window glasses and frames ,and connections between window frames and bulkheads);
(7) hydrostatic pressure test of viewports installed below waterline and leakage test of hull connect components (if applicable);
(8) to examine anchoring and mooring equipment;
(9) inclination test.
1.4.2.2 Machinery surveys and electrical surveys of newbuildings are as follows:
(1) to confirm marine products certificates of essential machinery equipment;

(2) tightness test of piping system after installation onboard;
(3) installation and test of essential machinery, e.g.: main engine, shafting, propeller, gear box, generator group, essential pump, steering engine, anchor windlass, air compressor, heat exchanger, sea valve, side valve, etc.;
(4) installation and test of systems, e.g.: fuel oil, lubrication oil, bilge, ballasting, fire-fighting, ventilation, sounding, heating, cooling, venting, remote control of valves, etc.;
(5) to confirm product certificates of electrical equipment in primary purposes, e.g.: main source of power, emergency source of power, main switchboard (box), emergency switchboard (box), remote control system of propulsion plant, engine room monitoring and alarm system, valve remote control system, shipside installations of shore connection systems (if fitted), etc.;
(6) to examine and test the generators, storage batteries and switchboards;
(7) cable specification check and installation survey;
(8) internal communication equipment test;
(9) survey and test of main/auxiliary engines, steering systems and control, safety and alarm systems;
(10) to examine lighting system;
(11) to confirm the efficiency of shipside installations of shore connection systems (if fitted).

1.4.2.3 Additional requirements for survey of boats propelled purely by battery:

(1) certification requirements for products

The surveyor is to confirm that main components of battery system, e.g.: single accumulator battery, accumulator battery module (accumulator battery package) and battery management system are type approved. The battery system is to be subject to the product survey and issued with a product certificate.

(2) survey items of accumulator batteries compartment

① to examine the access of accumulator batteries compartment;
② to examine the installation of equipment in the accumulator batteries compartment;
③ to test and examine the ventilation system of accumulator batteries compartment;
④ to examine the fire division between accumulator batteries compartment and other compartments;
⑤ to examine the fire-fighting appliances in the accumulator batteries compartment;
⑥ to examine and test the temperature monitoring device in the accumulator batteries compartment.

(3) installation survey

① to examine whether the arrangement of battery group is easy for replacement, inspection, testing and cleaning;
② to examine whether the distance from the battery group to bulkhead and deck are in compliance with the requirements of rules;
③ to examine whether the battery group is installed in a space where the battery group is likely to be subject to overheating, overcooling, splashing, vapor, other effects which may impair or accelerate the deterioration of its performance.

(4) function survey

① function test of battery charge-discharge device;
② function test of the monitoring and alarm of battery management system;
③ function test of fire-fighting appliance (temperature detection) in the accumulator batteries compartment;
④ security function test of battery management system;
⑤ operation test of battery system.

1.4.2.4 Additional requirements for LPG fueled boats:

(1) installation and test of LPG engine;
(2) installation, tightness and test of LPG supply system;
(3) installation examination of LPG gas tank;
(4) installation and test of ventilation system in LPG machinery space and gas tank space;
(5) installation and test of LPG remote closing device;
(6) to examine the installation location, quantity of LPG detectors and to test the LPG detection and alarm system;

(7) confirmation and safety examination of explosion-proof equipment and anti-ignition equipment.
1.4.2.5 Additional requirements for surveys of sailing boats:
(1) to inspect the connection between chainplates and hull structure;
(2) to inspect the connection between ballast keel and bottom structure;
(3) to inspect the connection between masts and the bulkhead or deck or bottom;
(4) to perform the operation test of sail hoisting and sail lowering.
1.4.2.6 Additional requirements for surveys of windfarm service boats:
(1) FMEA test;
(2) FMEA test procedures and testing report are to be kept onboard the boat.
1.4.2.7 Additional requirements for surveys of solar powered boats:
(1) to confirm that solar cell module, photo-voltaic controller and photovoltaic inverter are in compliance with the specifications.
1.4.2.8 Additional requirements for surveys of wooden boats:
(1) flooding test is to be carried out for hull plate and watertight bulkhead;
(2) hose test is to be carried out for deck, deckhouse enclosure and hatch cover;
(3) water pouring test is to be carried out for weather casing, wheelhouse doors and windows and other non-watertight doors and windows.
1.4.2.9 Mooring trials and sea trials are to be carried out in accordance with the requirements of Programme of Mooring and Sea Trials.
1.4.2.10 Initial classification survey of existing boats
(1) Plans and documents to be submitted for initial survey of existing boats are to be in accordance with the requirements of 1.4.1.11 of this Section.
(2) The initial classification survey items may be determined depending on the boat's age and actual condition, but to be carried out at least in accordance with the annual survey items. For passenger boats over 5 years of age, surveys are to be carried out in accordance with the renewal survey items.

1.4.3 Annual survey

1.4.3.1 Hull surveys are as follows:
(1) for fabric reinforced plastics boat, to examine exterior of hull structure and superstructure for cracks, whitening or delamination;
(2) for metal boats, to examine shell plating, deck and bulkheads for any corrosion;
(3) to examine for evidence of loosing or water leakage in way of connections of the hull;
(4) for high speed craft, to examine connection effectiveness between fore window frame and glass;
(5) to examine effectiveness of the viewports installed below the waterline (if applicable);
(6) to examine whether natural vents of engine room for outboard/inboard petrol engines are effective;
(7) to examine provision and effectiveness of anchoring, mooring and rudder equipment.
1.4.3.2 Machinery surveys and electrical surveys are as follows:
(1) an external examination of propelling unit, auxiliary engine for essential purposes. If deemed necessary, an function test may be conducted for some items;
(2) a general examination of machinery spaces;
(3) to examine remote control system of main engines and hydraulic operating system of Z-type propelling units and to confirm they are in good order;
(4) to examine whether oil tanks and fuel oil system are in good order without leakage;
(5) to examine steering gears and control system, and function test to be carried out under working conditions;
(6) to examine operating condition of essential piping systems such as bilge system and main engine cooling system, etc.;
(7) to examine effectiveness of ventilation system and related alarm signals in gasoline engine room;
(8) internal communications test;
(9) an external examination of generators and storage batteries, and its operation;
(10) a general examination and test of electrical equipment and cables under working conditions as far as practicable;

(11) a general examination of earthing and lightning-rod earthing;
(12) an external examination of shore power supply box, cable and its plugs, and its operation, if applicable.
1.4.3.3 Additional requirements for surveys of boats propelled purely by battery:
(1) to examine the operation records of battery and battery management system. The battery is to be replaced when the life expectancy of battery specified by the manufacturer is due or the battery is damaged;
(2) to examine whether heat source equipment is added in the battery room;
(3) to examine whether temperature detection device operates normally;
(4) to examine whether ventilation system operates normally.
1.4.3.4 Additional requirements for surveys of LPG propelled boats:
(1) overall examination of LPG machinery space and gas tank space to confirm that no fire and explosion risks exist in the spaces and the ventilation system is in a good working condition;
(2) to examine remote-control system of LPG main engine and confirm that it is in a good working condition;
(3) to examine LPG supply system, action is to be taken timely if substantial corrosion or leakage of the pipelines and valves is found;
(4) to examine working conditions of LPG detection and alarm system;
(5) to test the mechanism which remotely closes the LPG supply manifold valve;
(6) to examine working conditions of explosion-proof or ignition-proof electrical equipment;
(7) to examine the bottom plating of gas tank space and engine room and the bulkheads requiring tightness to ascertain whether their tightness is good.
1.4.3.5 Additional requirements for surveys of sailing boats:
(1) to examine the effectiveness of connection between chainplates and hull structure;
(2) to examine the effectiveness of connection between ballast keel and bottom structure;
(3) to examine the effectiveness of connection between masts and the bulkhead or deck or bottom;
(4) to perform the operation test of sail hoisting and sail lowering.
1.4.3.6 Additional requirements for surveys of windfarm service boats:
(1) to examine FMEA related equipment, system and isolation measures (if any) and to confirm that proper maintenance is carried out and is in good condition.
1.4.3.7 Additional requirements for surveys of solar powered boats:
(1) to confirm that the consolar cell module, photo-voltaic controller and photovoltaic inverter are in good working condition.
1.4.3.8 Additional requirements for surveys of wooden boats:
(1) to examine the corrosion, moth damage and damage of structural members, shell plate, deck and bulkhead;
(2) to examine the looseness of seams and leakage in the tank.
1.4.3.9 For high-speed craft, the items of annual survey is to be the same as those of special survey.

1.4.4 Surveys of the outside of the boat’s bottom and related items

1.4.4.1 Surveys of the outside of the boat’s bottom and related items are as follows:
(1) to examine cracks, damages and corrosions of shell under waterline;
(2) to examine the integrity of viewports installed below waterline and, if necessary, to conduct leakage test for the connecting components between viewport and hull (where applicable);
(3) to examine integrity of rudders, rudder stocks, rudder bearings, Z-type propelling units, propellers, screw shaft and bearings, water-jet unit, sea chest and gratings;
(4) to examine whether the earth plates of shell are in good order.

1.4.5 Special surveys

1.4.5.1 In addition to annual survey specified in 1.4.3 and surveys of the outside of the boat’s bottom and related items specified in 1.4.4, the special survey items are to include the following:
(1) for engines: to examine cylinders, cylinder heads, valves, pistons, connecting rods, crank shafts and all of the parts including bearings, engine foundations, engine mount, coolers, shock dampers, engine-driven pumps;
(2) for gear boxes: to examine wheels, pinions, shafts, bearings and clutch arrangements;

(3) for Z-type propelling units: to examine wheels, pinions, shafts, bearings and sealing arrangements;
(4) maneuvering test is to be carried out on propelling working condition for the propulsion machinery, the remote control system and hydraulic operating system of main engines and Z-type propelling units are in good order;
(5) to withdraw screw shaft and examine shafts, liners, keys, shaft cones, fillets of flanges, stern tube bearings, oil sealing arrangement and the fit conditions of propellers and screw shaft cones;
(6) for jet propeller: to examine blades, shafts, shaft seals, guiding nozzles, reverse and control systems in way of ingress-egress shafts and measure clearance between blades and guide ducts;
(7) measurement of insulation resistance for electrical equipment and circuits;
(8) to examine generators, storage batteries and steering motor (if any), and a running test under working conditions;
(9) to examine stand-by motors together with controls for essential equipment, and a running test as far as practicable under working conditions;
(10) to examine switchboards (box), to confirm in good working order;
(11) to confirm the efficiency of alternative maritime power supply system (if fitted).
1.4.5.2 Additional requirements for survey of boats propelled purely by battery:
(1) operation test of temperature monitoring system;
(2) operation test of ventilation system;
(3) operation test of battery management system.
1.4.5.3 Additional requirements for surveys of LPG propelled boats:
(1) maneuvering test is to be carried out on working condition for LPG main engines and the remote control system of main engines is to be in good order;
(2) where necessary, to examine LPG gas tank, action is to be taken or replacement to be made timely if substantial corrosion or leakage of the tank is found.
1.4.5.4 Additional requirements for surveys of windfarm service boats:
(1) to examine and confirm the condition of FMEA related equipment, system and isolation measures (if any) and to sample check the FMEA test if necessary.
1.4.5.5 The items in 1.4.5.1 (1) to (4) of this Chapter may be replaced by the examination of their maintenance records.
1.4.5.6 The plywood of hull of FRP boat is not to leak and obviously turn to white or delaminate .
1.4.5.7 For metal boats, thickness measurements on suspect areas of hull plating are to be carried out at the second and subsequent special surveys.

Chapter 2 HULL STRUCTURE

Section 1 General Provisions

2.1.1 Scope of application

2.1.1.1 This chapter applies to boats with fibre reinforced plastics, steel and aluminium alloys as hull materials, including high speed crafts. For boats with overall length L_{oa} of less than 6 m, the scantlings of their components can be verified according to drop test for boats①.
2.1.1.2 The materials, construction and arrangement of wooden boats are to comply with standards② accepted by CCS.

2.1.2 Definitions

2.1.2.1 **Primary member:** The primary supporting members of hull, such as keels, girders, plate floors, web frames, web beams, etc.
2.1.2.2 **Secondary member**: The secondary supporting members of hull, such as longitudinals,

① For details, see Small craft — Hull construction and scantlings — Part 5: Design pressures for monohulls, design stresses, scantlings determination (ISO 12215-5), Appendix B.
② For details, see Small craft — Hull construction and scantlings (ISO 12215).

frames, beams, bulkhead stiffeners, etc.
2.1.2.3 **Spacing of members *s*** (m): Unless otherswise provided, spacing of members *s* means the spacing of secondary members for secondary members, and the average breadth of supporting load area for primary members.
2.1.2.4 **Span of members *l*** (m): Unless otherwise provided, Where end brackets are fitted, the span points may be taken at half length of the brackets. Where there are no end brackets, the span points are to be taken at the ends of the members. For primary members such as keels, plate floors， web frames, etc., the bulkheads or decks connected may be taken as the end points of the primary members. If there is a hard angle of less than 130° along the hull cross section line in way of the center keelson, this position can be taken as the span point of the plate floor. For primary members of decks and the superstructures (such as web beams, deck girders, etc.), in addition to the bulkheads, the pillars connected may also be taken as the end points of the primary members. If the structure in way of the support a primary member can effectively prevent the primary member from rotating or displacing at that point, this position may be taken as the end point of the primary member.
2.1.2.5 **Section modulus W (cm^3) of members**: The required value of the member and attached plate with effective breath and it is assumed that the member web is vertical to the attached plate. When the member web is not vertical to the attached plate and angle α between the web and the attached plate is less than 75°, the actual section modulus W may be approximately determined according to the following formula: $W = W_0 \sin\alpha$, in cm^3, where: W_0 — section modulus, assuming web is vertical to attached plate, in cm^3.
2.1.2.6 **Effective breadth b_e (mm) of the attached plate**: For members of fiber-reinforced plastic hull structures, it is to be taken according to the provisions in 2.2.1.8 of this Chapter. For members of metal hull structures, it is to be taken according to the provisions in 2.3.1.5 of this Chapter.
2.1.2.7 **Load point for which the local pressure is to be calculated**: For vertical plates subjected to non-uniformly distributed loading, the point is to be taken at the lower edge of the plate. For secondary members such as longitudinals, beams, frames, bulkhead stiffeners, in general, the point is to be taken at the midpoint of span, and when the pressure on the secondary member varies other than linearly, the load point to calculate pressure is to be taken as the greater of the pressure at midpoint of span and the average pressure at both ends of the member. For primary members, such as keels, plate floors, web frames, web beams, girders,etc., the point is to be taken at midpoint of load area.
2.1.2.8 **Bottom area**: The area between the plate keel (or keel) and the upper corner of the bilge.
2.1.2.9 **Side area**: The area from the upper corner of the bilge to the top of the side shell plating.

2.1.3 Principle of structural design and arrangement

2.1.3.1 The hull structure is to be so designed that the boat can withstand the maximum external force that may be encountered throughout its whole period ofservice.
2.1.3.2 The hull longitudinal components are to be kept continuous within the whole length of boat as far as possible.
2.1.3.3 The primary transverse members of the hull, i.e. bottom floors, side frames and deck transverses are to be arranged in the same transverse section and connected reliably, to form a continuous and closed transverse frame.
2.1.3.4 For boats with a moulded depth of less than 0.9 m, if bottom shell plating or side shell plating is not strengthened by longitudinals, measures such as knuckles and flanges are to be taken to strengthen the bottom or side, and the longitudinal strength of the hull is to be checked according to 2.1.4.
2.1.3.5 Spacing of longitudinals for longitudinally framed hull structures or of frames for transversely framed structure is not to be more than 500 mm in general.
2.1.3.6 Except for the engine room, the spacing of bottom plate floors for a transversely framed boat is not to be more than 2 frame-spaces, and that for a longitudinally framed boat is not to be more than 4 frame-spaces.
2.1.3.7 Unless otherwise provided, The spacing of keels and spacing between keel and bilge knuckle lines or midpoints of bilge arc are not to be more than 2 m.
2.1.3.8 For fiber-reinforced plastic hull structures, the width of plate keel or girth of hood keel is not to be less than 0.1B, the thickness is not to be less than 1.5 times that of the adjacent bottom

plating; for metal hull structures, the width of plate keel is not to be less than 600 mm, the thickness is to be 1.2 mm plus the thickness of the bottom plating at this position, and is kept unchangeable within the whole length of boat.

2.1.3.9 Openings on shell plating and deck plating are to be avoided as far as possible. If it is needed, the opening corners are to be rounded with a radius of 12% b (b is the width of the opening), but not exceeding 300 mm. For large openings (such as sunken openings in cargo holds, engine rooms, cabins, etc.), compensation is to be made by means of thick plates or cover plates under certain cases.

2.1.3.10 Where doors, windows and openings are provided in side walls of superstructures or deckhouses, the corners are to be rounded as far as practicable.

2.1.3.11 The shell plating for penetration of propeller shaft bracket, rudder post and their attachments or the structures at the strong points for anchoring, mooring and towing are to be suitably strengthened.

2.1.3.12 For pillars of steel and aluminium alloy, reference may be made to the relevant requirements in CCS Rules for Construction and Classification of Sea-going High Speed Craft. Other materials used for pillars are to be subject to approval of CCS.

2.1.3.13 The structure of vehicle deck and vehicle ramp is to comply with the relevant provisions of Chapter 9, PART TWO of CCS Rules for Classification of Sea-going Steel Ships.

2.1.3.14 The direct calculation method may be used to check the hull structure, but the hull plate thickness still needs to comply with the minimum plate thickness requirements provided in this Chapter.

2.1.3.15 If a viewport is provided on the hull shell plating below the waterline, the direct calculation method for the whole boat's structural strength is to be used to check the hull structural strength in full load condition. The calculation method can be referred to in the relevant contents in 1.5.7, Section 5, Chapter 1, PART TWO of CCS Rules for Classification of Sea-going Steel Ships. For yield and buckling strength assessment, reference may be made to Appendix 1, Chapter 18, PART TWO of CCS Rules for Classification of Sea-going Steel Ships. For high speed crafts, direct calculation is also to be carried out in accordance with the applicable requirements of Appendixes 2, 3 and 5 of CCS Rules for Construction and Classification of Sea-going High Speed Craft.

2.1.4 Overall strength of hull

2.1.4.1 For metal hull high speed craft with length L greater than or equal to 15 m, if it is a decked boat with L/D greater than or equal to 12 or with openings of more than 0.25B in width (this width is taken as the sum of the widths of the hatches if there are multiple hatches in parallel) on strength deck within 0.5L amidships, or, it is an open deck boat, the longitudinal strength of hull girder is to be checked according to the relevant provisions of CCS Rules for Construction and Classification of Sea-going High Speed Craft.

2.1.4.2 For fiber-reinforced plastic boats with length L greater than or equal to 15m, if the size of the hull meets the requirement that L/D is greater than or equal to 12, the overall longitudinal strength of hull girder is to be checked according to the relevant provisions of CCS Rules for Construction and Classification of Sea-going High Speed Craft. It is also acceptable that only the midship section modulus W is checked, which is not to be less than the value of W_0 calculated according to the following formula:

$$W_0 = fL^2 B_{WL}\left(C_b + 0.7\right) \qquad \text{cm}^3$$

where: f – factor, $f = 0.25L + 24$;

L – length of boat, in m;

B_{WL} – breadth in way of full load waterline, in m;

C_b – block coefficient of the boat.

2.1.4.3 The minimum midship section modulus W_0 provided in 2.1.4.2 above is based on the mechanical properties of the standard laminated single skin plate moulded by lay-out with glass fiber biaxial woven rovings. For other fiber laminated designs, if the strength of the single plate is not consistent with that of the standard layout design, the minimum midship section modulus W_0 may be corrected by multiplying the coefficient K as specified below:

$$K=180/\sigma_t$$

where: σ_t – the ultimate tensile strength of the laminate, in N/mm^2.

2.1.4.4 Calculation of midship section modulus W for fiber-reinforced plastic boats:

(1) All continuous longitudinal members within 0.4 L amidships may be taken into account in the calculation of midsection modulus, however the areas of openings on them are to be deducted from the midsection area.

(2) In general, a superstructure having a length greater than 0.2 L but within 0.4 L amidships may be taken into account in the longitudinal strength. Where there are large amount of openings on the side walls of above-mentioned superstructure and the sum of length of all openings on each side wall exceeds half of the superstructure length, the superstructure is not to be considered to make contribution to the longitudinal strength.

(3) Where a boat adopted sandwich construction as parts of hull's members, the concept of equivalent section modulus (W_e) is to be introduced.

For the longitudinal bending of hull girder, the equivalent section modulus (W_e) of the middle transverse section composed by some of members made of sandwich construction is to be calculated as follows:

$$W_e = \frac{\sum\left(E_i I_i\right)}{EY} \qquad \text{cm}^3$$

where: E – modulus of elasticity of material at the point calculated, in N/mm^2;

Y – vertical distance from the point calculated to the neutral axis of the mid-boat section in cm;

E_i, I_i – modulus of elasticity for each member's material composing of the midship section, in N/mm^2 and moment of inertia to the neutral axis of the midship section for each member, in cm^4, respectively.

If ineffective core such as cellular plastics, balsa wood is used in the sandwich construction, the core materials of all such sandwich construction in the midship section are not included in the calculation of the midship section modulus.

2.1.4.5 For fiber reinforced plastic boats with a length L greater than or equal to 15m and L/D greater than or equal to 12, rigidity of the hull is also to be checked, that is, moment of inertia to the neutral axis of the midship section of hull is not to be less than the value calculated according to the following formula:

$$I = 4.0 W_0 L \qquad \text{cm}^4$$

Where: W_0 –the minimum section modulus amidships calculated according to 2.1.4.2 and 2.1.4.3.

2.1.4.6 For all multi-hull boats, the transverse strength and the torsional strength of their cross deck structures are to be checked. Strength criteria and check methods may be referred to in CCS Rules for Construction and Classification of Sea-going High Speed Craft.

Section 2 Fiber-reinforced Plastic Boats

2.2.1 General requirements

2.2.1.1 This Section applies to boats whose hull structures are of FRP material.

2.2.1.2 The manufacturers of FRP boats are to be subject to the assessment of shipyard fitness conditions. Construction quality is to be controlled strictly by the manufacturers.

2.2.1.3 The mechanical properties of test specimen of FRP are to comply with the minimum requirements of CCS Rules for Materials and Welding.

2.2.1.4 The thickness t of laminated plate reinforced by glass fiber is to be taken as follows:

$$t = \left(\frac{1}{\gamma_R G} + \frac{1}{\gamma_G} - \frac{1}{\gamma_R}\right) W \qquad \text{mm}$$

Where: W– Total fiber weight of fiber glass mat and/or glass cloth per unit area of laminate, in kg/m^2;

G – Total nominal glass fiber content ratio in the laminate, may be determined according to the relevant provisions of CCS Rules for Materials and Welding;

γ_R – specific gravity of resin after solidification, in g/cm^3, may be taken as 1.2 if without measured data;

γ_G – specific gravity of glass-fiber mat or fiber cloth, in g/cm^3, may be taken as 2.5 if without measured data.

2.2.1.5 The thickness of fibre-reinforced plastic laminates is to be taken as the thickness excluding gelcoat and repaired composites or other non-reinforced materials.

2.2.1.6 The thickness change of laminated hull plates in different areas is to be gradual and the breadth of transition region is at least 30 times the thickness difference.

2.2.1.7 Size of members is to be as follows:

(1) For hood type members, the ratio of web height to the thickness of web on one side is not to exceed 30, and the ratio of the face plate width to thickness is not to exceed 20.

(2) For T type sectional members, the ratio of web height to the thickness is not to exceed 20, and the ratio of face plate width to thickness is not to exceed 10.

(3) Members of other sectional types are to be specially considered.

2.2.1.8 Effective breadth b_e of attached plates of members is to be taken as follows:

(1) Where the attached plate is of a single plate, the lesser of following is to be taken:

$$b_e = s, \quad b_e = 23t + b_s \qquad \text{mm}$$

(2) Where the attached plate is of sandwich plate:

For ineffective core such as cellular plastics, balsa wood, etc., the lesser of following is to be taken:

$$b_e = s, \quad b_e = 11d \qquad \text{mm}$$

For effective core such as plywood, etc., the lesser of following is to be taken:

$$b_e = s, \quad b_e = 35d \qquad \text{mm}$$

where: t – thickness of attached plate in case of single plate, in mm;

d – distance between centerlines of the thickness of the inner face plate and outer face plate of attached plate in case of sandwich attached plate, in mm;

b_s – net breadth of members, in mm.

2.2.1.9 Where the effective material such as pine or plywood is employed as core of the member or its attached sandwich plate, the effect of core may be taken into account in calculation of the section modulus. But the sectional area of the core is to be calculated by multiplying the ratio of the bending elastic modulus of the core to the bending elastic modulus of the laminate.

2.2.1.10 If it is impractical for the spacing of hull frames or longitudinals to satisfy the provisions in 2.1.3.5, the spacing is allowed to exceed 500 mm, but in this case, the scantlings of members are also to meet the requirements for local strength and hull longitudinal strength and rigidity.

2.2.2 Additional requirements for engine room structure arrangement and stern transom plating

2.2.2.1 For engine room of single-engine boat or flat bottom boat, the center keelson may be replaced by girder of main engine's foundation or two side keelsons (one at each side). The girder of main engine's foundation or side keelson or center keelson are not to be interrupted in way of any bulkhead and are to extend on the back of the bulkhead with the length not to be less than 2 frame-spaces.

2.2.2.2 The structures of main engine's foundations are to have enough strength and rigidity. Transverse separating plates and transverse bracket plates are to be provided in each frame space for girders of foundations to ensure the effective supporting.

2.2.2.3 In order to increase the compression and bending rigidity, timbers or aluminum alloy sections may be used as core materials of girder of engine foundations, however, the core materials are to be effectively bound with the surface of FRP and the bottom floor of boat.

2.2.2.4 The frames in engine rooms are to be kept continuous to avoid stress concentration.

2.2.2.5 Plate floors are to be provided in each frame space when the boat's bottom is transversely framed; plate floors are to be provided in alternative frame space when the boat's bottom is longitudinally framed. The sectional modulus of plate floors are to be increased 10% of the values provided in 2.2.3.4(1) and 2.2.4.6(1) of this Section, and the plate floors are to be effectively connected with foundation girders.

2.2.2.6 Web frames are to be provided at sides in way of engine room and they are to be fitted in way of plate floors with spacing not to be more than 4 frame-spaces. The sectional moduli of frames and web frames are to be increased by 10% of the values specified in 2.2.3.4(1) and 2.2.4.6(4) of this Chapter.

2.2.2.7 Stern transom plating is to comply with the following requirements:
(1) The thickness of stern transom plating is not to be less than 1.2 times that of shell side plating, the requirements for stiffeners for stern transom plating are the same as those for shell side plating.
(2) The stern transom plating is to be so designed as to ensure that an excessive stress is not produced when bending moment and thrust caused by propelling unit installed on stern transom plating are transmitted to hull structure.
(3) In general, the stern transom plating of a boat with the outboard motor or stern propelling unit is to be sandwich plate with core material such as plywood or similar rigid material. The total thickness of the stern transom plating is not to be less than that as required in Table 2.2.2.7(3).

Total thickness of stern transom plating **Table 2.2.2.7 (3)**

Power of engine P (kW)	Total thickness of stern transom plating(mm) (outboard motor)	Total thickness of stern transom plating(mm) (stern propelling unit)
18 ≤ P < 30	30	35
30 ≤ P < 60	35	40
60 ≤ P < 150	40	45
150≤ P < 250	45	50
P≥ 250	Specially considered as per specific case	Specially considered as per specific case

2.2.3 Hull structural scantlings of high speed crafts
2.2.3.1 Vertical acceleration at gravity center of a boat
(1) An average value a_{cg} of the 1/100 maximum vertical acceleration at gravity center of a boat is to be taken as the design acceleration to determine design load of the structure. This design acceleration is finally determined by the ship owner or the designer to select a reasonable a_{cg}.
(2) When a boat navigates at high speed in waves, the relation among the designed vertical acceleration at gravity center of a boat a_{cg} and significant wave height $H_{1/3}$ specified in its service restriction and its speed V_H corresponding to this wave height $H_{1/3}$ is as follows:

$$a_{cg}=\frac{1}{426}\left(\frac{V_H}{\sqrt{L}}\right)^{1.4}\left(\frac{H_{1/3}}{B_{WL}}+0.07\right)(50-\beta)\left(\frac{L}{B_{WL}}-2\right)\frac{B_{WL}{}^3}{\Delta}g \qquad \text{m/s}^2$$

Where: g–acceleration of gravity, g = 9.81 m/s^2;
V_H–speed at sea with significant wave height $H_{1/3}$, in kn;
$H_{1/3}$–significant wave height, in m, $H_{1/3max}$ = 6m for greater coastal service restriction; $H_{1/3max}$ = 4m for coastal service restriction; $H_{1/3max}$=2m for sheltered water service restriction and $H_{1/3max}$=1m for calm water service restriction;
L– length of boat, in m;
B_{WL} – width of the boat at full load waterline, in m, means the maximum moulded width measured along the full load waterline of a boat in rest floatation at full load displacement. For multi-hull boat, it means the sum of maximum moulded widths of each hull at full load waterline;
β – deadrise angle of the transverse section at the center of gravity of the hull, in °, taken as β_{max}=30°, β_{min}=10°, see Fig. 2.2.3.1 (2);
Δ– full load displacement, in t.

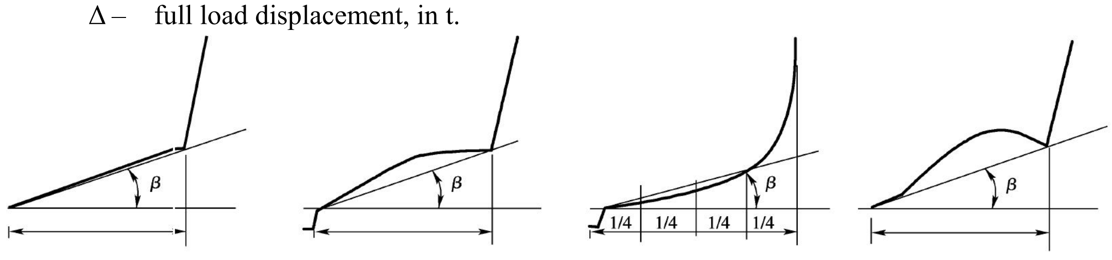

Figure 2.2.3.1(2)
(3) Several groups of corresponding values of $H_{1/3}$～V_H are to be provided by the designer, and a corresponding group of a_{cg} values can be calculated according to the formula in (2). One a_{cg} value is to be selected by the shipowner or the designer as the design value of vertical acceleration

at gravity center of the boat. The $H_{1/3}$ ～V_H curve corresponding to the design value a_{cg} is to be recorded in the boat's operation manual, and to be marked on a label to be fixed and displayed in the bridge room, to remind the Master to properly control the boat's speed when sailing in wind and waves to ensure that the vertical acceleration at gravity center of the boat does not exceed the design value.

2.2.3.2 Local calculated pressure

(1) The wave slamming pressure on bottom P_{sl} is to be calculated by the following formula, but is not to be less than the slamming pressure on side in way of corresponding position as determined by 2.2.3.2 (3) of this Section:

$$P_{sl} = 1.16K_{l1}\left(\frac{\Delta}{nA}\right)^{0.3}\frac{50-\beta_x}{50-\beta}a_{cg}d \qquad \text{kN/m}^2$$

where: K_{l1} – longitudinal pressure distribution factor. K_{l1} = 1 for forward of amidship, K_{l1} = 0.5 for stern, the factor between amidship and stern is to be obtained by linear interpolation;

Δ – full load displacement, in t;

A – calculated area for the pressure point considered, in m^2,

for panels, *A* is normally not to be taken greater than 2.5 S^2; where *S* is the length of the short side of the panel, in m;

for stiffeners or girders, *A* is to be taken as: A＝loaded breath× span;

but for plates or members, the final value of A is not be smaller than 0.002△/d;

n – number of hulls, for monohull, n＝1; for catamaran, n＝2.

β , β_x – deadrise angle (°) of the section at the center of gravity of the boat and of the section at the calculated point, respectively, as shown in Figure 2.2.3.1 (2). Their maximum and minimum values are both 30° and 10°;

a_{cg} – design vertical acceleration, in m/s^2, to be taken in accordance with that in 2.2.3.1 of this Section;

d – full load draft; in m.

(2) Wave slamming pressure P_{wd} on the cross deck bottom of catamaran and on the out-of-water bottom of air-cushion vehicle and of hydrofoil craft is to be determined by the following formula, but is not to be less than the pressure on side above the waterline in way of corresponding position as determined by 2.2.3.2 (3) of this Section:

$$P_{wd} = K_{l2}\left(\frac{\Delta}{A}\right)^{0.3}a_{cg}\left(1-\frac{H_{tx}}{CL}\right) \qquad \text{kN/m}^2$$

where: K_{l2} – longitudinal pressure distribution factor, to be taken as follows:

within *L*/3 from F.P.: for catamarans, K_{l2} ＝2.6;

for hydrofoil crafts, K_{l2} ＝1.3;

for air-cushion vehicles K_{l2} ＝2.1;

aft of amidship all taken as K_{l2} ＝1.3 ;

forward of amidship excluding *L*/3 from F.P., to be obtained by linear interpolation;

Δ, A, a_{cg} – same as above (1);

H_{tx} – vertical distance from point for pressure calculation of cross deck bottom or of out-of-water bottom of air-cushion vehicle or hydrofoil craft to design waterline, in m, but the maximum value is not to exceed CL;

C – factor, C = 0.066-0.000175L.

(3) Slamming pressure P_s on side is to be taken as:

$$P_s = 9.81h + 0.15P_{sl} \qquad \text{kN/m}^2$$

where: h – vertical distance between the lowest point of side plate and the upper edge of freeboard deck at sides (deck boat) or upper edge of top strake at sides (open boat), in m;

P_{sl} – slamming pressure on bottom in way, in kN/m^2.

(4) Pressure P_d on deck is to be taken as:

for exposed deck: P_d = C(0.25L+4.6) kN/m^2,

for unexposed freeboard deck, unexposed deck of the first-floor superstructure /deckhouse and other internal decks taken into account in the overall strength:

P_d = 0.1L+4.6 kN/m^2

for other unexposed deck: P_d = 4.5 kN/m^2 ;

where: C – coefficent:

C=1.05 for greater coastal service restriction;
C=1.0 for coastal service restriction;
C=0.9 for sheltered water service restriction;
C=0.85 for calm water service restriction;

(5) Pressure P_h on bulkhead is to be taken as:

for watertight bulkheads, collision bulkheads and their stiffeners: P_h =10h kN/m^2

for bulkheads and their stiffeners of liquid tanks: P_h =10h$_d$+10 kN/m^2

where: h – vertical distance from the bottom edge of plate or midpoint of span of stiffener to the upper deck, in m;

h_d – vertical distance from the bottom edge of plate or midpoint of span of stiffener to the top of the liquid tank, in m.

(6) Pressure P on superstructure and deckhouse is to be taken as:

for fore end bulkhead and its stiffeners P＝C(0.3L＋5) kN/m^2

for side bulkheads, aft end bulkhead and their stiffeners P＝0.2L＋2.5 kN/m^2

for top plates and their stiffeners P＝3 kN/m^2

where:L – length of boat, in m.

C – coefficent:

C=1.05 for greater coastal service restriction
C=1.0 for coastal service restriction
C=0.9 for sheltered water service restriction
C=0.85 for calm water service restriction

2.2.3.3 Scantling of laminated plates

(1) The minimum thickness t_{min} of single plate is to be taken as follows:

$$t_{\min} = K_0\sqrt{L} \quad \text{mm}$$

where: K_0 – coefficient, obtained from Table 2.2.3.3 (1);

L – length of boat, in m.

Coefficient K_0 Table 2.2.3.3(1)

Coefficient	Bottom shell plating Cross deck bottom plating	Side plating	Deck plating	Superstructure & deckhouse			Bulkhead		Engine foundation
				Front	Side, behind	Top	Watertight	Collision, liquid tank	
K_0	1.30	1.15	1.00	1.00	0.85	0.85	1.10	1.20	1.90

(2) The thickness t of single plate is not to be less than the following:

$$t = 44.8Cs\sqrt{\frac{P}{\sigma_{fnu}}} \quad \text{mm}$$

where: C – correction factor of the ratio of the long side l to the short side s of the panel, taken as follows:

if l/s<2 $C = \frac{l}{s}\left(1 - 0.25\frac{l}{s}\right)$

if $l/s \geqslant 2$ $C = 1.0$

σ_{fnu} – ultimate bending strength of laminate, in N/mm^2;

P – design value of positive pressure in member's unit area in the calculation of hull local strength, calculated in accordance with the requirements of 2.2.3.2 of this Section.

s – length of short side of the panel, taken as the spacing between two adjacent members along the long side of the panel. If the member is of hood type, the width w of the bottom edge of the hood member is to be deducted, see Figure 2.2.3.3(2), in m;

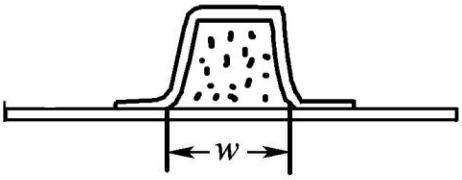

Figure 2.2.3.3(2)

l – Length of the long side of the panel, taken as the span of the member along the long side of the panel, in m.

(3) The minimum thickness t_{min} of each skin laminate on sandwich plates is to be calculated as follows:

$t_{\min} = K_0\sqrt{L}$ mm, and not less than 2.0 mm for exposed skin laminate ①;

$t_{\min} = K_0\sqrt{L} - 0.5$ mm, and not less than 1.5 mm for inner skin laminate ②;

where: K_0 – coefficient, obtained from Table 2.2.3.3 (3);

L – length of boat, in m.

Coefficient K_0 Table 2.2.3.3(3)

Coefficient	Bottom shell plating Cross deck bottom plating	Side plating	Deck plating	Superstructure & deckhouse			Bulkhead		Engine foundation
				Front	Side,behind	Top	Watertight	Collision, liquid tank	
K_0	0.6	0.5	0.45	0.45	0.35	0.35	0.4	0.45	0.8

(4) The total thickness t of a sandwich plate is not to be less than:

$$t = \frac{1.428}{K}\left(1 + \frac{1}{\gamma}\right)\frac{sP}{\tau_c} \quad \text{mm}$$

where: γ – ratio of the distance between the centerlines of opposite skin laminates to the mean thickness of opposite skin laminates, $6 \leqslant \gamma \leqslant 14$;

τ_c – ultimate shear strength of sandwich core material, in N/mm^2;

K – coefficient,

for core of PU cellular plastic, $K = 1.86 - 0.06\gamma$, and $K \geqslant 1$;

for core of PVC cellular plastic, $K = 1.95 - 0.079\gamma$, and $K \geqslant 1$;

for core of plywood, K=1.0

P, s – refer to 2.2.3.3(2).

2.2.3.4 Bending strength of members

(1) The section modulus W of stiffeners and frames is not to be less than that obtained from the following

$$W = K\frac{l^2 sP}{\sigma_{fnu}} \quad \text{cm}^3$$

① Exposed skin means the skin laminate subjected to liquid continuously or milling of machine or impacting load.

② Inner skin means the laminate not subjected to the above load.

where: σ_{fnu} – ultimate bending strength of laminate, in N/mm^2;

K – coefficient, obtained from Table 2.2.3.4 (1);

P – refer to 2.2.3.3 (2) of this Section.

Coefficient K Table 2.2.3.4(1)

Name	K	
	Keel, web frame, plate floor, web beam, girder,	Longitudinals, floor, frame, beam, stiffener
Bottom, cross deck bottom	480	400
Side	480	400
Deck	480	400
Superstructure	—	400
Watertight bulkhead	—	400
Liquid tank & collision bulkhead	—	480

(2) Where calculation of section modulus for keels as per (1) above is not practicable, such section modulus may be specially considered, but at least the following conditions are to be satisfied simultaneously:

① the section modulus for center keelson is to be at least 1.5 times the section modulus for plate floor in this position; the section modulus for side keelson is to be equal to that for plate floor in this position; and

② hull longitudinal strength requirements.

(2) The web height of sloping bottom boat's plate floors may be reduced gradually from longitudinal centerplane to sides, however for boat of more than 6 m in length, the web height in way of 3/8 breadth from longitudinal centerplane is not to be less than 1/2 of that in way of longitudinal centerplane.

2.2.3.5 Shear strength of girders

(1) The effective web plate area of girders A_e is to be calculated as follows:

$$A_e = 0.01 h_W t_W \quad \text{cm}^2\text{, for no bracket at ends of girder}$$

$$A_e = 0.01 h_W t_W + \delta A_e \quad \text{cm}^2\text{, for bracket at ends of girder}$$

where: h_W – effective web plate height after deduction of cutouts in the cross section considered, in mm;

t_W – total thickness of FRP web plate, in mm;

δA_e – additional shear area for girder with bracket at end, in cm^2, obtained in accordance with the horizontal angle of the bracket's face plate, refer to Fig. 2.2.3.5(1). $\delta A_e =$ 0.9 f_1, where θ＝45°; $\delta A_e = 0$, where θ=0°; the value δA_e may be obtained by linear interpolation where θ= 0 ~ 45°, f_1 is area of the bracket's face plate in the cross section considered, in cm^2.

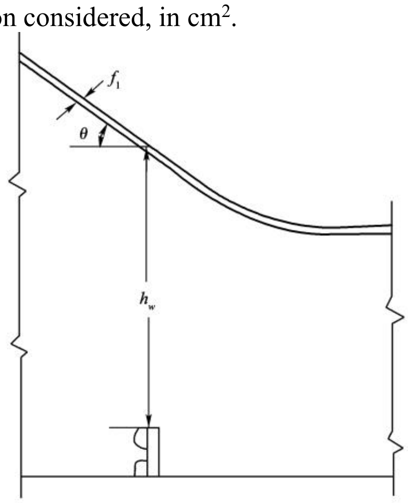

Figure 2.2.3.5(1)

(2) The effective web plate area A_e calculated in accordance with the requirements of (1) above is not to be less than $A_{e\min}$ as follows:

$$A_{e\min} = \frac{25.5slP}{\tau_c}$$

where: τ_c – in-plane longitudinal-transverse shear strength① of girder web plate, in N/mm^2;

P – refer to 2.2.3.3 (2) of this Section.

2.2.4 Hull structural scantlings of non-high speed boats

2.2.4.1 General requirements

(1) The hull structural scantlings specified in this paragraph are based on the mechanical properties of the standard laminated single skin plate moulded by lay-out with glass fiber biaxial woven rovings.

(2) For laminates of non-standard layout design, considering that the mechanical properties of such laminated plates are different from those of the standard layout design, the scantlings specified in this paragraph may be corrected by multiplying the coefficient K as specified below:

① for thickness correction: $K = \sqrt{\dfrac{180}{\sigma_{fnu}}}$

where: σ_{fnu} – the ultimate bending strength of the laminate of non-standard layout design, in N/mm^2;

② for member section modulus correction: $K = 180/\sigma_t$

where: σ_t – the ultimate tensile strength of the laminate of non-standard layout design, in N/mm^2;

③ For the laminate with its ultimate bending strength and/or tensile strength more than 400 N/mm^2, in addition to the above correction, rigidity of the hull constructed by this laminate is to be checked.

2.2.4.2 Shell plating

(1) If single plate is used as shell plating, the minimum plate thickness is to meet the requirements of 2.2.3.3 (1).

(2) The thickness t of single plate used as bottom plating is not to be less than:

$$t = 13.4s\sqrt{h} \qquad mm$$

where: s – length of short side of the panel, see 2.2.3.3(2), in m;

h – vertical distance between the lower edge of the lowest place of bottom plating and the upper edge of freeboard deck at boat's sides (decked boat) or the upper edge of side top strake (open deck boat), in m.

(3) For boats navigating in calm water service restriction, where the draught is less than 0.35 times moulded depth, the thickness of bottom single plate is to be 0.9 times the values obtained from the above (2) respectively.

(4) The thickness t of single plate used as side plating within 0.4 L amidship is not to be less than:

$$t = 12.4s\sqrt{h} \qquad mm$$

Where: s – length of short side of the panel, see 2.2.3.3(2), in m;

h – vertical distance between the lowest point of side plate and the upper edge of freeboard deck at boat's sides, in m.

(5) The thickness of single plate used as side plating may be reduced gradually from 0.4 L amidships to fore and aft ends, and the thickness at fore and aft ends may be 0.85 times that at amidship.

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① For details, see Fibre-reinforced plastic composites — Determination of the in-plane shear stress/shear strain response, including the in-plane shear modulus and strength, by the plus or minus 45 degree tension test method (ISO 14129: 1997).

(6) Where the shell plating is a sandwich plate, the minimum thickness t_{min} of each skin laminate on sandwich plate is to be in compliance with the requirements in 2.2.3.3(3).
(7) the total thickness of sandwich plate t is not to be less than:

$$t = \frac{11hs}{\tau_c} \qquad mm$$

where: s – length of short side of the panel, see 2.2.3.3(2)，in m;

h – refer to (2) above for bottom plating; refer to (4) above for side plating;

τ_c – ultimate shear strength of core material of sandwich plate, in N/mm^2.

(8) The thickness of shell plating of fore and aft parts (except stern transom plating), if sandwich plate is used, is not to be less than that of shell plating at amidship.

2.2.4.3 Deck

(1) The calculated pressure head on deck (h) is obtained from:

for exposed deck: h=C(0.02L+0.46) m

for unexposed freeboard deck, unexposed deck of the first-floor superstructure /deckhouse and other internal decks taken into account in the overall strength: h=0.01L+0.46 m

for other non-exposed deck: h=0.45 m

where: C – coefficient:

C=1.05 for greater coastal service restriction
C=1.0 for coastal service restriction;
C=0.9 for sheltered water service restriction
C=0.85 for calm water service restriction

(2) The thickness t of single plate used as deck within 0.4 L amidships is not to be less than:

$$t = 16.2s\sqrt{h} \qquad \text{mm}$$

where: s – length of short side of the panel, see 2.2.3.3(2), in m

h – calculated pressure head on deck, in m, obtained in accordance with the (1) of this paragraph.

(3) The thickness of single plate used as exposed deck may be reduced gradually from 0.4 L amidships to ends of boat, however, the thickness is not to be less than 0.85 times that of exposed deck at amidship.

(4) Where the deck is a sandwich plate, the total thickness t of deck is not to be less than:

$$t = \frac{11hs}{\tau_c} \qquad \text{mm}$$

where: s – length of short side of the panel, see 2.2.3.3(2), in m;

h – calculated pressure head on deck, in m, obtained in accordance with the (1) of this paragraph;

τ_c – ultimate shear strength of core material of sandwich plate, in N/mm^2.

2.2.4.4 Bulkhead plating

(1) The thickness t of single plate used as bulkhead plating is not to be less than:

$$t = 12.2s\sqrt{h} \qquad \text{mm}$$

where: s – length of short side of the panel, see 2.2.3.3(2), in m;

h – calculated pressure head, in m; vertical distance measured from lower edge of bulkhead plating to tank top;

(2) Where the bulkhead is a sandwich plate, the total thickness t of the plate is not to be less than:

$$t = \frac{11hs}{\tau_c} \qquad \text{mm}$$

where: s – length of short side of the panel, see 2.2.3.3(2), in m;

h – calculated pressure head，m；vertical distance measured from lower edge of bulkhead plating to tank top；

τ_c – ultimate shear strength of core material of sandwich plate, in N/mm^2.

(3) In calculation of scantling of collision bulkhead, the calculated pressure head h is to be 1.25 times of the corresponding specified height.

2.2.4.5 Wall plating of superstructure and deckhouse

(1) The calculated pressure head h of fore end walls, side walls and aft walls of superstructures or deckhouses are to be as follows:

$h=C(0.02L+0.5)$ m , for fore end wall;

$h=0.02L+0.25$ m, for side and aft end wall;

$h=0.3$ m, for top plate.

where: C – coefficient:

C=1.05 for greater coastal service restriction

C=1.0 for coastal service restriction;

C=0.9 for sheltered water service restriction

C=0.85 for calm water service restriction

(2) The thickness t of single plate used as wall plating of superstructure or deckhouse is not to be less than:

$$t = 11.7s\sqrt{h} \quad \text{mm}$$

where: s – length of short side of the panel, see 2.2.3.3(2), in m;

h – calculated pressure head, m; to be obtained in accordance with the above(1);

(3) Where the wall plating of superstructure or deckhouse is a sandwich plate, the total thickness t of the plate is not to be less than:

$$t = \frac{11hs}{\tau_c} \quad \text{mm}$$

where: s – length of short side of the panel, see 2.2.3.3(2), in m;

h – calculated pressure head, m; to be obtained in accordance with the above(1);

τ_c – ultimate shear strength of core material of sandwich plate, in N/mm^2.

2.2.4.6 Members

(1) The section modulus W of plate floor is not to be less than:

$$W = 15.4sDl^2 \quad \text{cm}^3$$

where: s – spacing of plate floor, in m;

D – moulded depth, in m;

l – span of plate floor, in m; if longitudinal bulkhead is provided, it is the distance between longitudinal bulkhead and sides or the distance between longitudinal bulkheads, whichever is the greater

The web height of sloping bottom boat's plate floors may be reduced gradually from longitudinal centerplane to sides, however for boat of more than 6 m in length, the plate floor web height in way of 3/8 breadth from longitudinal centerplane is not to be less than 1/2 of that in way of longitudinal centerplane.

(2) The web height of center keelsons in a single bottom boat is not to be less than the height of plate floors in way and the section modulus is at least to be 1.5 times that of plate floors in way. The section modulus of side keelsons is to be equivalent to those of plate floors in way.

(3) The section modulus W of longitudinals at boat's bottom is not to be less than:

$$W=25.7shl^2 \quad \text{cm}^3$$

where: s – spacing of longitudinals, in m;

h – calculated pressure head, in m; the vertical distance measured from lower edge of bottom plating to upper edge of freeboard at sides in the midspan of longitudinal;

l – span of longitudinals, in m; the distance between plate floors or the distance between plate floor and bulkhead, whichever is greater.

(4) Frames

① The section modulus W of frames is not to be less than:

$$W=24shl^2 \quad \text{cm}^3$$

where:s – frame spacing, in m;

l – frame span, in m; for bottom frame, it is the distance between keels or the distance between keel and side, whichever is the greater; for side frame, it is the vertical distance between upper surface of bottom plating and deck;

h– calculated pressure head, in m; for bottom frame, the vertical distance measured from the lower edge of bottom plating to the upper edge of freeboard deck at sides in the midpoint of frame span, for side frame, the vertical distance between the midpoint of frame span and the freeboard deck margin line.

② The section modulus W of web frame is not to be less than:

$$W = 22.6 sh l^2 \quad cm^3$$

where: s – web frame spacing, in m;

h – calculated pressure head, in m; the distance between the midpoint of web frame span and the freeboard deck margin line;

l – web frame span, in m.

(5) The Section modulus W of side longitudinal is not to be less than:

$$W = 22.6 sh l^2 \quad cm^3$$

where:s – spacing of longitudinals, in m;

h– calculated pressure head, in m; the distance between longitudinal and freeboard deck margin line in way of amidship sides;

l – longitudinal span in m; the distance between web frames or the distance between web frame and bulkhead, whichever is the greater.

(6) Deck beam

① The section modulus W of deck beam is not to be less than:

$$W = 19.6 sh l^2 \quad cm^3$$

where:s – beam spacing, in m;

h – beam spacing, in m; calculated pressure head on deck, in m, obtained in accordance with the relevant requirements of 2.2.4.3(1) of this section.

l – beam span, in m; the distance between side and girder (longitudinal bulkhead) or the distance between girders, whichever is the greater.

② The section modulus W of web beam is not to be less than:

$$W = 17.0 sh l^2 \quad cm^3$$

where:s – beam spacing, in m;

h – calculated pressure head on deck, in m, obtained in accordance with the relevant requirements of 2.2.4.3(1) of this section

l – web beam span, in m; the distance between sides, the distance between side and pillar or the distance between pillars, whichever is the greater.

(7) The section modulus W of deck longitudinal is not to be less than:

$$W = 21.0 sh l^2 \quad cm^3$$

where: s – spacing of longitudinals, in m;

h – calculated pressure head on deck, in m, obtained in accordance with the relevant requirements of 2.2.4.3(1) of this section;

l – longitudinal span, in m; the distance between web beams or the distance between web beam and bulkhead, whichever is the greater.

(8) Deck girder

① The deck girder and keel are to be arranged in the same plane as far as possible.

② The section modulus W of deck girder is not to be less than:

$$W = 17.1 bh l^2 \quad cm^3$$

where: b – mean breadth of deck area supported by deck girder, in m;

l – girder span, in m, the distance between pillars or the distance between pillar and bulkhead, whichever is the greater;

h – calculated pressure head on deck, in m, obtained in accordance with the relevant requirements of 2.2.4.3(1) of this section

③ Where deck girder is subjected to concentrated load, in addition to meeting the requirements of ② above, W is to be added as follows:

$$W = 0.102 cP l \quad cm^3$$

where: P – concentrated load, in kN;

l – girder span, in m, as the same as ② above;

c– coefficient, obtained from Table 2.2.4.6(8); where a is the distance between the action point P and the further fulcrum of girder, in m;

Coefficient c Table 2.2.4.6(8)

a/l	0.94	0.90	0.85	0.80	0.75	0.70	0.60	0.50
c	3.56	8.32	14.06	18.22	21.39	22.77	23.73	24.75

(9) The section modulus W of bulkhead stiffener is not to be less than:

$$W = Ksh l^2 \quad \text{cm}^3$$

where: s– stiffener spacing, in m;

l – stiffener span, in m;

h – calculated pressure head, in m; the vertical distance measured from the midpoint of stiffener span to the top of tank;

K– coefficient, obtained in the following cases:

K = 21.67 for stiffener with two ends connected with bracket;

K = 28.87 for stiffener with one end connected with bracket;

K =34.61 for stiffener with two stiffener scarfing.

(10) Framing of superstructure or deckhouse

① The scantling of framing for superstructure or deckhouse is to comply with the relevant requirements of 2.2.4.6(6) to 2.2.4.6(8).

② The section modulus W of trunk stiffener of superstructure or deckhouse is not to be less than:

$$W = 20.3sh l^2 \quad \text{cm}^3$$

Where: s – stiffener spacing, in m;

l – stiffener span, in m, the practical length of stiffener;

h – calculated pressure head, in m; obtained in accordance with the relevant requirements of 2.2.4.5(1).

Section 3 Steel Boats

2.3.1 General requirements

2.3.1.1 This Section applies to boats whose hull structures are of steel material.

2.3.1.2 In addition to the requirements of 2.1.3 in Section 1 of this Chapter, the structural design and arrangement principles are also to meet the following requirements:

(1) Web plates of bilge keel taken into account in longitudinal strength are to be continuous in way of the transverse watertight bulkheads, or to be equivalently continuous.

(2) The plate floors are to be fitted on each frame in the engine room, and additional strengthening is to be provided in way of the thrust bearing. For engine room area of a longitudinally framed non-high speed boat, it is allowed that plate floors are provided at alternative frame space.

(3) The plate floors are to be fitted on both ends of a main engine in the engine room.

(4) The thickness of stern transom plating is not to be less than that of shell side plating, however where propelling unit is fitted on the stern transom plating, the thickness of stern transom plating is not to be less than 1.2 times that of shell side plating.

2.3.1.3 The overall hull strength of steel boats is to meet the provisions of 2.1.4.1 and 2.1.4.6 of Section 1 of this Chapter.

2.3.1.4 The calculated plate thickness is rounded as follows: where the decimal part of the calculated plate thickness is 0.25 mm or less, it may be neglected; where it is greater than 0.25 mm but less than 0.75 mm, it is to be taken as 0.5 mm; where it is 0.75 mm or more, a round number of 1.0 mm is to be taken.

2.3.1.5 When calculating section modulus of members, the effective breadth b_e of attached plates of members is to be taken as follows:

For secondary members: $b_e = s$;

For primary members: $b_e = 0.3s\left(\frac{l}{s}\right)^{2/3}$, but not greater than $l/5$;

2.3.2 Hull structural scantlings of high speed crafts

2.3.2.1 The requirements for determining vertical acceleration at gravity center of a boat and local calculated pressure of hull structure are the same as in 2.2.3.1 and 2.2.3.2 of Section 2 of this Chapter.

2.3.2.2 Thickness of plating

(1) The minimum thickness $t_{\min}$ of plating is to be taken as follows:

for monohull and catamarans: $t_{\min} = K_0 \sqrt[3]{L}$ mm

for hydrofoil crafts: $t_{\min} = 0.85 K_0 \sqrt[3]{L}$ mm

for air-cushion vehicles: $t_{\min} = 0.8 K_0 \sqrt[3]{L}$ mm

where: K_0—Coefficient, see Table 2.3.2.2 (1).

Coefficient *K0* Table 2.3.2.2(1)

Item		K_0
Bottom shell plating		1.40
Connecting structure bottom		1.30
Side plating		1.30
Main deck plating		Longitudinally framed: 1.10 (not less than 3mm) Transversely framed:1.30
Unexposed deck plating		0.90
Bulkhead plating		1.00
Superstructures, deckhouse	Fore end bulkhead	1.20
	Side bulkhead, aft bulkhead	0.86
	Top plates	0.65 (not less than 2mm）
Main engine foundations(1)		1.90

Note: (1) The minimum plate thickness of main engine foundations of any type of high-speed craft is to be calculated according to $t_{\min} = K_0 \sqrt[3]{L}$.

(2) Built-up sections of bottom, including engine seating, are to comply with the following requirements:

① The minimum web thickness $t_{\min}$ is not to be less than that calculated from the following formula:

$$t_{\min} = \frac{h}{70}\sqrt{\frac{\sigma_S}{235}} \quad \text{mm}$$

where: *h* — web height or spacing of web stiffeners, whichever is smaller, in mm;

σ_S—yield stress of material, in N/mm^2.

② The minimum thickness $t_{\min}$ of face plating is to be taken not less than that from the following:

$$t_{\min} = \frac{b}{15}\sqrt{\frac{\sigma_S}{235}} \quad \text{mm}$$

where: *b*—plate width, in mm;

σ_S—yield stress of material, in N/mm^2.

(3) The thickness t of plating is to be taken not less than that from the following:

$$t = K_1 C_1 C_2 s \sqrt{\frac{P}{\sigma_S}} \quad \text{mm}$$

where: K_1— to be obtained from Table 2.3.2.2(3). The intermediate area may be obtained by linear interpolation method;

s — length of short side of the panel, , in m, see 2.2.3.3(2);

P—design pressure, to be taken as required by 2.2.3.2 of this Chapter;

σ_S － yield stress of material, in N/mm^2;

C_1— reduction factor for curved plates; $C_1 = 1 - 0.5\ s/r$, where: r is radius of curvature, in m;

C_2 — correction factor for ratio of the long side l to the short side *s* of the panel, to be taken as follows:

if l/s <2, $C_2 = \frac{l}{s}\left(1 - 0.25\frac{l}{s}\right)$

if l/s $\geqslant 2$, $C_2 = 1.0$

where: l — length of long side of the panel, in m, See 2.2.3.3(2).

Coefficient K_1 Table 2.3.2.2(3)

Item		K_1		
		Forward of 0.1L from F.P.	Within 0.4L at amidship	Aftward of 0.1L from A.P.
Bottom, connecting structure bottom		21.5	25.0	21.5
Side	Near bottom	21.5	25.0	21.5
	Near neutral axis	20.5	20.5 for longitudinally framing 21.5 for transversely framing	20.5
	Near deck	20.5	25.0	20.5
Deck, including superstructure/deckhouse top		20.5 for longitudinally framing 21.5 for transversely framing	25.0	20.5 for longitudinally framing 21.5 for transversely framing
Superstructure/deckhouse wall		21.5		
Bulkhead	Collision	21.5		
	Watertight	19.0		
	Liquid tank	21.5		

2.3.2.3 Bending strength of stiffeners and frames

(1) The section modulus W including attached plating of stiffeners and frames is not to be less than:

$$W = K_2 \frac{l^2 sP}{\sigma_S} \quad \text{cm}^3$$

where: K_2 — coefficient, to be obtained from Table 2.3.2.3(1);

P, σ_S — same as in 2.3.2.2 (3) of this Section.

Coefficient K_2 Table 2.3.2.3(1)

Item		Secondary members			Primary members
		Longitudinals	Beam, frames, floors	stiffeners	Keels, web frames, plate floors, web beams, girders
Bottom, connecting structure bottom		136	150	—	150
Side		128	150	—	150
Deck, including superstructure/deckhouse top		Deck: 212 Top: 150	150	—	150
Superstructure/deckhouse front and side walls		—	—	150	150
Superstructure/deckhouse rear walls		—	—	150	150
Bulkhead	Collision and liquid tank	—	—	150	150
	Watertight	—	—	110	110

2.3.2.4 Shearing strength for longitudinals and girders

(1) The effective shear area A_e at end of longitudinals is not to be less than $A_{e\min}$ obtained from the following formula:

$$A_{e\min} = 22.67\frac{(l - s)sP}{\sigma_S} \quad \text{cm}^2$$

The effective shear area A_e is to be calculated as follows:

$$A_e = 0.01ht \quad \text{cm}^2$$

where: h — web depth of longitudinals, in mm;

t — web thickness of longitudinals, in mm;

P, σ_S — same as in 2.3.2.2 (3) of this Section.

(2) The effective shear area A_e at end of girders is not to be less than $A_{e\min}$ obtained from the following formula:

$$A_{e\min} = 13.5\frac{slP}{\sigma_S} \quad \text{cm}^2$$

The effective shear area A_e is to be calculated as follows:

$A_e = 0.01 h_W t_W$ cm², for no brackets at ends of girder;

$A_e = 0.01 h_W t_W + \delta A_e$ cm², for brackets at ends of girder

where: h_W — net web height after deduction of cutouts in the cross section considered, in mm;

t_W — web thickness, in mm;

P、σ_S — same as in 2.3.2.2 (3) of this Section.

δA_e — additional shear area at end of girder with bracket, obtained according to the horizontal angle θ of the bracket's face plate, see Fig. 2.2.3.5 (1) of Section 2 of this Chapter. $\delta A_e = 0.9 f_1$ where $\theta = 45^\circ$; $\delta A_e = 0$ where $\theta = 0^\circ$; θ may be obtained by linear interpolation where $\theta = 0\text{-}45^\circ$; f_1 is area of the bracket's face plate in the cross section considered, in cm².

2.3.3 Hull structural scantlings of non-high speed boats

2.3.3.1 General provisions

(1) The requirements of this paragraph are applicable to conventional steel boats with transverse framing.

(2) Hull structural scantlings calculated from the requirements of this paragraph are required for boats in the coastal service restriction. Boasts in greater coastal service restriction are to be strengthened according to the requirements in ① below; scantlings of boats in the sheltered water service and calm water service restrictions may be reduced in accordance with the requirements in ②~④ below:

① The thickness of bottom plating, side plating, strength deck and fore end bulkhead of superstructure or deckhouse is to be increased by 5% of the calculated thickness as specified in this paragraph, and the section modulus of hull framing is to be increased by 5% of the calculated section modulus as specified in this paragraph.

② The thickness of bottom plating, side plating and strength deck may be reduced by 8% of the calculated thickness as specified in this paragraph, but the minimum thickness of the reduced bottom plating, side plating and strength deck is not to be less than 4 mm for L ⩾ 10 m, and that is not to be less than 3.5 mm for L < 10 m.

③ The section modulus of hull framing may be reduced by 10% of the calculated section modulus as specified in this paragraph, but the thickness of plate floors and inner keel webs, but the web thickness of plate floors and inner keelson is only allowed to be reduced by 0.5 mm.

④ The thickness of boundary bulkheads, deck plating of superstructures and deckhouses may be reduced by 0.5 mm of the calculated thickness as specified in this paragraph, but the minimum thickness is not to be less than 3.0 mm. The section modulus of framing of superstructures and deckhouses may be reduced by 10%.

2.3.3.2 Shell plating and deck

(1) The thickness t of bottom plating is not to be less than that obtained from the following two formulae, and not less than 4 mm:

$t = 0.062s\,(L+170)$ mm

$t = 6.5s\sqrt{d} + 1$ mm

where: s – frame spacing, in m;

L – length of boat, in m;

d – draft, in m.

(2) The thickness t of side plating is not to be less than that obtained from the following two formulae, and not less than 4 mm:

$$t=0.07s\,(L+115)\quad \text{mm}$$

$$t=6s\sqrt{d}\quad \text{mm}$$

where: s – frame spacing, in m;
L– length of boat, in m;
d – draft, in m.

(3) The thickness t of strength deck is to be less than that obtained from the following formula, and not less than 4 mm:

$$t=1.05s\sqrt{L+75}\quad \text{mm}$$

where: s– beam spacing, in m;
L – length of boat, in m.

(4) The thickness t of the lower deck is not to be less than that obtained from the following formula, and not less than 4 mm:

$$t=10s\quad \text{mm}$$

where: s– beam spacing, in m.

2.3.3.3 Hull Framing

(1) The height h, thickness t of web plates and sectional area A of face plates of plate floors at center longitudinal section are not to be less than those obtained from the following formulae respectively:

$$h=42(B+d)-70\quad \text{mm}$$

$$t=0.01h+3\quad \text{mm}$$

$$A=4.8d-3\quad \text{cm}^2$$

where: B – breadth of boat, in m. For a multi-hull boat, it is the breadth of a single hull;
d – draft, in m.

(2) The face plate thickness of the floor is not to be less than that of web plates, and the breadth of face plates is not to be less than 10 times the thickness of face plates, but need not be more than 15 times.

(3) The web plate thickness of floors in engine rooms is not to be less than that of the web plate of center keelson.

(4) The height of center keelson is to be equal to that of the plate floor. The thickness t of web plates and sectional area A of face plates are not to be less than those obtained from the following formulae respectively:

$$t=0.06L+6.2\quad \text{mm, within 0.4 L amidships;}$$

$$t=0.05L+5.5\quad \text{mm, within 0.075L at ends;}$$

$$A=0.65L+2\quad \text{cm}^2$$

where: L – length of boat, in m.

(5) The center keelson in forepeak may have the same height, thickness and face plate sectional area as that of the floor respectively.

(6) The scantling of side keelsons is to be the same as that of the plate floors in way. In engine room, the web plate thickness of the side keelsons is not to be less than that of the center keelson. The spacing of the side keelsons is not to be more than 2.5 m.

(7) The section modulus W of frames is not to be less than that obtained from the following formula:

$$W=Csdl^2\quad \text{cm}^3$$

where: s – frame spacing, in m;
d – draft, in m;
l – frame span, in m; but to be taken not less than $\sqrt{D}$, where, D is the moulded depth;
C– coefficient, to be obtained from the following formula:

$$C=\frac{2+0.65\frac{d}{D}}{1.45-\frac{\sqrt{D}}{l}}$$

where: D is the moulded depth, in m.

(8) Where side stringers are fitted to support the frames, the section modulus of frames calculated in (7) above may be reduced by half.

(9) Web frames are to be fitted in engine room with spacing not more than that of 4 frame-spaces, and are to extend from the inner bottom to upper deck. The section modulus W is not to be less than that obtained from the following formula:

$$W = 5sh l^2 \quad cm^3$$

where: s– spacing of web frames, in m;

l – span of web frames, in m;

h– vertical distance, in m, measured from the mid-point of web frame span to upper deck at side.

(10) The section modulus W of side stringers is not to be less than that obtained from the following formula:

$$W = 7.8bh l^2 \quad cm^3$$

where: b – supporting breadth of side stringers, in m;

l – span of side stringers, in m;

h – vertical distance in m, measured from the mid-point of side stringer span to upper deck at side amidships.

(11) The moment of inertia I of the side stringers is not to be less than that obtained from the following formula:

$$I = 2.5W l \quad cm^4$$

where: W– section modulus of side stringers, in cm^3;

l – span of side stringers, in m.

2.3.3.4 Deck framing

(1) The design heads h of deck framing are to be selected from Table 2.3.3.4(1). h_0 in the table is to be obtained from the following formula:

$$h_0 = 0.025L + 0.45 \quad m$$

where: L– length of boat, in m.

Heads Table 2.3.3.4(1)

Deck position	Design heads h of deck members (m)
1.Weather strength deck forward of 0.15 L from F.P.	$1.2h_0$
2. Weather strength deck aftward of 0.15 L from F.P.	h_0, but not less than 0.8m
3. Deck cargo area of weather deck	P+0.3 or h_0, whichever is greater
4. Strength deck of the superstructure and deckhouse area used for accommodation and stacking sundries, platform deck, deck of the first tier deckhouse	$0.8h_0$
5. Each layer of deck above the superstructure deck or the first tier deckhouse	Taking, in turn, $0.6h_0$, $0.4h_0$ …, but not less than 0.45m

Notes:

1) P in Table is the equivalent height (m) of the water column of cargo weight on cargo decks;

2) Design heads h of decks (platforms) of cargo tanks are not to be less than the height (in m) to the top of overflow pipe of the tank top.

(2) The section modulus W of deck beams is not to be less than that obtained from the following formula:

$$W = 3.5C_1sh l^2 + C_2Dd \quad cm^3$$

where: s – spacing of beams, in m;

l – span of beams, in m, but not less than 2 m;

h – calculated heads of deck members, in m, selected according to above (1);

D – moulded depth, in m;

d– draft, in m;

C_1 – coefficient,

$C_1 = 0.0065L + 0.61$ for weather strength deck;

$C_1 = 1$ for other decks;

C_2 – coefficient,

$C_2 = 0.8$ for strength deck of boat with single deck;

$C_2 = 0.5$ for other decks.

(3) The section modulus W of deck transverses is not to be less than that obtained from the following formula:

$$W = 5shl^2 \quad cm^3$$

where: s– spacing of deck transverse, in m;

l – span of deck transverse, in m;

h– calculated pressure head of deck members, in m, selected according to above (1);

(4) The section modulus W of deck girders is not to be less than that obtained from the following formula:

$$W = 4.75bhl^2 \quad cm^3$$

where: b – mean breadth, in m, of deck area supported by the deck girders;

l – span of deck girders, in m;

h –calculated pressure head of deck members, in m, selected according to above (1);

(5) The moment of inertia I of deck girders is not to be less than that obtained from the following formula:

$$I=2Wl \quad cm^4$$

where: W – section modulus of deck girders, in cm^3;

l – span of deck girders, in m.

2.3.3.5 Bulkhead

(1) The thickness t of watertight bulkhead plating is not to be less than that obtained from the following formula, and not less than 4.5 mm:

$$t=4.2s\sqrt{h} \quad mm$$

where: s – spacing of stiffeners, in m;

h– vertical distance, in m, measured from the lower edge of the plate in a strake to the bulkhead deck at side, but not to be taken as less than 2.5 m.

(2) The thickness *t* of collision bulkhead plating is not to be less than that obtained from the following formula, and not less than 4.5 mm:

$$t=4.7s\sqrt{h} \quad mm$$

where: s, h – see (1) above.

(3) The thickness of plating for the lowest strake of bulkheads is to be increased by 0.5 mm, and be increased by 1.5 mm in way of the sewage drains and bilge well. The thickness of bulkhead plating in way of the stern tube is to be doubled.

(4) The section modulus W of watertight bulkhead stiffeners is not to be less than that obtained from the following formula:

$$W = Cshl^2 \quad cm^3$$

where: s – spacing of stiffeners, in m;

h – vertical distance, measured from the mid-point of stiffener span to the bulkhead deck at side, in m, but not to be taken as less than 2 m;

l – span of stiffeners, in m, where girders are fitted, it is the distance between the end of stiffener and the girder or between the girders, whichever is the greater;

C– coefficient, to be taken as follows:

C=6 for stiffeners unattached at both ends, or directly attached to unstiffened plating;

C=3 for stiffeners bracketed at ends, stiffeners directly lap-connected to longitudinal members at ends, stiffeners directly connected to deck plating or girder web at ends, provided that on the other side of the deck or girder, an adjacent member is provided with the same section as and in line with the said stiffener.

(5) The section modulus W of collision bulkhead stiffeners is not to be less than that obtained from the following formula:

$$W = 1.25Cshl^2 \quad cm^3$$

where: s, h, l, C – see (4) above.

2.3.3.6 Superstructures and deckhouses

(1) The standard spacing s_0 of boundary stiffeners or deck frames of the superstructure and deckhouse, to which this paragraph is applicable, is 500 mm. If the actual spacing s is greater than the standard spacing s_0, the following required plate thickness of the superstructure and deckhouse covered by in this paragraph is to be multiplied by $\sqrt{s/s_0}$.

(2) The thickness t of fore end bulkheads of superstructures is not to be less than that obtained from the following formulae:

$t=0.025L+4$ mm, for $L \geqslant 10$m;

$t=0.025L+3.5$ mm, for $L < 10$ m

where: L – length of boat, in m.

(3) The thickness of aft end bulkheads of superstructures may be reduced by 0.5 mm of that obtained from the calculation in (2) above.

(4) The section modulus W of end bulkhead stiffeners of superstructures is not to be less than that obtained from the following formula:

$$W = 3.5 s h l^2 \quad \text{cm}^3$$

where: s – spacing of stiffeners, in m;

l – span of stiffener, in m, but not to be taken as less than 2 m;

h – calculated heads, in m, to be selected as follows:

for fore end bulkheads, to be taken as $0.132L\ (d/D)^{2.5}$, but not to be less than $0.008L+2.5$ m;

for aft end bulkheads, to be taken as $0.045L\ (d/D)^2$, but not to be less than $0.004L+1.25$ m;

where: L – length of boat, in m;

d/D – the ratio of draft to moulded depth:

0.7 for $d/D < 0.7$;

0.8 for $d/D > 0.8$.

(5) The thickness of side plating of superstructures is to comply with the following requirements:

① The thickness of side plating of bridges is to be equal to that of side plating amidship.

② The thickness t of side plating of forecastle and poop is not to be less than that obtained from the following formulae:

$t=0.04L+4$ mm, for $L \geqslant 10$m

$t=0.04L+3.5$ mm, for $L<10$m

where: L– length of boat, in m.

(6) The side framing of superstructures is to comply with the relevant requirements of 2.3.3.3 (7) of this Section.

(7) The thickness t of decks of superstructures is not to be less than that obtained from the following formulae:

$t=0.035L+4$ mm, for $L \geqslant 10$m

$t=0.035L+3.5$ mm, for $L<10$m

where: L – length of boat, in m.

(8) The deck framing of superstructures is to comply with the relevant requirements of 2.3.3.4 of this Section.

(9) The thickness t of boundary bulkheads of deckhouses is not to be less than that obtained from the following formula:

$t=0.025L+3.5$ mm

where: L – length of boat, in m.

(10) The section modulus W of the stiffeners of the deckhouse boundary bulkheads is not to be less than that obtained from the following formula:

$$W=3.5 s h l^2 \quad \text{cm}^3$$

where: s, l – see 2.3.3.6 (4) of this Section;

h – calculated heads of stiffners, in m, to be selected as follows:

for fore end bulkheads of deckhouses, to be taken as $0.12L\ (d/D)^{2.5}$, but not to be less than $0.008L+2.5$ m;

for side bulkheads and aft end bulkheads of deckhouses, to be taken as $0.045L\ (d/D)^2$, but not to be less than $0.004L+1.25$ m.

where: L, d/D are the same as those in 2.3.3.6 (4) of this Section.

(11) The thickness t of the deckhouse decks is not to be less than that obtained from the following formula:

$$t=0.04L+3 \quad \text{mm}$$

where: L– length of boat, in m.

Section 4 Aluminum Boats

2.4.1 General requirements

2.4.1.1 This Section applies to boats whose hull structures are of aluminum material. For air-cushion vehicles, the structures are to comply with the requirements of CCS Rules for Construction and Classification of Sea-going High Speed Craft.
2.4.1.2 The design and arrangement principles of hull structures are to comply with the provisions of 2.1.3 of Section 1 and 2.3.1.2 of Section 3 of this Chapter.
2.4.1.3 The overall hull strength is to comply with the relevant provisions of 2.1.4.1 and 2.1.4.6 of Section 1 of this Chapter.
2.4.1.4 The calculated plate thickness is to be rounded according to the requirements in 2.3.1.4 of Section 3.
2.4.1.5 The effective breadth b_e of attached plates of members is to be taken according to the requirements in 2.3.1.5 of Section 3.

2.4.2 Vertical acceleration at gravity center

2.4.2.1 The requirements for determining vertical acceleration at gravity center of a boat are same as that in 2.2.3.1 of Section 2 of this Chapter.

2.4.3 Local calculated pressure

2.4.3.1 The requirements for local calculated pressure of bottom, side, deck, bulkhead and superstructure are same as that in 2.2.3.2 of this Chapter.

2.4.4 Plating

2.4.4.1 The minimum thickness $t_{\min}$ of plating is to be taken as follows:

for monohull and catamarans: $t_{\min} = K_0\sqrt[3]{L}$ mm

for hydrofoil crafts: $t_{\min} = 0.85K_0\sqrt[3]{L}$ mm

for air-cushion vehicles: $t_{\min} = 0.8K_0\sqrt[3]{L}$ mm

where: K_0 — Coefficient, see Table 2.4.4.1;

L — length of boat, in m.

Coefficient K_0 **Table 2.4.4.1**

Item		K_0
Bottom shell plating		1.55
Connecting structure bottom		1.40
Side plating		1.40
Main deck plating		Longitudinally framed: 1.40 Transversely framed: 1.50
Unexposed deck plating		1.16
Bulkhead plating		1.16
Superstructures, deckhouse	Fore end bulkhead	1.30
	Side bulkhead, aft bulkhead	0.92
	Top plates	0.80
Main engine foundations(1)		1.90

Note: (1) The minimum plate thickness of main engine foundations of any type of high-speed craft is to be calculated according to $t_{\min} = K_0\sqrt[3]{L}$.

2.4.4.2 Built-up sections of bottom, including engine seating, is to comply with the following requirements:

(1) The minimum web thickness $t_{\min}$ is not to be less than that calculated from the following formula:

$$t_{\min} = \frac{h}{50}\sqrt{\frac{\sigma_{SW}}{125}} \quad \text{mm}$$

where: h — web height or spacing of web stiffeners, whichever is smaller, in mm;

σ_{SW} — yield strength after welding of aluminum alloy sections, in N/mm², to be taken as yield strength $\sigma_{p0.2}$ of aluminum alloy in the annealed condition. See relevant provisions in CCS Rules for Materials and Welding.

(2) The minimum thickness $t_{\min}$ of face plating is to be taken not less than that from the following:

$$t_{\min} = \frac{b}{12}\sqrt{\frac{\sigma_{SW}}{125}} \qquad \text{mm}$$

where: b— plate width, in mm;

σ_{SW} — yield strength after welding of aluminum alloy sections, in N/mm², to be taken as yield strength $\sigma_{p0.2}$ of aluminum alloy in the annealed condition. See relevant provisions in CCS Rules for Materials and Welding.

2.4.4.3 The thickness t of plating is to be taken not less than that from the following:

$$t = KC_1C_2s\sqrt{\frac{P}{\sigma_{SW}}} \qquad \text{mm}$$

where: K— coefficient, to be obtained from Table 2.4.4.3;

s – length of short side of the panel, see 2.2.3.3(2), in m;

P— design pressure, to be taken as required by 2.2.3.2 of Section 2 of this Chapter;

σ_{SW} — yield strength after welding of aluminum alloy plates, in N/mm², to be taken as yield strength $\sigma_{p0.2}$ of aluminum alloy plates in the annealed condition. See relevant provisions in CCS Rules for Materials and Welding.

C_1— reduction factor for curved plates; $C_1 = 1 - 0.5\ s/r$, where: r is radius of curvature, in m;

C_2 — correction factor for ratio of the long side l to the short side s of the panel, to be taken as follows:

if l/s <2, $C_2 = \frac{l}{s}\left(1 - 0.25\frac{l}{s}\right)$

if l/s ≥2, $C_2 = 1.0$

where: l — length of long side of the panel, in m, See 2.2.3.3(2).

Coefficient K Table 2.4.4.3

K		Plating	Secondary members			Primary members
			Longitudinals	Beam, frames, floors	stiffeners	Keels, girders, web frames, plate floors, web beams,
Bottom, connecting structure bottom		25.0	115	135	—	135
Side		25.8	130	150	—	150
Deck, including superstructure/deckhouse top		27.8	130	150	—	150
Superstructure/deckhouse front walls		25.8	—	—	170	150
Superstructure/deckhouse side and rear walls		25.8	—	—	150	150
Bulkhead	Collision and liquid tank	25.8	—	—	130	150
	Watertight	23.4	—	—	120	150

2.4.5 Members

2.4.5.1 The section modulus W including attached plating of members is not to be less than:

$$W = K\frac{l^2 sP}{\sigma_{SW}} \qquad \text{cm}^3$$

where: K — coefficient, to be obtained from Table 2.4.4.3;

P—same as 2.4.4.3 of this Section.

σ_{SW} —yield strength after welding of aluminum alloy members, in N/mm^2, to be taken as follows:

① Except for bulkhead stiffeners, the yield strength σ_{SW} of aluminum alloy after welding is to be taken for secondary members at all positions, to be taken as yield strength $\sigma_{p0.2}$ of aluminum alloy plates in the annealed condition. See relevant provisions in CCS Rules for Materials and Welding.

② Except for primary members at boat bottom and connecting structure bottom, yield strength $\sigma_{p0.2}$ of aluminum alloy material may be taken for primary members at all other positions. See relevant provisions in CCS Rules for Materials and Welding.

③ $\sigma_{SW} = 0.9\sigma_{p0.2}$ for riveting structure, where, $\sigma_{p0.2}$ is the yield strength of aluminum alloy material.

2.4.5.2 The requirements for the shearing strength for members are same as in 2.3.2.4 of Section 3 of this Chapter.

Section 5 Doors, Windows and Covers

2.5.1 General requirements

2.5.1.1 The external doors of enclosed superstructures or deckhouses, and the hatches on open decks are to be provided with weathertight closing devices. The strength of weathertight doors and hatch covers is to be equivalent to that of adjacent structures.

2.5.1.2 In general, side scuttles are not to be provided in way of sides under freeboard deck. Where it is necessary to provide side scuttles, they are to be fitted with hinged inner scuttle cover, which can ensure effective closing and secure watertightness.

2.5.1.3 No door is to be provided on collision bulkhead but watertight man-hole cover with bolts may be allowed. The door in watertight bulkhead must be of watertight type and is to be kept closed during navigation.

2.5.1.4 The external windows and their frames of superstructure or deckhouse are to be capable of ensuring weathertightness. The connection between window glass and frame and the connection between frame and wall plating are to be firm and reliable, and capable of sustaining wave slamming as the boat is navigating normally in its service restriction. The structural strength is to be equivalent to that of adjacent structure.

2.4.1.5 The external windows are to be adopted of toughened glass or polycarbonate glass or laminated glass in compliance with the relevant standards accepted by CCS, and the mechanical properties of glass materials are to be submitted to CCS.

2.5.2 Thickness of window glass and adhering

2.5.2.1 The thickness t of the outer window glass is not to be less than:

$$t = \frac{b}{31.6}\sqrt{\frac{kcP}{\sigma_b}} \quad \text{mm}$$

where: b– short side length of window opening, in mm;

P –load on the window glass, in kN/mm^2, to be taken according to 2.2.3.2 (6) for high speed craft or 2.2.4.5 (1) for non-high speed boat;

c– coefficient, obtained from Fig. 2.5.2.1;

σ_b – ultimate bending stress of glass, in MPa;

k– safety factor,

k = 4.0, for toughened safe glass;

k = 3.5 for polycarbonate glass.

Each glass is to be of toughened safe glass in case of sandwich glass. The maximum glass layers are to be of three, and the thickness difference for any two layers of them is not to be more than 2 mm. The thickness of plastic membranes in between is not to be more than 0.76 mm. The thickness t of sandwich glass is not to be less than:

for two-layer sandwich glass $t=t_1+t_2=1.2t_{eq}$
for three-layer sandwich glass $t=t_1+t_2+t_3=1.5t_{eq}$
where: t_1, t_2, t_3 – thickness of each glass, in mm;

t_{eq}– equivalent thickness as calculated from single layer toughened safe glass, in mm.

In addition, the thickness t to be taken is not to be less than the following minimum values t_{min}:
front window glass of superstructure or bridge room:

t_{min}＝4mm, for toughened safe glass;

t_{min}＝5mm, for polycarbonate glass;

side window glass of superstructure or deckhouse:

t_{min}＝3mm, for toughened safe glass;

t_{min}＝4mm, for polycarbonate glass.

2.5.2.2 Where the window glass is of polycarbonate glass, depth of glass inserted in the frame of window is not to be less than 0.03 times the length of short side of the window glass.

2.5.2.3 The outer window glass may be connected directly to wall plating by means of adhering. Where necessary, metal horizontal members are to be provided at the lower edge of window glass to support the glass weight. The adhesive adopted is to be capable of resisting ultraviolet light, low and high temperature and chemical cleaning agent. The properties of adhesive such as long-life adhering strength and its working requirements and procedure documents are to be submitted to CCS for approval.

2.5.2.4 In addition, the adhering methods as mentioned in 2.5.2.3 above are to comply with the following requirements:

(1) The adhering width d is not to be less than:

$$d=\frac{2.5P_W bl}{\sigma_t\left(b+l\right)} \quad \text{mm}$$

where: P_W＝$0.0125(50+0.5v)^2$ kN/m^2;
v– maximum speed in calm water, in Kn;
b – short side length of window, in m;
l – long side length of window, in m;
σ_t – minimum tensile stress of adhesive, in MPa.

The minimum adhering width is d_{min}＝20b mm.

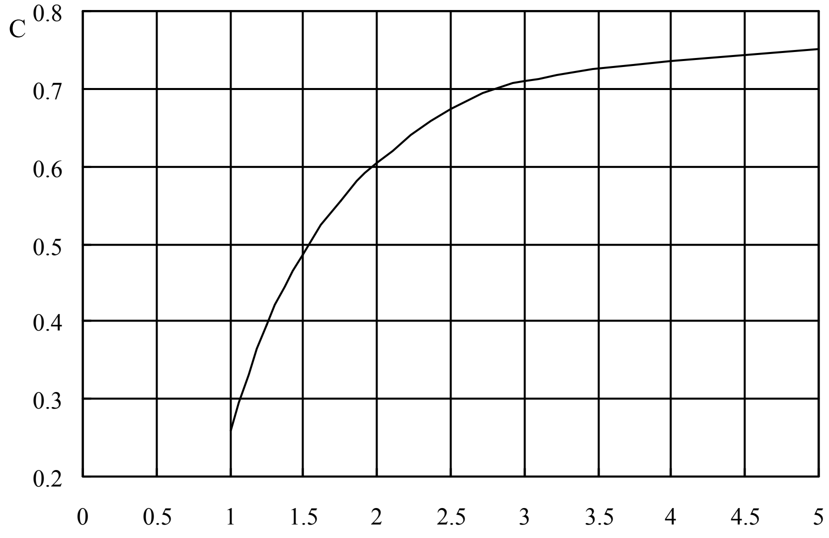
(2) The thickness t of adhesive is not to be less than:

$t=5l$ mm, for toughened safe glass;

$t=8l$ mm, for polycarbonate glass.

The minimum adhering thickness is t_{min}=6 mm.

(3) The tensile strength of adhesive is not to be less than 0.7 MPa, the tensile strength is not to be less than 0.14 MPa when the elongation is 12.5%, and the elongation is to be more than 50% when the adhesive is broken.



Window aspect ratio = Long side length/ Short side length

Figure 2.5.2.1

2.5.3 Underwater viewports

2.5.3.1 The provisions in this paragraph apply only to underwater viewport using toughened safe sandwich glass. For viewport glass using polymethyl methacrylate (polyacrylate or organic glass for short) as glass material, please refer to the relevant requirements in Section 2 of Chapter 5 of the CCS Rules for Classification of Diving Systems and Submersibles.

2.5.3.2 The design of underwater viewport glass is to meet the following formula:

$$\sigma \leqslant f_g$$

where:

σ—design value of maximum bending stress of glass section due to water pressure, in N/mm^2;

f_g—design value of strength of toughened glass under long-term load, in N/mm^2, may be calculated according to 2.5.3.3.

2.5.3.3 Design value f_g of strength of toughened glass under long-term load may be obtained from the following:

$$f_g = c_1 c_2 c_3 c_4 f_0 \quad N/mm^2$$

where:

c_1 — coefficient of glass type, taken as 2.5;

c_2 — position coefficient of glass strength, taken as 1.0 in the middle;

c_3 — load type coefficient, taken as 0.5 for long-term load;

c_4 —glass thickness coefficient, taken as 1.0 for glass thickness between 4mm and 12mm, taken as 0.85 for glass thickness between 15mm and 19mm, taken as 0.7 for glass thickness greater than or equal to 20mm, and other thickness is to be determined by interpolation.

f_0—design value of middle strength of flat glass under short-term load, taken as $28N/mm^2$.

2.5.3.4 Water pressure is to be considered for underwater viewport glass, including seawater static pressure and seawater dynamic pressure. Sea water dynamic pressure may be determined by ship model test method or by wave load direct calculation method. Please refer to the relevant provisions in 1.5.7 of Chapter 1 of PART TWO in CCS Rules for Classification of Sea-going Steel Ships. Wave load is to be calculated based on two-dimensional linear slice theory, three-dimensional linear theory (considering nonlinear correction) or nonlinear wave theory. P-M wave spectrum is to be used in the long-term prediction and calculation of dynamic pressure. The wave dispersion chart taken in the calculation is the worst wave dispersion chart in the sea area where the boat navigates. The long-term forecast result with probability level of 10^{-8} is taken as the calculation result. For high speed crafts, the wave shock pressure in 2.2.3.2 is also to be taken into account for viewport glass.

2.5.3.5 When under water pressure, the deflection of the viewport glass plate is not to be greater than 1/200 of its span; the deflection of the installed frame is not to be greater than 1/500 of its span, which may be determined by model test or direct calculation.

2.5.3.6 The design value of maximum bending stress σ and maximum deflection u in the middle of vertical rectangular glass supported at four sides are to be calculated as follows:

$$\sigma = \beta_1 \rho (H+H_w) L^2/(nt^2) \qquad N/mm^2$$

$$u = \alpha_1 \rho (H+H_w) L^4/(nt^3) \qquad mm$$

where:

ρ—seawater density, to be taken as $1025kg/m^3$;

H—vertical distance from the highest load line to the lowest point of the viewport sill, in m;

H_w—equivalent water pressure head corresponding to the seawater dynamic pressure, in m, taken as the maximum value on the bearing surface of glass;

L—span, in m;

t—thickness of single sheet of glass, in mm;

n— number of single sheet of glass of sandwich glass;

β_1, α_1—coefficients related to aspect ratio of glass, to be taken according to Figure 2.5.3.6 and Table 2.5.3.6 (1) (2).

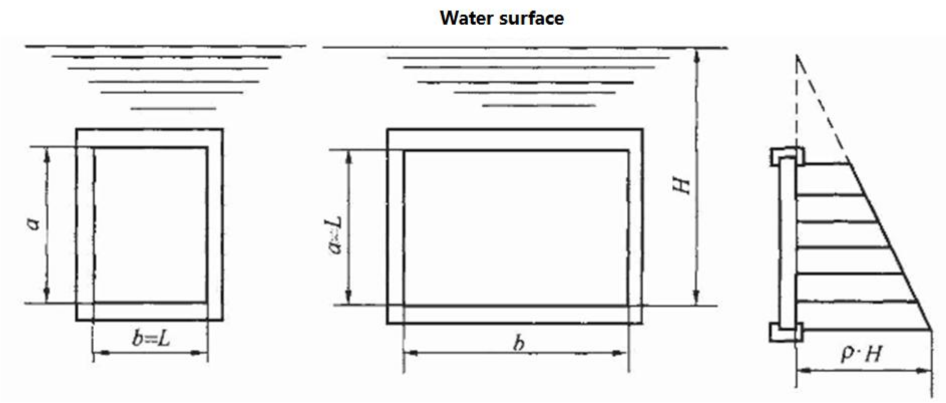


Figure 2.5.3.6 Vertical rectangular glass supported at four sides under hydrostatic pressure

Value of coefficient β_1 Table 2.5.3.6(1)

k \ $(H+H_w)/a$	1.0	1.2	1.4	1.6	1.8	2.0	2.5	3.0	4.0	6.0	10.0	∞
1.0	1.57	1.70	1.87	1.97	2.05	2.11	2.24	2.32	2.43	2.54	2.63	2.76
1.2	2.00	2.24	2.43	2.57	2.68	2.78	2.95	3.07	3.20	3.35	3.48	3.66
1.4	2.37	2.69	2.92	3.10	3.25	3.37	3.57	3.71	3.89	4.07	4.22	4.44
1.6	2.69	3.06	3.34	3.55	3.71	3.85	4.09	4.25	4.46	4.67	4.84	5.10
1.8	2.95	3.36	3.67	3.91	4.10	4.24	4.51	4.69	4.93	5.16	5.35	5.63
2.0	3.15	3.60	3.94	4.20	4.40	4.56	4.84	5.05	5.30	5.55	5.75	6.05
2.5	3.49	4.00	4.39	4.67	4.90	5.08	5.40	5.62	5.90	6.19	6.41	6.74
3.0	3.66	4.22	4.62	4.93	5.16	5.35	5.69	5.93	6.23	6.52	6.76	7.11
4.0	3.80	4.38	4.80	5.12	5.36	5.56	5.93	6.17	6.48	6.79	7.03	7.40
5.0	3.83	4.42	4.85	5.17	5.42	5.62	5.98	6.23	6.54	6.85	7.10	7.48

Note: k—ratio of long side to short side.

Value of coefficient α_1 Table 2.5.3.6(2)

k \ $(H+H_w)/a$	1.0	1.2	1.4	1.6	1.8	2.0	2.5	3.0	4.0	6.0	10.0	∞
1.0	3.09	3.59	3.93	4.20	4.41	4.58	4.88	5.09	5.34	5.60	5.79	6.09
1.2	4.28	4.96	5.46	5.84	6.14	6.36	6.78	7.07	7.34	7.77	8.06	8.48
1.4	5.34	6.41	6.84	7.32	7.68	7.98	8.51	8.87	9.33	9.75	10.11	10.64
1.6	6.26	7.26	8.03	8.58	9.00	9.36	9.98	10.40	10.91	11.43	11.85	12.47
1.8	7.01	8.16	8.99	9.62	10.10	10.49	11.19	11.66	12.24	12.81	13.28	13.98
2.0	7.61	8.87	9.78	10.46	10.98	11.40	12.17	12.68	13.31	13.94	14.45	15.20
2.5	8.63	10.07	11.09	11.87	12.47	12.95	13.80	14.37	15.09	15.81	16.38	17.25
3.0	9.18	10.71	11.81	12.62	13.26	13.77	14.69	15.29	16.05	16.82	17.43	18.35
4.0	9.62	11.22	12.38	13.23	13.89	14.43	15.38	16.02	16.83	17.63	18.27	19.23
5.0	9.74	11.36	12.51	13.38	14.06	14.60	15.57	16.22	17.03	17.84	18.48	19.46

Note: k—ratio of long side to short side.

2.5.3.7 The design value of maximum bending stress σ and maximum deflection u in the middle of vertical circular glass plate with continuous peripheral support are to be calculated as follows:

$$\sigma=\beta_2 \rho(H+H_w)L^2/(nt^2) \qquad \text{N/mm}^2$$

$$u=\alpha_2 \rho(H+H_w)L^4/(nt^3) \qquad \text{mm}$$

where:

ρ—seawater density, to be taken as 1025kg/m^3;

H—vertical distance from the highest load line to the lowest point of the viewport sill, in m;

H_w—equivalent water pressure head corresponding to the seawater dynamic pressure, in m, taken as the maximum value on the bearing surface of glass;

L—radius of the circular glass, in m;

t—thickness of single sheet of glass, in mm;

n—number of single sheet of glass of sandwich glass;

β_2, α_2—coefficients related to glass radius, to be taken from Figure 2.5.3.7 and Table 2.5.3.7.

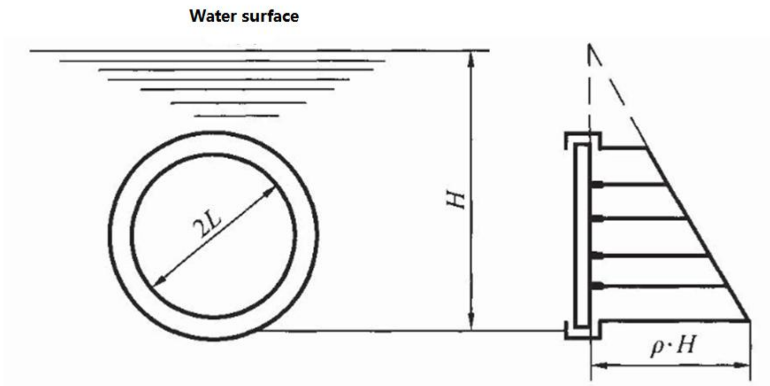


Figure 2.5.3.7 Vertical circular glass with continuous peripheral support under hydrostatic pressure

Values of coefficients β_2, α_2 Table 2.5.3.7

$(H+H_w)/L$	1.0	1.2	1.4	1.6	1.8	2.0	2.5	3.0	4.0	6.0	∞
β_2	6.48	7.38	7.98	8.52	8.88	9.24	9.78	10.20	10.68	11.16	12.2
α_2	49.50	57.60	63.45	67.80	71.10	73.80	78.75	82.05	86.10	90.30	98.40

2.5.3.8 The design value of maximum bending stress σ and maximum deflection u in the middle of horizontal rectangular glass supported at four sides are to be calculated as follows:

$$\sigma=\beta_3\rho(H+H_w)L^2/(nt^2) \quad \text{N/mm}^2$$

$$u=\alpha_3\rho(H+H_w)L^4/(nt^3) \quad \text{mm}$$

where:

ρ—seawater density, to be taken as 1025kg/m³;

H—vertical distance from the highest load line to the lowest point of the viewport sill, in m;

H_w—equivalent water pressure head corresponding to the seawater dynamic pressure, in m, taken as the maximum value on the bearing surface of glass;

L— span, in m.

t—thickness of single sheet of glass, in mm;

n—number of single sheet of glass of sandwich glass;

β_3, α_3—coefficients related to aspect ratio of glass, to be taken according to Figure 2.5.3.8 and Table 2.5.3.8.

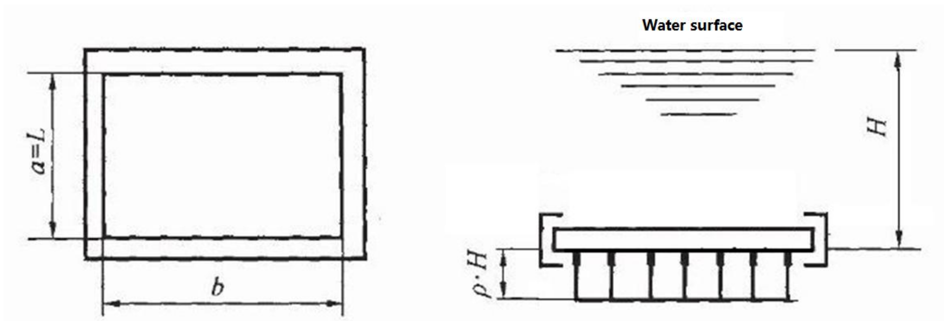


Figure 2.5.3.8 Horizontal rectangular glass supported at four sides under hydrostatic pressure

Values of coefficients β_3, α_3 Table 2.5.3.8

b/a	1.0	1.2	1.4	1.6	1.8	2.0	3.0	4.0	6.0	∞
β_3	2.72	3.62	4.41	5.07	5.60	6.03	7.11	7.40	7.48	7.50
α_3	6.30	8.76	11.10	12.87	14.52	15.75	19.04	20.00	20.13	20.27

2.5.3.9 The design value of maximum bending stress σ and maximum deflection u in the middle of horizontal circular glass with continuous peripheral support are to be calculated as follows:

$$\sigma=12.2\rho(H+H_w)L^2/(nt^2) \quad \text{N/mm}^2$$

$$u=98.4\rho(H+H_w)L^4/(nt^3) \quad \text{mm}$$

where:

ρ – seawater density, to be taken as 1025kg/m³;

H – vertical distance from the highest load line to the lowest point of the viewport sill, in m;

H_w – equivalent water pressure head corresponding to the seawater dynamic pressure, in m, taken as the maximum value on the bearing surface of glass;

L – radius of the circular glass, in m;

t – thickness of single sheet of glass, in mm;

n – number of single sheet of glass of sandwich glass.

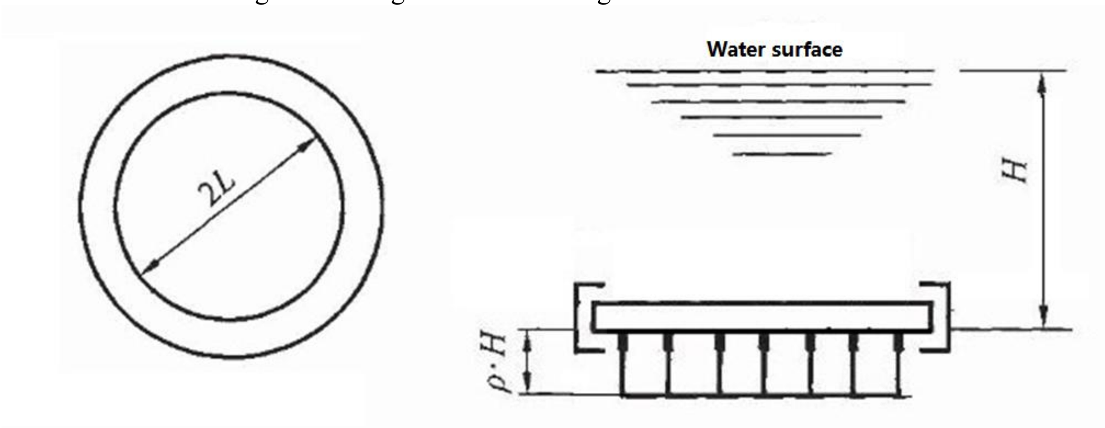


Figure 2.5.3.9 Horizontal circular glass with continuous peripheral support under hydrostatic pressure

2.5.3.10 Collision between underwater viewports and other objects is to be avoided as far as possible through reasonable layout or additional protective structures.

2.5.3.11 Underwater viewports are to be securely installed with reliable seals. The glass is not to be rigidly connected with the installed frame, and the edge is to allow deformation and lateral displacement of the glass.

2.5.3.12 At least one underwater viewport of the same type (including viewport frame) is to be prototype tested before being installed onboard, including at least hydrostatic pressure test. The test pressure is not to be less than P_e. After being installed onboard, all viewport s are to be subject to flushing test.

$$P_e = 1.5\rho g(H+H_w)/10^6 \quad \text{N/mm}^2$$

where:

ρ—seawater density, to be taken as 1025kg/m^3;

g—acceleration of gravity, taken as 9.81m/s^2;

H—vertical distance from the highest load line to the lowest point of the viewport sill, in m;

H_w—equivalent water pressure head corresponding to the seawater dynamic pressure, in m, taken as the maximum value on the bearing surface of glass.

Section 6 Other Structures

2.6.1 Shaft brackets

2.6.1.1 For single arm or double arm shaft brackets, where the normal arched or wing-shaped arm section with length to thickness ratio of 4 to 5 is adopted, the scantlings of their arms are to be determined from 2.6.1.2 to 2.6.1.6. Special consideration is to be given to arms with an abnormal section.

2.6.1.2 For single arm shaft brackets, a section modulus *Zxx* at root to its longer axis *x-x* is to be not less than that determined from the following formula:

$$Z_{xx} = 2.23Kd_S^2 l \times 10^{-5} \ \text{cm}^3$$

where: K — material factor of shaft bracket, $K = 400/\sigma t$, where σt is ultimate tensile strength of shaft bracket material, in N/mm^2;

d_S — the Rule diameter for propeller shaft, in mm, as given by:

$d_s = 128\sqrt[3]{\frac{N_e}{n_e}}$ mm, where N_e is the rated power transmitted by propeller shaft, in kW, and n_e is the revolution per minute at rated power N_e transmitted by propeller shaft, in r/min;

l — length of the arm of single arm shaft brackets, in mm, to be measured from the centre of the section at root to the centerline of the shaft boss, see Figure 2.6.1.2.

2.6.1.3 The area of any cross section along the arm length of single arm shaft brackets is to be not less than 60% of the area of the bracket at root.

2.6.1.4 Where double arm shaft brackets are adopted, the angle between two arms is not to be less than 50°. The thickness t of any arched/wing-shaped section of both arms is not to be less than that determined from the following formula:

$$t = 2.24K^{0.5}d_s\left[1 + \left(1 + \frac{0.0112l^2}{Kd_s^2}\right)^{0.5}\right]^{0.5} \times 10^{-2} \text{ cm}$$

where: l — length of the longer arm, in mm, to be measured from the centre of the section at root of the longer arm to the centerline of the shaft boss, see Figure 2.6.1.2.

K and d_s are the same as those in 2.6.1.2.

2.6.1.5 For any arched/wing-shaped section, the arms of double arm shaft brackets are to have a section modulus Z_{xx}, to its longer axis x-x, of not less than that determined from following formula:

$$Z_{xx} = 0.45t^3 \text{ cm}^3$$

where: t —thickness of sectional area, in cm, obtained by the formula in 2.6.1.4.

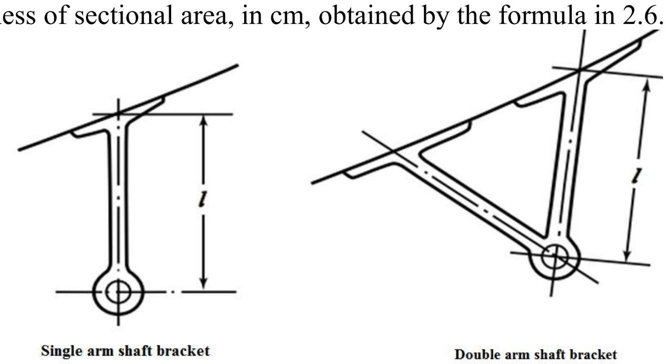


Figure 2.6.1.2

2.6.1.6 For shaft brackets having hollow arms, the cross-sectional areas at the root and the boss are to be not less than that required for a solid arm which satisfies the above requirements for its section modulus.

2.6.1.7 For double arm and single arm shaft brackets, the scantlings of shaft boss are not to be less than as given below:

Thickness of shaft boss: $t = 0.2d_W (K_1 + 0.25)$ mm

Length of shaft boss: $l = 3.5d_W$ mm

where: d_w — diameter of propeller shaft at shaft bracket, in mm;

K_1 — material coefficient, $K_1 = \sigma_{tw} / \sigma_{tb}$, where σ_{tw} is tensile strength of propeller shaft material, σ_{tb} is tensile strength of shaft boss material.

2.6.1.8 For double arm and single arm shaft brackets, where bracket arms are carried through the shell plating, they are to be attached to floors or girders. Where double arm shaft brackets are adopted, the thickness of the shell plating through which bracket arms are carried is to be at least 1.5 times that of the adjacent shell plating. Where single arm shaft brackets are adopted, the thickness of the shell plating through which bracket arms are carried is to be at least 2 times that of the adjacent shell plating. Where shaft brackets are connected with hull in any other way, approval by CCS is required.

Chapter 3 OUTFITTING

Section 1 Rudders

3.1.1 General requirements

3.1.1.1 The requirements of this Section apply to boat with spade rudders or single-plate rudders.

3.1.1.2 The steering gears are to comply with the relevant requirements of Section 8 of Chapter 4.

3.1.1.3 In general, the design of rudder stocks, blades, rudder bearings and the connection between rudder stocks and blades are to comply with the relevant requirements of CCS Rules for Classification of Sea-going Steel Ships. The rudders for high speed craft may comply with the relevant requirements of CCS Rules for Construction and Classification of Sea-going High Speed Craft.

Section 2 Anchoring and Mooring Equipment

3.2.1 General requirements

3.2.1.1 Unless specified otherwise, all motor boats are to be provided with anchors and chains. For non-propulsion boats and public affair boats, anchors and chains may be provided as necessary. The anchors and chains are to be kept connected and to be arranged available for use at any time.

3.2.1.2 Securing of anchors and storage of chains are to be suitably arranged.

3.2.1.3 Effective measures are to be taken in board for securing bower chains.

3.2.2 Equipment number

3.2.2.1 The equipment number N is to be calculated by the following formula:

$$N = \left[\Delta^{2/3} + 2(BH_C + \Sigma S_i \sin\theta_i) + 0.1A\ \right]k$$

where: Δ — full-loaded displacement, in t;

B — breadth of boat, in m, see definition in 1.1.2.1(5) of Chapter 1; for catamarans, the breadth of the tunnel between the twin hull is to be deducted;

Hc — vertical distance from full load waterline of a boat in rest floatation to upper deck (for decked boat) or top end of side plate (for open boat), in m;

S_i — projection area of front bulkhead of each tier of deckhouse whose breadth exceeds $B/4$ to section, in m^2;

θ_i — angle between the horizontal level and the front bulkhead of each tier of deckhouse whose breadth exceeds $B/4$, in ^{o};

A — area in profile view of the hull above the full load waterline and the houses whose breadth exceeds $B/4$, in m^2;

k — coefficient, to be taken according to the service restriction:

$k = 1.5$, for greater coastal service restriction;

$k = 1.2$, for coastal service restriction;

$k = 1.0$, for sheltered water service restriction;

$k = 0.7$, for calm water service restriction.

For boats with no deckhouse but with windscreen or awning, the projection area of windscreen or awning is to be taken into account.

3.2.3 Anchoring equipment

3.2.3.1 An anchor with high holding power is normally to be arranged at the bow. The weight of it is not to be less than that obtained from Table 3.2.3.1 based on the equipment number. Where it is not a high holding power anchor, the weight is not to be less than 1.3 times that obtained from Table 3.2.3.1.

3.2.3.2 Where two anchors are provided at the bow, the weight of each anchor is not to be less than 0.7 times that of a single anchor.
3.2.3.3 The anchor may be exempted according to the practical service restriction, e.g. a boat having an overall length less than 8 m and only operating in harbors.
3.2.3.4 The anchor chain and cable may be used, or cable may be used in total length, however, the cable is to be approved by CCS. The overall length and diameter of anchor chain or breaking strength of cable are not to be less than that obtained from Table 3.2.3.1 based on the equipment number.
3.2.3.5 Boats equipped with anchors 30 kg and more in weight are to be provided with anchoring equipment. Hand anchor capstan or hand capstan may be allowed for substituting for windlass, provided that it can effectively handle chain cables.

Anchoring and mooring equipment **Table 3.2.3.1**

Equipment number		Bow anchor	Specifications and diameter of chain (mm)				Chain or cable		Fiber ropes for mooring	
Exceeding	Not exceeding	Weight of H.H.P anchor (kg)	Studless chain		Stud link chain cable		Length (m)	Breaking strength (kN)	Number × length (m)	Breaking strength (kN)
			BM1	BM2	AM1	AM2				
—	5	12	9	8	—	—	75	29.4	2×22.5	25
5	10	12	9	8	—	—	75	29.4	2×22.5	25
10	15	14	9	8	—	—	75	29.4	2×25	25
15	20	20	9	8	—	—	80	29.4	2×25	30
20	25	25	9	8	—	—	84	29.4	2×25	30
25	30	31	9	8	—	—	87	29.4	2×35	30
30	35	37	9	8	—	—	90	29.4	2×40	32
35	40	43	9	8	—	—	93	29.4	2×40	32
40	50	51	9	8	—	—	97	29.4	2×40	32
50	70	67	11	9	—	—	105	38.3	3×50	34
70	90	90	—	10	11	—	113	50.8	3×50	37
90	110	112	—	—	12.5	11	121	63.3	3×55	39
110	130	137	—	—	14	12.5	128	75.8	3×55	45
130	150	165	—	—	16	12.5	134	87.5	3×60	50

3.2.4 Mooring equipment

3.2.4.1 The length and breaking strength of fiber ropes for mooring provided onboard are to be obtained from Table 3.2.3.1 based on the equipment number. However, the coefficient k in the formula for calculating the equipment number is: $k = 1$ for offshore service restriction, coastal service restriction and sheltered water service restriction, $k = 0.85$ for calm water service restriction. The diameter of ropes is not to be less than 15 mm and the overall length is not to be less than 4 times the length of boat. For fiber ropes in the boat having an overall length less than 8 m, special consideration may be given under certain cases.
3.2.4.2 Suitable number of bitt or cleat is to be fitted respectively on stem, stern and both sides onboard. For boats having an overall length L_{oa} more than 6 m, at least one bitt or cleat is to be fitted respectively on stem or stern.
3.2.4.3 Protective measures, i.e. fender rubber and collision mat are to be provided in both sides onboard in order to prevent hull damage caused by repeated collision between side and wharf when the boat is calling at ports or daily mooring at wharfs.
3.2.4.4 The hull structure in way of the installation places of the equipment (bitt bollard, cleat and towing post) for securing chains, cables, ropes and towing ropes is to be strengthened and capable of bearing the pulling force.

Chapter 4 MACHINERY INSTALLATIONS

Section 1 General Provisions

4.1.1 Application

4.1.1.1 The design, manufacture, installation and testing of main propulsion device, auxiliary machinery, pump and piping system for boats are to comply with the relevant requirements of this Chapter.

4.1.2 Design and installation

4.1.2.1 Design and construction of machinery, fuel oil tanks and associated piping and fittings are to comply with their intended purposes, and are to be so installed and protected as to minimize the hazards to persons when the boat is in normal navigation. Therefore, particular attention is to be paid to moving parts, thermal surfaces and other hazards.

4.1.3 Ambient conditions

4.1.3.1 Main propelling machinery and auxiliary machinery essential to boat's propulsion and safety are to be so designed as to ensure normal operation under the following conditions:

(1) boat's upright;

(2) static heal not more than 15° and dynamic rolling not more than 22.5°;

(3) static trim not more than 7.5° and dynamic pitching not more than 7.5°.

4.1.3.2 In general, the rated power of engine means the maximum continuous power for the engine under the ambient conditions of 0.1 MPa absolute atmosphere, 45℃ ambient temperature, 60% relative humidity and 32℃ sea water temperature.

4.1.4 Means of going astern

4.1.4.1 Suitable power for going astern is to be provided to secure proper control of the boat in all normal circumstances.

4.1.5 Ventilation

4.1.5.1 Diesel oil engine room is to be adequately ventilated so as to ensure that an adequate supply of air is maintained to the engine room when the engines are operated at full power under any weather conditions for the safety of personnel and normal operation of engines.

4.1.5.2 The ventilation in compartments installed petrol engine and/or petrol tank is to comply with the requirements of Section 3 in this Chapter.

4.1.6 Material

4.1.6.1 Materials of main and auxiliary machinery and pumps and piping are to be suitable for the environment and medium in which they are to serve.

4.1.6.2 Plastic or heat-sensitive material, if used, is to be subject to agreement of CCS.

4.1.6.3 Parts and components, such as side fittings, sea connection, etc. are to be made of steel, bronze or other material approved by CCS.

4.1.7 Control and instrument

4.1.7.1 Passenger boats are to be provided with a central control station at an easily accessible location outside the engine room as far as practicable, so that the personnel can effectively maneuver and control the boat in either normal or emergency condition. In addition, the control center is to be provided at least with instrument having the following indicating (or testing) functions:

(1) power source for maneuver the boat;

(2) main propulsion power;

(3) main fire-extinguishing system, if any;

(4) engine room ventilation;

(5) fuel pump;

(6) bilge pump and bilge water level;
(7) main source of electrical power and ship electrical power.

4.1.8 Products

4.1.8.1 The propelling units of outboard engines and inboard engines are to have marine product certificates or to be approved by CCS. The certification requirements for other machinery installations and equipment are to comply with the relevant provisions of 1.1.1.7, Section 1, Chapter 1 of the Rules.

4.1.9 Testing

4.1.9.1 The mooring trials and sea trials, after completion of installation of machinery, are to be carried out according to the test programmes approved by CCS.

Section 2 Engines

4.2.1 General requirements

4.2.1.1 Each engine driving propelling machinery is to be provided with reliable governors and overspeed protective devices, which are to comply with the following requirements:
(1) Governors are to prevent the engine from exceeding 115% of its rated speed.
(2) Overspeed protective devices are to be independent of governors, and to prevent the engine from exceeding 120% of its rated speed.
4.2.1.2 Each engine driving generators is to be provided with reliable governors and safety devices, which are to comply with the following requirements:
(1) When sudden rated load drops or sudden rated load accelerates, the rate of instantaneous and steady regulating speed is not to be more than 10% and 5% of the rated speed respectively. When sudden rated load accelerates, the steady time (i.e. the time of returning to the range with pulsating rate being ±1%) is not to be more than 5 s.
(2) When rated power of engine is more than 220 kW, overspeed protective devices independent of governors are to be provided to prevent the engine from exceeding 115% of its rated speed.
4.2.1.3 Main engines are to be provided with emergency stopping devices. For main engine remotely controlled in bridge room, the emergency stopping device is to be provided in the bridge room.
4.2.1.4 The total capacity of the starting arrangements is to be sufficient to provide, without replenishment, not less than six consecutive starts of the main engine in cold condition and not less than three consecutive starts of the auxiliary engine in cold condition.

4.2.1.5 The engines are to be so installed inside the boat as to be easily accessible and be maintained and inspected conveniently by operators.
4.2.1.6 The rigid installation of engines inboard is to comply with the following requirements:
(1) The nuts for securing bolts are to be provided with locking devices.
(2) The securing bolts of main engine and gear box are to be provided with at least two fitting bolts respectively.
(3) The main engine and gear box are to use a common foundation as far as practicable.
4.2.1.7 Not less than two sea inlets are to be connected with the cooling water pump of sea-water cooling piping system or circulating system and to be fitted on both sides of boat as far as practicable. For a boat of less than 10 m in length, one sea inlet may be fitted only if the water supply can be ensured. For boats with two main engines, it is acceptable for the cooling water systems of the two main engines to be connected to the sea inlets on different sides if the other main engine is able to ensure the safe navigation of the boat when one main engine is out of operation.

4.2.2 Alarm device

4.2.2.1 Main engines (except outboard engines) are to be provided with the following alarm devices:
(1) low-pressure alarm device for lubricating oil;

(2) high-temperature alarm device for cooling water.
For main engine remotely controlled in bridge room, the above alarms are to be provided or extended in the bridge room
4.2.2.2 For prime motor of generator with power more than 35 kW, low-pressure alarm device for lubricating oil is to be provided.

4.2.3 Special requirements for outboard engine
4.2.3.1 The outboard engines are to be reliably fixed on the stern transom plating by through bolts or equivalent means.
4.2.3.2 The installation trunk of outboard engine is to have sufficient dimension so that the outboard engine can be moved around according to the operating conditions.
4.2.3.3 The openings for operational cable and fuel hose of outboard engine are to be effectively sealed if penetrating hull structure.
4.2.3.4 For outboard engine with total power less than 40 kW, the speed and direction can be operated by single tail handle. For outboard engine with total power of 40 kW and above, handwheel console is to be provided in stem.
4.2.3.5 Where the steering position is open onboard a boat with the speed exceeding 20 kn, a safety rope is to be provided near the steering position. Where the navigating officer falls outside, the safety rope can stop the outboard engine.

Section 3 Petrol Engine and/or Petrol Tank Compartments

4.3.1 Definitions
4.3.1.1 **Open compartment** means a compartment or space having at least 0.34 m^2 of permanent open area directly exposed to the atmosphere for each cubic meter of net compartment volume.

4.3.2 General requirements
4.3.2.1 Except open compartments, natural ventilation system is to be provided in petrol engine and petrol tank compartments in accordance with the requirements of 4.3.3 of this Section. Powered ventilation system is to be provided in petrol engine compartments in accordance with the requirements of 4.3.4 of this Section.
4.3.2.2 Compartments containing petrol engines and/or petrol tanks are to be separated from the independent passenger's cabins to prevent the petrol gas from entering the passenger's cabins.
4.3.2.3 For compartments containing petrol engines and/or petrol tanks, neither supply nor exhaust ducts are to open into a passenger's cabin.
4.3.2.4 Except open compartments, all electrical components installed in compartments containing petrol engines and/or petrol tanks and in other compartments connecting to such compartments are to be of ignition-protected type.[①]
4.3.2.5 The electrical components installed on the petrol engines are to comply with the relevant requirements of Chapter 5.
4.3.2.6 Portable petrol tank or equipment with petrol fuel is not to be arranged in enclosed spaces. They are to be arranged in a place provided with quick-securing devices and to be ready for jettison in an emergency. The leaked petrol is to be able to be drained directly outboard.

4.3.3 Natural ventilation system
4.3.3.1 A supply opening or duct from the atmosphere and an exhaust opening or duct to the atmosphere are to be provided in natural ventilated compartments. Each exhaust opening or duct is to originate in the lower 1/3 of the compartment. Each supply opening or duct and each exhaust opening or duct in compartment are to be above the normal level of accumulated bilge water.
4.3.3.2 Compartment air intake and exhaust duct openings are to be separated by at least 600 mm with compartment dimension permitting. The ventilation outlet of compartment is to be as far

[①] Refer to Small craft - Electrical devices - Protection against ignition of surrounding flammable gases (ISO 8846:2017).

apart as possible from the ventilation inlet of other compartments and other openings.

4.3.3.3 The combined area of supply openings or ducts, and the combined area of exhaust openings or ducts are to have a minimum internal cross-sectional area calculated as follows, and not less than 3000 mm^2:

$$A = 3300\ l_n\ (V/0.14)$$

where: A – the minimum combined internal cross-sectional area of the openings or ducts, in mm^2;

V – the net compartment volume equal to the total compartment volume minus the volume of permanently installed components in it, in m^3;

l_n – natural logarithm.

4.3.4 Powered ventilation system

4.3.4.1 The total airflow capacity Q of each exhaust blower or combination of blowers in compartment is not to be less than that in Table 4.3.4.1.

Total airflow capacity Q **Table 4.3.4.1**

Net volume of compartment (m^3)	Total airflow capacity Q (m^3/min)
< 1	1.5
1 ≤ V ≤3	1.5V
> 3	1.5V + 3

4.3.4.2 The blower is to be of non-spark type.

4.3.4.3 Each intake duct for an exhaust blower is to be in the lower 1/3 of the compartment and above the normal level of accumulated bilge water.

4.3.4.4 The exhaust outlet of blower is to be as far apart as possible from the outlet of exhaust pipe for engine.

4.3.4.5 The suction blower fitted in the petrol engine compartment is to be operated 4 min before starting of engine. During the service period of boat (including embarkation, disembarkation or laid-up), continuous powered ventilation is to be kept in petrol engine compartment and the blower is not to be stopped. When it stops due to any reasons, visual and audible alarms are to be given in the machinery space and bridge.

Section 4 Shafting and Propulsor

4.4.1 General requirements

4.4.1.1 The materials of shafting and propeller are to comply with the relevant provisions of CCS Rules for Materials and Welding and to meet the following requirements:

(1) The shafting is to be made of forged or rolled carbon steel, carbon manganese steel and other materials approved by CCS;

(2) For shafts with a maximum diameter of not more than 80mm, material testing may not be required, but applicable documents describing the properties of the material are to be submitted to CCS.

4.4.1.2 Unless otherwise stated in this Section, the water-jet units, diameters of shafts, shaft liners (if any), stern tube and bearings, couplings, blade thickness of propeller and the installation of propeller to screwshaft are to comply with the relevant requirements of CCS Rules and Regulations for Construction and Classification of Sea-going High Speed Craft or the standards accepted by CCS.

4.4.2 Z-type propelling unit

4.4.2.1 The diameters of input shaft, vertical spindle and screwshaft of Z-type propelling unit and the strength and installation requirements for propeller of Z-type propelling unit are to comply with the relevant requirements of CCS Rules and Regulations for Construction and Classification of Sea-going High Speed Craft.

4.4.2.2 The design and manufacture of involute conic gear for transmitting shafting of Z-type propelling unit are to comply with the standards accepted by CCS.

4.4.2.3 Z-type propelling unit is to be well lubricated with a temperature of lubricating oil not more than 70℃.

4.4.2.4 The full-rotatable or semi-rotatable Z-type propelling unit 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 2.3°/s with the ship running ahead at the maximum ahead service speed;

4.4.2.5 Where the power unit of rotatable system is electro-dynamic or electro-hydraulic, stand-by power unit or other emergency operating means are to be provided. Power unit can be exempted if the boat is provided with two or more Z-type propelling units.

4.4.2.6 The hydraulic piping for rotatable system is to comply with the requirements of 4.8.1.7 of this Chapter.

4.4.2.7 Rudder indicators for Z-type propelling unit are to be provided in bridge room and steering gear room.

4.4.2.8 After completion of manufacture, the parts and components of the Z-type propelling unit, such as upper gear box, lower gear box and rotatable gear box are to be subject to a hydraulic test at 0.2 MPa and after assembly, they are to be subject to a tightness test at 0.1 MPa.

4.4.2.9 Hydraulic testing is to be carried out for hydraulic piping with 1.5 times the design pressure, after installation onboard, the hydraulic piping together with its accessories are to be subject to a tightness test at 1.25 times the design pressure.

Section 5 Fuel Oil System

4.5.1 General requirements

4.5.1.1 Each part of fuel oil system is to have a sufficient strength and to be so installed as to be capable of bearing impact and vibration which will possibly take place and not to cause any leakage.

4.5.1.2 The material of parts of fuel oil system is to be capable of resisting environment corrosion and temperature affect.

4.5.2 Fuel oil tanks

4.5.2.1 The structure and arrangement of fuel oil tanks are to comply with the following:

(1) The fuel oil tanks are to be tightly fixed on the foundation and certain spaces between fuel oil tanks and bulkheads or other equipment are to be kept as to ensure free ventilation.

(2) Hydraulic pressure testing is to be carried out before fuel oil tank is installed, the test head is to reach 2.4 m above the top of the tank, and leakage is not to be allowed.

(3) The fuel oil tanks are not to be positioned above engines, exhaust pipes and electrical installations, and are to be apart from accumulator batteries, etc. as far as possible.

(4) Fuel oil tanks are to be provided with vent pipes with sufficient flow area and a diameter not less than 10mm. For tanks that can be filled by pumps, the total cross-sectional area of the vent pipes is to be at least 25% greater than the effective cross-sectional area of the filling pipes. Vent pipes are led to open spaces where neither flooding nor danger caused by leakage of oil or oil gases. Flame-proof gauze diaphragm is to be provided for opening of vent pipe.

(5) Sounding pipes are to be provided for fuel oil tanks, and the liquid level indicator approved by CCS is allowed to substitute for sounding pipe.

(6) The space where fuel oil tank is located is to be effectively ventilated.

(7) Fuel oil tanks are not to be arranged forward of collision bulkheads.

4.5.2.2 The diesel oil tank is to have enough strength and the minimum wall thickness is not to be less than the following:

Austenite chrome nickel steel	1 mm
Low carbon steel subjected to external hot dipping zinc after manufacture	1.5 mm
Aluminum alloy with the content of copper not more than 0.1%	2 mm
Polyethylene	5 mm

For diesel oil tanks made of other materials, the material quality and wall thickness are to comply with the standards accepted by CCS.

4.5.2.3 The petrol tank is to comply with the following:

(1) The petrol tank is to have sufficient strength and the minimum wall thickness is not to be less than:

Austenite chrome nickel steel	1 mm
Aluminum alloy with the content of copper not more than 0.1%	2 mm

For petrol tanks made of other materials, the material quality and wall thickness are to comply with the standards accepted by CCS.
(2) No oil draining pipes are allowed to be provided for petrol tanks.
(3) Petrol tanks are to be so arranged as to avoid direct sunlight, and means for prevention of shifting of petrol tank is to be provided.
(4) Petrol tanks are to be filled in such a way as to prevent oil gas from entering the non-open compartments and to avoid accumulation of oil gas.

4.5.3 Fuel oil pipeline
4.5.3.1 The pipeline is to be suitably fastened and protected to prevent from damage and abnormal wearing. Pipeline is not to be combined with the attachment made of different metal material in order to avoid electric erosion.
4.5.3.2 The pipeline is to be made of seamless annealed copper, copper-nickel alloy, aluminum alloy with copper content not more than 0.1% or other equivalent alloy.
4.5.3.3 Where hose is used for pipeline, the fire-proof type hose[①] is to be adopted. Non-fireproof hoses[②] may be used for outboard engine.
4.5.3.4 Stop valve is to be provided on the fuel oil pipeline as near as possible to the oil tank. The valve can be closed at an appropriate position outside the engine room.

Section 6 Exhaust System

4.6.1 General requirements
4.6.1.1 Exhaust pipe is to be bound with suitable insulation material, and the surface temperature of insulation is not to exceed 60℃. Means is to be taken to prevent the high temperature surface from injuring persons.
4.6.1.2 If metal hose is fitted on exhaust pipes, the hose is to be approved by CCS and capable of bearing its corresponding work temperature.
4..6.1.3 The material of water-cooling exhaust pipes is to be of an anti-corrosion type, otherwise the thickness is to be suitably increased.
4.6.1.4 The exhaust pipes are to be so arranged that the outboard water cannot flood into the engine. Anti-back-water device is to be provided for the discharge positioned at less than 300 mm above waterline, and draining cock is to be provided in the lowest place of exhaust pipes where water may easily accumulate. If the highest point of the center line of the exhaust pipe is 500 mm above the waterline, anti-back-water device may not be required for the exhaust outlet, but the exhaust pipe from 300 mm above the waterline to the side is to be of equal strength to the hull plating through which it passes.

Section 7 Bilge Pumping System

4.7.1 General requirements
4.7.1.1 Effective bilge pumping system is to be provided in each boat. The system is to be so arranged as to drain water effectively from any watertight compartment other than that intended for permanently storing liquid and prevent water flowing from one compartment to another.
4.7.1.2 For ships requiring power bilge pumps, the main propulsion engine room is to be provided with a direct bilge suction connected to the power bilge pump.
4.7.1.3 The drainage may be exempted for a compartment provided that the safety of the boat is

① Refer to Small craft - Fire-resistant fuel hoses (ISO 7840).
② Refer to Small craft - Non-fire-resistant fuel hoses (ISO 8469).

not affected by drainage of this compartment through calculation or necessary demonstration.
4.7.1.4 Where deemed necessary, the bilge suction pipes are to be fitted with effective strum boxes for the purpose of protecting bilge water piping. The strum boxes are to be easily removed and replaced for cleaning and the combined area of a box is not to be less than twice the sectional area of the bilge suction pipe.
4.7.1.5 Where deemed necessary, bilge suction valves are to be of non-return type for the purpose of preventing water from flooding.
4.7.1.6 When all hatches are closed, bilge pumps (other than portable pumps) and necessary valves are to be capable of being operated for high speed craft, otherwise bilge pumps and related valves are to be capable of being operated remotely.
4.7.1.7 Discharge of bilge water is to satisfy the pollution prevention requirements of the Administration.

4.7.2 Bilge pump
4.7.2.1 In general, the bilge pump is to be of self-priming type.
4.7.2.2 A hand bilge pump is to be provided for a boat of less than or equal to 6 m in length. At least one power bilge pump and one hand bilge pump are to be provided for a motor boat or a non-propulsion boat with auxiliary power of more than 6 m in length. Two hand bilge pumps are to be provided for a non-propulsion boat without auxiliary power of more than 6 m in length. Open deck boat is to be additionally provided with a bailer or a bucket.
4.7.2.3 The bilge pump driven by power may be used for other purposes, but is not to be used as an oil pump.
4.7.2.4 The displacement of each bilge pump is not to be less than the requirements of Table 4.7.2.4.

Displacement of bilge pump **Table 4.7.2.4**

Length of boat L (m)	Displacement of power bilge pump (m^3/h)	Displacement of hand bilge pump (m^3/h) (at 45 strokes per minute)
$L \leqslant 6$	—	2.8
$6 < L \leqslant 10$	6.0	3.9
$10 < L \leqslant 15$	7.5	5.0
$15 < L \leqslant 20$	9.0	6.0

4.7.2.5 The two bilge pumps on passenger ships are to be arranged to ensure that one pump is still available for the drainage of each compartment in the event of any compartment being damaged.

4.7.3 Discharges
4.7.3.1 Screw-down non-return valve is to be fitted in an accessible place for all the discharges draining to the outboard. In general, the said valve may be exempted for the discharge located at a place 350 mm above the waterline and no water flooding will take place due to boat's rolling in navigation.

4.7.4 Bilge water level alarms
4.7.4.1 A watertight compartment fitted with propelling machinery, or any other compartment (except void space) where bilge water may easily accumulate but not be found easily, is to be provided with a bilge alarm of high water level.
4.7.4.2 Any one dry compartment fitted with fixed or portable bilge water suction, where bilge water level is not found easily, are also to be provided with bilge water high level alarms.
4.7.4.3 Visual and audible alarms for bilge water high level are to be provided at the maneuvering position of the boat.

Section 8 Steering Gear

4.8.1 General requirements

4.8.1.1 The steering gear is to ensure the reliable maneuvering for the boat in navigation.
4.8.1.2 Power steering gears are generally to be provided with an emergency steering gear.
4.8.1.3 Where a steering gear comprises two or more power units, the emergency steering gear may be exempted.
4.8.1.4 Emergency steering gear may be exempted for directional control device of outboard engine or inboard engine.
4.8.1.5 The Z-type propelling unit is to comply with the requirements of 4.4.2 of Section 4 in this Chapter.
4.8.1.6 The directional control device of the water-jet unit is to be maneuverable in the bridge room.
4.8.1.7 For hydraulic steering system, the following requirements are also to be complied with:
(1) Material of system components is to be suitable for its working medium.
(2) Oil filter and overflow valve are to be fitted in hydraulic piping system, in general, oil spill is to be back to tanks.
(3) Gas-releasing arrangement is to be provided for hydraulic piping system and hydraulic oil cylinder.
(4) Hoses or pipelines are to avoid heat influence and the hose is to be approved by CCS.
(5) Low level alarms are to be provided for the circulating oil box of each hydraulic system and to give visual and audible alarms in machinery spaces and bridge room, however, steering gear for outboard engine may be exceptional.
4.8.1.8 The steering position is to have a good visibility of navigation for the steering persons.

Chapter 5 ELECTRICAL INSTALLATIONS

Section 1 General Provisions

5.1.1 General requirements

5.1.1.1 Electrical installations onboard are to ensure:

(1) that they are capable of giving power supply to all electrical auxiliary services necessary for maintaining the boat in normal operation;

(2) electrical services essential for safety under various emergency conditions;

(3) the safety of passengers, crew and the boat from electrical hazards.

5.1.1.2 The design, manufacture, test and installation of main electrical installations onboard are to comply with the relevant requirements of this Chapter, or to meet other corresponding standards accepted by CCS.

5.1.2 Design, manufacture and installation of electrical equipment

5.1.2.1 Electrical equipment are to be so designed, manufactured and installed as to ensure safe operation and facilitate inspection and repair.

5.1.2.2 Electrical equipment are to be operated satisfactorily under the voltage and frequency variations as given in Table 5.1.2.2.

Voltage and frequency variations Table 5.1.2.2

Equipment	Parameters	Permanent (%)	Transient	
			%	Maximum recovery time (s)
General AC equipment	Voltage	+6 to -10	± 20	1.5
	Frequency	± 5	± 10	5
Equipment supplied by accumulator batteries: Connected to batteries during charging Not connected to batteries during charging	Voltage Voltage	+ 30 to - 25 + 20 to - 25	—	—

5.1.2.3 All electrical equipment are to be operated satisfactorily under the following environmental conditions:

(1) The ambient air temperature is as given in Table 5.1.2.3(1).

Ambient air temperature Table 5.1.2.3(1)

Location	Temperature
In enclosed spaces	0℃ to 40℃
In spaces subject to temperatures over 40℃ or below 0℃	According to temperatures in such spaces
On the open deck	- 25℃ to 40℃

Note: For tropical areas, the upper limit of temperature is 45 ℃ , however, the upper limit of ambient air temperatures for the electronic equipment is to be 55℃.

(2) Moisture, sea air, oil vapour and mould.

(3) Vibration and shock likely to arise in normal service of boat.

(4) The inclination and roll of the boat is as given in Table 5.1.2.3(4).

Angle of Inclination Table 5.1.2.3(4)

Installations, components	Angle (°) ①			
	Athwartships		Fore-and-aft	
	Static	Dynamic	Static	Dynamic
Emergency electrical installations, switchgear, electrical and electronic appliances	22.5	22.5	10	10
Electrical equipment excluding stated above	15	22.5	5	7.5

Note: ① Athwartship and fore-and-aft inclinations may occur simultaneously.

5.1.2.4 The electrical equipment are to be arranged apart from inflammable material and with effective ventilation and in the places where no inflammable gas may concentrate and where they are not easily subjected to mechanical damage or oil and water corrosion. Where they are fitted in the above mentioned various hazardous places, suitable structural protection or enclosure is to be provided for such equipment.

5.1.2.5 The type of protective enclosures selected for electrical equipment is to meet the requirements in Table 5.1.2.5.

Minimum Requirements for the Degree of Protection by Enclosure

Table 5.1.2.5

Location onboard	Degree of protection
Compartments with well protection below deck	IP20
On the tank top sheltered deck	IP22
On the splashed deck	IP44
On the immersed deck	IP56

5.1.3 Earthing

5.1.3.1 All accessible metal parts of electrical equipment and cables, other than current-carrying ones, are to be earthed reliably, except for:

(1) lamp caps;

(2) shades, reflectors and guards supported on lamp holders or lighting fittings constructed of, or shrouded in, non-conducting material;

(3) metal parts on, or screws in or through, non-conducting material, which are separated by such material from current-carrying parts and from earthed non-current-carrying parts in such a way that in normal use they cannot become live or come into contact with earthed parts;

(4) portable appliances having double and/or reinforced insulation, provided that the appliances conform with recognized safety requirements;

(5) bearing housings which are insulated in order to prevent circulation of current in the bearings;

(6) clips for fluorescent lamps;

(7) apparatus supplied at a working voltage not more than 50 V. For the alternating current, this voltage is a value of root mean square. Autotransformers are not to be used for the purpose of achieving this voltage;

(8) cable clips.

5.1.3.2 For metal structure boats, the earthing of electrical equipment is to meet the following requirements:

(1) When the electrical equipment is directly fixed on the metal hull of the boat or securely fixed on bedplates (or supports) which have a good electrical contact with the metal hull of the boat, a special earthing conductor may not be required. The surfaces in contact are to be clean, flat and bright so as to ensure an effective contact, and measures are to be taken to prevent the connection from loosening and corrosion.

(2) When special earthing conductors are used for permanently installed electrical equipment, they are to be of copper or other corrosion-resistant materials of good conductivity, and are to be protected against mechanical damage and corrosion. The relationship between the cross-sectional area Q of the copper earthing conductors and the cross-sectional area S of the power line of electrical equipment or relevant current-carrying conductors is to comply with the following requirements:

$Q=S$ and $Q \geqslant 1.5\text{mm}^2$, for $S \leqslant 2.5\text{mm}^2$;

$Q=0.5S$ and $Q \geqslant 4\text{mm}^2$, for $2.5\text{mm}^2 < S \leqslant 120\text{mm}^2$.

(3) The electrical equipment that is not permanently installed is to be earthed by means of an earth-continuity conductor in the flexible cable or cord through the associated plug and socket outlet, and the cross-sectional area of the earth conductor is to comply with the following requirements:

$Q=S$, for $S \leqslant 16\text{mm}^2$;

$Q=0.5S$ and $Q \geqslant 16\text{mm}^2$, for $S > 16\text{mm}^2$.

(4) Metal sheathings or coverings of cables are to be effectively earthed at both ends of the run, except that final sub-circuits may be earthed at the supply end only. This does not necessarily apply to control and instrumentation cables where single point earthing is permitted for technical reasons.

5.1.3.3 For non-metallic structure boats, the earthing of electrical equipment is to meet the following requirements:

(1) All accessible metal parts of electrical equipment, other than the metal shell and current-carrying ones, are to be connected together by bonding conductors to form a continuous and complete earthed system, and connected to the metal earthing bedplate with an area greater

than or equal to $0.1m^2$ and a thickness greater than or equal to 2mm. The metal earthing bedplate is to be installed in a position to ensure that it can be immersed in water in any navigation conditions and to be corrosion resistant. Where engines or propellers have an equivalent function of the earthing bedplate, such earthing bedplate is not required.
(2) The bonding conductors of earthed systems are not to be used as conducting loops of distribution system.
(3) All metal parts onboard (such as pipes, guardrails, oil tanks, etc.) are, as far as possible, to be connected to the earthing bedplate referred to in the (1) above by bonding conductors. Especially when the main and auxiliary engines use fuel oil with a flash point less than 60° or LPG, their oil tanks and pipes must be connected to the earthing bedplate referred to in the (1) above by special conductors.
(4) Consideration is to be given to electrochemical action between different metals for the connection points of all earthed systems or appropriate measures are to be taken.

5.1.4 Lightning protection

5.1.4.1 Newbuildings are be provided with reliable lightning protection devices when one of the following conditions occurs:
(1) The boat is equipped with a steel mast with the electrical equipment on the mast top;
(2) The boat is equipped with a non-metallic mast;
(3) The boat is equipped with a non-metallic hull.
If a mast is equipped for open boats, the lightning protection device is to be provided.
5.1.4.2 The specifications of lightning rods are to meet the following requirements:
(1) The diameter of copper lightning rod is to be greater than or equal to 8mm;
(2) The diameter of steel lightning rod is to be greater than or equal to 16mm, and its tip is to be protected against corrosion;
(3) The diameter of aluminum lightning rod is to be greater than or equal to 12mm.
5.1.4.3 The lightning rod is to project at least 300mm beyond the top of the mastor the electrical equipment on the mast top.
5.1.4.4 When the boat is equipped with a steel mast, the lightning rod can be directly welded or riveted to the mast. When the boat is equipped with a non-metallic mast, the lightning rod is to be directly connected to the hull by a down conductor.
The down conductor between the lightning rod and the hull may be made of continuous copper tape (cable) with a cross-sectional area of more than or equal to 70 mm^2, or continuous steel tape (cable) with a cross-sectional area of more than or equal to 100 mm^2.
5.1.4.5 The adjustable mast is to have reliable electrical connection to the hull, and the cross-sectional area of the soft copper conductor is to be greater than or equal to $70mm^2$ while the cross-sectional area of the steel conductor is to be greater than or equal to $100mm^2$.
5.1.4.6 For non-metallic structure boats, the down conductor of the lightning protection device is to be connected to the earthing bedplate referred to in 5.1.3.3.

Section 2 Source of Electrical Power and Lighting

5.2.1 Main source of electrical power for boats of greater coastal service restriction

5.2.1.1 The main source of electrical power is to be provided with sufficient capacity to supply power to the equipment necessary for normal propulsion and steering① and for ensuring the safety of the boat.
5.2.1.2 Unless expressly provided otherwise, the main source of electrical power is to consist of at least two generating sets and the following requirements are to be complied with:
(1) Where the main source of electrical power is necessary for propulsion of the boat, at least two independent generating sets are to be provided. In the event of any one generating set being stopped, the remainder will still be able to supply the equipment in 5.2.1.1;
(2) Where the main source of electrical power is unnecessary for propulsion of the boat, at least one independent generating set is to be provided with sufficient capacity to supply all electrical

① Where the main source of electrical power is necessary for propulsion and steering of the boat.

installations onboard the boat and charge the accumulator batteries (if any) to 80% of the rated capacity within 10h.

5.2.1.3 The main lighting system providing lighting to spaces normally accessible to the crew is to be supplied from the main source of electrical power.

5.2.1.4 The arrangement of the main lighting system is to be such as to ensure that a fire or other casualty in spaces containing the main source of electrical power, associated transforming equipment (if any), and the main switchboard will not lead to the failure of the emergency lighting system as required in 5.2.1.5.

5.2.1.5 The arrangement of the emergency lighting system is to be such as to ensure that a fire or other casualty in spaces containing the emergency source of electrical power, associated transforming equipment (if any), and the emergency switchboard will not lead to the failure of the main lighting system as required in 5.2.1.3.

5.2.1.6 For sailboats, one generating set or two accumulator batteries may be provided for the main source of electrical power. The capacity of the main source of electrical power is to be sufficient to ensure the demands of the boat in normal operational conditions within a period corresponding to the whole voyage. If accumulator batteries are used, they are to comply with the requirements of 5.3.2 of Section 3 or Section 4 of this Chapter.

5.2.1.7 For open boats and non-propulsion boats, the main source of electrical power may be provided as necessary.

5.2.2 Emergency source of electrical power for boats of greater coastal service restriction

5.2.2.1 Boats of greater coastal service restriction are to be provided with an independent emergency source of electrical power. For open boats and non-propulsion boats, emergency source of electrical power may be provided as necessary.

5.2.2.2 The emergency source of electrical power may be a generating set or an accumulator battery. If accumulator batteries are used, they are to comply with the requirements of 5.3.2 of Section 3 or Section 4 of this Chapter.

5.2.2.3 In the event of fire and flooding in the spaces where the main source of electrical power is located, the normal use of emergency source of electrical power may not be affected.

5.2.2.4 The capacity of the emergency source of electrical power is to supply at least the following services:

(1) emergency lighting at every muster and embarkation station and over the sides for a period of 3 h.

(2) emergency lighting in the following spaces (if any) for a period of 12 h (for passenger ships) or 6 h (for cargo ships):

① in all services and accommodation alleyways, stairways and exits

② in the propulsion machinery spaces for navigation and main source of electrical power including their control positions;

③ in all control stations, machinery control rooms, and at each main and emergency switchboard;

④ at the steering gear.

(3) the navigation lights and other signal lights for a period of 12 h (for passenger ships) or 6 h (for cargo ships);

(4) the radio communication equipment, whistle and all internal signals that are required in an emergency for a period of 12 h (for passenger ships) or 6 h (for cargo ships).

5.2.3 Electrical power source for boats of other service restrictions

5.2.3.1 Unless expressly provided otherwise, at least two sources of electrical power are to be provided onboard. In the event of any one electrical power source in failure, the capacity of remainder is to still meet the demands of the boat in normal operational conditions. The demands of the boat in normal operational conditions are to include electric fire-fighting pumps (if any), electric bilge pumps (if any), lighting, communications, signals and other equipment essential for normal navigation and safety (if any and driven by electricity).

5.2.3.2 The sources of electrical power may be either:

(1) generators driven by main independent prime movers;

(2) generators driven by main propulsion engine; or

(3) accumulator batteries.

5.2.3.3 If accumulator batteries are used for sources of electrical power, the capacity of each

accumulator battery is to be sufficient to ensure the demands of the boat in normal operational conditions within a period corresponding to the whole voyage, and to be capable of maintaining the power supply of the electrical equipment for at least 4h.
5.2.3.4 For boats navigating in sheltered water service restriction or calm water service restriction, where lighting is the main purpose, one set of accumulator batteries may be provided as the source of electrical power and the capacity is to meet the demands of electrical equipment within a period corresponding to the whole voyage.
5.2.3.5 For open boats and non-propulsion boats, sources of electrical power may be provided as necessary.

5.2.4 Lighting for boats of other service restrictions
5.2.4.1 Lighting is to be provided at least in the spaces (if any) specified in 5.2.2.4 of this Chapter.

Section 3 Distribution System and Equipment

5.3.1 Distribution system
5.3.1.1 Where the maximum rated voltage of distribution system does not exceed 1000 V (alternating current) or 1500 V (direct current), the following distribution systems may be used:
(1) D.C.
two wire insulated system
two wire system with negative pole earthed
(2) A.C.
single phase two wire insulated system
single phase two wire system with one pole earthed
three phase three wire insulated system
three phase four wire system with neutral point earthed
three phase four wire insulated system
5.3.1.2 The insulated distribution systems for power and lighting circuits, whether primary or secondary, are to be provided with a device capable of continuously monitoring the insulation level to earth and of giving an audible or visual indication in case of abnormally low insulation values.

5.3.2 Accumulator batteries as an integral part of the boat's electrical source
5.3.2.1 For a boat using accumulator batteries as electrical source, if the accumulator batteries have such as reasonable surplus of rated capacity and charging during navigation is not necessary, shore charging device instead of charging device onboard is to be provided.
5.3.2.2 Accumulator batteries are to be permanently installed in a dry, ventilated location above the anticipated bilge-water level. Batteries are to be installed in a manner to restrict their movement horizontally and vertically considering the intended use of the boat.
5.3.2.3 Accumulator batteries installed onboard are to be capable of inclination of up to 40° without leakage of electrolyte.
5.3.2.4 Accumulator batteries are to be so installed that mechanical damage can be prevented.
5.3.2.5 Accumulator batteries are not to be installed directly above or below a fuel tank or fuel filter.
5.3.2.6 The acid accumulator batteries are to be placed in different enclosed space apart from that for the alkaline accumulator batteries. The switch, fuse and other electrical appliances which are easily to cause electrical arc are not to be fitted in the space where accumulator batteries are placed.
5.3.2.7 The installation position of accumulator batteries is to be separated from the boat's shell with a certain distance.
5.3.2.8 Batteries connected to a charging device having a power[①] greater than 2 kW are to be

① The charging power means the nominal voltage of accumulator batteries multiples the value of maximum charging current.

installed in a room assigned to the batteries only, or may be located in a box or a locker if the batteries are installed on exposed decks.

5.3.2.9 The quantity of air removed Q of the gas-permeability battery rooms, boxes or lockers required in 5.3.2.8 is not to be less than:

$$Q = 0.11 \times In \qquad m^3/h$$

where: I – the maximum charging current during the production of gas, but not less than 25% of the maximum charging current output by the charger, in A;

n – number of battery cells.

5.3.2.10 The quantity of air removed of the valve-regulated sealed battery rooms, boxes or lockers may be reduced to 25% of that required in 5.3.2.9.

5.3.2.11 For sailboats, the batteries are to be of the sealed type.

5.3.2.12 Battery charging and discharging devices are to comply with the following requirements:

(1) Charging and discharging devices with sufficient capacity are to be provided to charge and discharge the propulsion accumulator batteries.

(2) Charging and discharging devices are to be equipped with short circuit, overload and other protection devices.

(3) Charging and discharging devices are to be provided with insulation monitoring devices, voltmeters, ammeters and indicator lights indicating the charging and discharging state.

(4) Except for lithium-ion batteries, charging and discharging devices are be able to recharge the completely discharged battery to the rated capacity in not more than 10 h.

(5) Battery charging and discharging devices are to be equipped with protective links to prevent the battery from overcharging and overdischarging and failure alarms.

(6) Battery charging and discharging devices are to be installed as close as possible to the batteries.

5.3.3 Switchboards (boxes)

5.3.3.1 The switchboards (boxes) are to be installed in a dry, readily accessible and well-ventilated position.

5.3.3.2 Boats equipped with both D.C. and A.C. electrical systems are to have their distribution from either separate panel boards or from a common one with a partition or other positive means provided clearly to separate the A.C. and D.C. sections from each other, and be clearly identified. Wiring diagrams to identify circuits, components and conductors are to be included with the boat.

5.3.3.3 Skid-proof and oil-resisting insulated carpet or insulated wood granting are to be provided in passages (if any) in the front of and behind the main switchboard (box), with the exception for the voltage less than 50 V.

5.3.3.4 In accordance with the actual situation of the boat's main power supply configuration and electrical equipment, suitable and safe switchgears and protective devices may be provided on the switchboard. Current and voltage indicators and power on-off indicator lights are to be provided at least on the switchboards or the charging and discharging boards.

5.3.4 Sockets

5.3.4.1 Sockets and matching plugs used on A.C. systems are not to be interchangeable with those used in the D.C. systems onboard.

5.3.4.2 Sockets installed in locations subject to rain, spray or splash are to be able to be enclosed in IP55 enclosures as a minimum, when not in use. Sockets mated with the appropriate plug are to be also remained sealed.

5.3.4.3 Sockets installed in areas subject to flooding or momentary submersion are to be in IP56 enclosures as a minimum, and also to meet these requirements when in use with electrical plugs.

5.3.4.4 Sockets provided for the galley area are to be located so that appliance cords may be plugged in without crossing above a galley stove or sink or across a traffic area.

5.3.5 Motor and its control device

5.3.5.1 Motors rated at 1 kW or above and motors required for essential services are to be supplied from distribution boards by separate final sub-circuits.

5.3.5.2 Every electrical motor is to be provided with efficient means of starting and stopping which are, in general, placed near the motor concerned. Where it is impracticable or unreasonable,

it may be started in the switchboard (box).
5.3.5.3 If the boat is provided with electrical or electrohydraulic steering gear, the motor is to be served by the exclusive circuit fed directly from the main switchboard. The protection device is to be equipped with short-circuit and undervoltage protection, without overload protection. An audible and visual alarm is to be provided for overload in the bridge room.
5.3.5.4 Cutoff devices for electric fans and fuel oil pump emergency are to be provided outside the engine room. Compartment air conditioners, fans and kitchen fans are to be capable of being stopped locally.

5.3.6 Aluminum boats
5.3.6.1 Distribution systems are to be insulated with hull or provided with cathodic protection system.
5.3.6.2 For D.C. system, accumulator batteries are not to be earthed through propelling machinery or associated machinery components. The starting accumulator batteries of engine may be earthed through the engine.

Section 4 Lithium-ion Accumulator Batteries

5.4.1 General requirements
5.4.1.1 The battery referred to in this Section applies only to lithium iron phosphate batteries.
5.4.1.2 Batteries are to be equipped with battery management system (BMS).
5.4.1.3 Battery charging and discharging equipment is to comply with the requirements of 5.3.2.12, and to be used in combination with BMS and controlled by it. Measures are to be taken to suppress radio interference for the charging device of lithium-ion battery.
5.4.1.4 Batteries are to be installed inside a battery cabin (room)/battery box (cabinet) with a controllable environment.

5.4.2 Definition
5.4.2.1 Unless expressly provided otherwise, the terms in this Section are defined as follows:
(1) **Battery pack** is made up of one or more battery modules in series or parallel connection as per voltage or power requirement. Battery pack is to include monitor circuit that provides information (such as voltage, temperature, etc.) for the battery system.
(2) **Battery management system** (BMS) refers to the electric device that controls or manages battery system's electric or thermal performance.
(3) **State-of-charge (SOC)** refers to the percentage of the capacity allowed to be released as per discharge condition stipulated by the manufacturers to the actual capacity of current battery cell, module, battery pack or system.
(4) **Battery system** refers to energy storage devices, including integration of battery cells or battery modules, battery management system, high voltage circuit, low voltage circuit, cooling devices and mechanical assembly.
(5) **Battery cabin (room)** refers to a space enclosed by structural divisions for the storage of batteries.
(6) **Stored energy** refers to the product of battery's rated capacity and rated voltage.

5.4.3 Definition
5.4.3.1 When arranging batteries, the arrangement mode is to be selected according to the total storage energy of the batteries:
(1) The batteries with total stored energy greater than 20 kWh are to be installed inside dedicated battery cabins (rooms) or inside battery boxes (cabinets) on open deck;
(2) A battery with total stored energy of or less than 20 kWh but greater than 2 kWh may be installed inside a dedicated battery box(cabinet), which may be placed inside the engine room when service environment of the box(cabinet) can be ensured;
(3) For a battery with the total stored energy of or less than 2 kWh, steel shell battery pack may be adopted, which may be installed in locations that are decently ventilated when service environment inside the pack is ensured.

5.4.3.2 Batteries are not to be installed inside accommodation space.
5.4.3.3 Batteries are to be located behind the collision bulkhead and in areas outside the engine room except as described in 5.4.3.1 (2) and (3).
5.4.3.4 The arrangement of batteries is to facilitate replacement, check, test and cleaning. Attention is to be given to the battery arrangement in order to avoid the stress concentration. When the battery arrangement is concentrated, the hull structure in this area is to be strengthened locally.
5.4.3.5 Batteries are not to be installed in locations where overheat, over cooling, splash, steam and other factors would damage their performance or accelerate their performance deterioration. Their installation is to prevent fire and explosion caused by their abuse from endangering personnel and damaging equipment.
5.4.3.6 For boats of 15m above in length, propulsion batteries are to be provided separately in at least 2 battery cabins (rooms).
5.4.3.7 All batteries are to be fitted in dedicated battery box (cabinet) or battery pack. A battery box (cabinet) is to be made of steel with thickness greater than or equal to 1mm. The horizontal projection area of a single battery box (cabinet) is not to exceed 1m^2.
The battery box (cabinet) arranged in the battery cabin (room) is to be appropriately provided with gratings or similar arrangements to facilitate ventilation, thermal dissipation and fire fighting. Exceptions could be granted if temperature regulating device and fire prevention measure are provided separately.
Battery boxes (cabinets) are not required where horizontal projected area of battery cabin (room) doesn't exceed 1m^2. Battery boxes (cabinets) are not required where the battery in the battery cabin (room) is in the form of battery pack and the shell of the battery pack is made of steel. The horizontal projected area of any battery pack is not to exceed 1m^2, and the weight of any battery pack is to be less than 130kg.
5.4.3.8 Equipment unrelated to batteries are not to be installed inside battery cabins (rooms) and battery boxes (cabinets).
5.4.3.9 Installation of electrical equipment other than the battery system inside battery cabins (rooms) and battery boxes (cabinets) is to be avoided. If it must be installed, it is to be as far away from batteries as possible, and its calorific value is to be included in the calculation of ventilation volume specified in 5.4.4.2.
5.4.3.10 Consideration is to be given to bilge facilities in battery cabins (rooms) which are to comply with the requirements of Section 7 of Chapter 4.

5.4.4 Ventilation and cooling

5.4.4.1 Battery cabins (rooms) are to be equipped mechanical ventilation or other temperature regulating device to prevent the ambient temperature of battery cabins (rooms) from being too high. For the battery boxes (cabinets) not installed in the dedicated cabins, effective temperature regulating devices are to be provided.
5.4.4.2 When mechanical ventilation is adopted in battery cabins (rooms), the mechanical ventilation calculation is to be carried out according to the method provided by the battery manufacturer. If the calculation method is not provided by the manufacturer, the ventilation is to be calculated according to the following method.
Ventilation volume is not to be less than the value calculated from the equation below:

$$q' = k(nQ + Q_1)/(0.335\Delta t) \quad \text{m}^3/\text{h}$$

Where: Q ——Heat productivity generated by single battery module in operation itself, W;

Q_1 ——Heat productivity of other heat sources, W;

n ——Total number of battery modules;

Δt ——Maximum temperature difference[①] between battery cabins (rooms) and outside air,℃;

k ——Surplus constant of fans, to be taken between 1.5~2 when practically chosen.

① Highest environment temperature possible for the ship's navigation area is taken as highest temperature, but it is not to exceed 45°C.

5.4.4.3 Measures that prevent water and flame from entering are to be provided at ventilation openings and air inlets are to be far away from air outlet.
5.4.4.4 The gas from the ventilator is to be led directly to safe locations on open decks and away from inhabited or heat-containing spaces.
5.4.4.5 Control facility is to be provided to shut down ventilation or other temperature regulating devices outside the battery cabins (rooms).

Section 5 System Protection

5.5.1 System protection

5.5.1.1 Electrical installations are to be protected against accidental over-current, including short-circuit by appropriate devices.
5.5.1.2 Each independent circuit is to be provided with a reliable short-circuit current and overload protective device, but protection of steering gears is to comply with the requirements of 5.3.5.3.
5.5.1.3 Generators are to be protected by means of circuit breakers, for a generator with the power of less than 24 kW, a multi-pole switch and fuse may be used for protection.
5.5.1.4 Over-current protection devices for motor loads are to have a predetermined value of current flow consistent with demand load characteristics of the protected circuit.
5.5.1.5 The rating of the over-current protection device is not to exceed the maximum current-carrying capacity of the conductor being protected.
5.5.1.6 For power transformer, including a bank of two or three single-phase transformers operating as a unit, overcurrent protection is to be provided. Each transformer is to be protected by an individual over-current device on the primary side, rated at not more than 125% of the rated primary current of the transformer.
5.5.1.7 The rated or corresponding setting value of the overload protection appliance for each circuit is to be permanently indicated at the location of the protection appliance.
5.5.1.8 Accumulator batteries, other than engine starting batteries, are to be protected against short-circuit with protection appliances positioned as near as possible to the accumulator batteries. Protection appliances generally can be provided on the charging and discharging boards they are connected to.
5.5.1.9 A section switch for accumulator battery is to be provided in a certain accessible position of accumulator batteries (generally can be provided on the charging and discharging board it is connected to) as near as practicable, i.e. in way of positive of power supplying system, with exception of:
(1) boats only having outboard motor starting and navigation light circuit;
(2) electronic equipment having protective storage and protecting devices, i.e. bilge pump and alarm, if breakers or fuses are to be protected independently in way of the connecting line terminals of battery as near as possible;
(3) ventilator of fuel oil tank for motor, if fuses are provided independently in way of the electrical source.

Section 6 Cables

5.6.1 General requirements

5.6.1.1 Marine flame retarding cables or wires are to be used onboard. Cables or wires selected are to be determined according to the environmental conditions of the location, laying methods, rated current, duty, diversity factor, permissible voltage drop, etc.
5.6.1.2 Conductor insulation temperature rating of cables or wires in engine room is to be oil-resistant at 70℃ minimum, or protected by insulating conduit or sleeving.
5.6.1.3 The insulation temperature rating of cables or wires outside the engine room is to be at least 60℃.

5.6.2 Cable runs

5.6.2.1 Cables or wire runs are to be straight and accessible for inspection and repair as far as possible.

5.6.2.2 Conductors that are not sheathed are to be supported throughout their length in conduits, cable trunking, or trays or by individual supports at maximum intervals of 250 mm.

5.6.2.3 Sheathed conductors and battery conductors to the battery disconnect switch are to be supported at maximum intervals of 450 mm, with the first support not more than 1 m from the terminal. Sheathed outboard-motor starter conductors constitute an exception.

5.6.2.4 Each conductor longer than 200 mm installed separately is to have an area of at least 1 mm^2. Each conductor in a multi-conductor sheath is to have an area of at least 0.75 mm^2 and may extend out of the sheath a distance not to exceeding 800 mm.

5.6.2.5 Each electrical conductor that is part of the electrical system is to have a means to identify its function in the system, except for conductors integral with engines as supplied by their manufacturers.

5.6.2.6 Conductor connections are to be in locations protected from the weather or in IP55 enclosures as a minimum.

5.6.2.7 Current-carrying conductors are to be routed above foreseeable levels of bilge water and other areas where water may accumulate. If conductors must be routed in the bilge area, suitable water-proof means are to be taken.

5.6.2.8 Metals used for terminal studs, nuts and washers are to be corrosion-resistant and galvanically compatible with the conductor and terminal. Aluminum and unplated steel are not to be used for studs, nuts or washer in electrical circuits.

5.6.2.9 All conductors are to have suitable terminals installed, i.e. no bare wires to stud connections unless end strands are made rigid by soldering over the length of their contact with the terminal post connection. Soldered connections are not to be used for connecting or terminating any conductor of nominal cross-sectional area greater than 2.5 mm^2.

5.6.2.10 Twist-on connectors (wire nuts) are not to be used.

5.6.2.11 Exposed shanks of terminals are to be protected against accidental shorting by insulating barriers or sleeves, except those in the protective conductor system.

5.6.2.12 Conductors are to be routed away from exhaust pipes and other heat sources which can damage the insulation. The minimum clearance is 50 mm from water-cooled exhaust components and 250 mm from dry exhaust components, unless an equivalent thermal barrier is provided.

5.6.2.13 Conductors which may be exposed to physical damage are to be protected by sheaths, conduits or other equivalent means. Conductors passing through bulkheads or structural members are to be protected against insulation damage by chafing.

5.6.2.14 No more than four conductors is to be secured to one terminal stud. Cable or wire runs are not to be in the laminating plate in FRP.

Section 7 Additional Requirements for Inboard-mounted Petrol Engine

5.7.1 General requirements

5.7.1.1 Engine-mounted electrical system components which, as designed and installed, can create an electrical arc externally or internally which is capable of igniting a petrol and air mixture, such as circuit breakers, switches, solenoids, alternators, generators, voltage regulators and electric motors, are to be ignition-protected in accordance with the standards[①] accepted by CCS.

5.7.2 Engine electrical systems and components

5.7.2.1 All electrical system components are to be mounted as high as practical on the engine. The engine-cranking motor and ignition distributor position may be as controlled by the basic engine manufacturer's design.

5.7.2.2 Ignition coils and magnetos are to be mounted or protected so that water will not

① Refer to Small craft - Electrical devices - Protection against ignition of surrounding flammable gases (ISO8846:2017).

accumulate around the high voltage cap.

5.7.2.3 If an electrical component is required to be ignition-protected and bands or other covers form part of the ignition-protection enclosure, a permanent warning tag is to be affixed to the component, or the band or cover is to be permanently and visibly marked, with appropriate language or symbols, indicating that the band or cover must be in place when the engine is operating.

5.7.2.4 Ignition distributors are to comply with the following requirements:

(1) The distributor, when operating during engine cranking and operation is to be of strength to resist lifting of the cap off the sealing surface in the event of an internal explosion of fuel and air vapour mixture. During test, high-tension (secondary) ignition wiring is to be in place on all distributor cap towers with terminal covering boots as installed during engine operation.

(2) All inlets or outlets are to be covered by effective flame-arrester screens or are to be of a size and length providing equivalent ignition-protection capability.

(3) Terminal covering boots are to be a close fitting to effect a water-tight seal on the outside of high-tension wire insulation and on the outside of the distributor cap tower when in place and meeting the requirements of 5.7.2.5(1).

5.7.2.5 The high-tension (secondary) ignition cable assemblies are to comply with the following requirements:

(1) The high-tension ignition cable assemblies are to have boots and nipples installed which form a water-tight seal with the outside of the high-tension wire insulation, the outside of the distributor cap terminal towers and the outside of the spark-plug ceramic insulator, such that leakage of electrical current will not occur when the connection is submerged for 2 h at 3 cm to 5 cm below the surface of a grounded 3% salt and water solution by weight, with an applied voltage of 20 kV peak (14 kV rms) 50 Hz to 60 Hz applied to the conductor. The voltage is to be applied at a rate of 500V peak (355V rms) per second between the free end of the high-tension lead and the grounded salt water solution.

(2) Boots and nipples installed on high-tension ignition cables are to meet the dielectric leakage test requirements of (1) after conditioning at 125 ℃ ±2 ℃ for 40 h and subsequent flexing by installation and removal, at room temperature, 10 times on the spark plug and distributor cap tower.

(3) Boots and nipples installed on high-tension ignition cables are to meet the dielectric leakage test requirements of (1) after conditioning for 30 h in a sealed glass container at room temperature when suspended 25 mm±5 mm above test liquid C in accordance with ISO 1817[①], and subsequent flexing by installation and removal 10 times from the spark plug and distributor cap tower.

(4) Boots and nipples installed on high-tension ignition cables are to meet the dielectric leakage test requirements of (1) after conditioning for 40 h in test oil No.3 in accordance with ISO 1817 maintained at 125℃±2℃. Remove from oil; cool to room temperature; remove excess oil. Flex boots and nipples by installing and removing 10 times from the spark plug and distributor cap tower.

(5) Tests as per (2) to (4) above are to be conducted on separate groups of high-tension ignition cable assemblies.

Section 8 Additional Requirements for Pure Battery-Powered Electric Propulsion Boats

5.8.1 General requirements

5.8.1.1 This Section applies to boats which use motor-driven propellers and use accumulator batteries as the power supply.

5.8.1.2 In addition to the requirements in this Section, propulsion accumulator batteries are to comply with the requirements in 5.3.2 of Section 3 or Section 4 of this Chapter. The relevant requirements of Section 2 of this Chapter are also to be met when the propulsion accumulator batteries are used as the main power source of the boat.

5.8.1.3 Propulsion accumulator batteries are to be so designed that their capacity meets the

① Refer to Rubber, vulcanized or thermoplastic - Determination of the effect of liquids (ISO 1817:2015).

power required for the voyage of the boat.

5.8.1.4 As propulsion accumulator batteries, the discharge termination voltage of acid lead plate type or alkaline nickel plate type batteries is to be at least 88% of its nominal voltage within the specified power supply time. The terminating discharge voltage/quantity of lithium-ion batteries is to comply with the requirements of the technical specifications provided by the manufacturer.

5.8.1.5 When charging accumulator batteries, uneven charging of each accumulator battery is to be avoided.

5.8.1.6 Some batteries of the accumulator batteries are not to be used to supply machinery and electrical equipment.

5.8.1.7 The battery is to be maintained according to the information provided by the manufacturer.

5.8.2 Control and protection of propulsion equipment

5.8.2.1 Variable speed propulsion machines fitted with an integral fan are to be capable of operating at speeds below the rated speed with full-load torque, full-load current, full-load excitation or in similar conditions, and temperature rises are not to exceed the limits given in Chapter 3, PART FOUR of CCS Rules for Classification of Sea-going Steel Ships.

5.8.2.2 The collector rings and commutators of propulsion machines are to be suitably arranged for easy maintenance. For purposes of inspection, repair, withdrawal and replacement of the field coils, provision is to be made for easy access to all windings and bearings.

5.8.2.3 Propulsion machines are to be capable of withstanding the short circuit current before the activation of protection device in case of a sudden short circuit at their terminals and in the systems under rated operating conditions without damage.

5.8.2.4 Propulsion motors are to be capable of driving the propeller continuously to run ahead and astern under various specified operating conditions, and to be capable of running well under the transition conditions of maneuver and astern. Reversible propulsion motors are to be capable of operating normally under the reverse working condition specified in the product technical specifications.

5.8.2.5 Stator windings of AC propulsion motors supplied by varied-frequency semiconductor converters are to be capable of withstanding the voltage variation due to action of the high-frequency switch of inverters.

5.8.2.6 Rotors of DC propulsion motors are to be capable of withstanding the limit speed set by the overspeed protection device according to normal operation.

5.8.2.7 The control station is to be provided with a separate emergency shutdown device unrelated to the control lever for normal operation.

5.8.2.8 The main propulsion circuit is to be protected against overload and short circuit. Fuses are not to be used as protection devices.

5.8.2.9 Where overspeed of the propulsion motors may occur (due to loss of propeller), suitable overspeed protection is to be provided.

5.8.2.10 Measures are to be taken that the control of the propulsion system can be activated only when the control lever is in zero position and the system is ready for operation.

5.8.2.11 In excitation circuits, there is to be no overload protection causing the opening of the circuit.

5.8.2.12 Any single fault in the propulsion machine excitation system is not to result in a total loss of propulsion power.

5.8.3 Monitoring instrumentation and alarms

5.8.3.1 The control station is to be provided with necessary instruments indicating the status. Where applicable, the control station is to be equipped with the instructions, displays and alarms in Table 5.8.3.1.

Indications, displays and alarms **Table 5.8.3.1**

System	Monitored parameter	Alarm	Display	Remark
Battery	Voltage	√	√	High/low voltage alarm
	Current		√	

	Charge and discharge indication		√	
	SOC	√	√	Low state of charge alarm, only applicable to lithium-ion batteries
	BMS self-checking function	√	√	BMS failure alarm, only applicable to lithium-ion batteries
Propulsion motor (AC &DC)	Armature current		√	To read all phases
	Excitation circuit		√	For synchronous motors
	Motor running		√	
Propulsion semiconductor converter	Voltage (input)		√	
	Current (input)		√	
	Overload (high current)	√		Alarms before protective device is activated
	Failure of converter cooling pump or fan motor	√		

Note: " √ " in the column indicates that it is to be provided when applicable.

5.8.3.2 Instruments and other devices installed on the control station are to be fitted with labels and instruments are to be fitted with identification marks indicating full load.
5.8.3.3 The metal casings of all fixed instruments are to be permanently firmly earthed.
5.8.3.4 Failure of measuring, indicating and monitoring equipment is not to cause failure of control and regulation.

Section 9 Supplementary Requirements for Boats Applying Solar Cells

5.9.1 General requirements

5.9.1.1 This Section applies to boats applying solar cells.
5.9.1.2 Solar cells consist of solar photovoltaic modules, controllers, accumulator batteries, and inverters (when applicable).
5.9.1.3 Solar cells are to be used only as auxiliary power sources for boats.

5.9.2 Solar photovoltaic modules

5.9.2.1 Solar photovoltaic modules are to comply with the requirements of the standards accepted by CCS.
5.9.2.2 Each module is to be durably and clearly marked (including manufacturer name, mark or symbol, product model, product number, polarity of terminal or lead wire, maximum system voltage allowed for module, date and place of manufacture).
5.9.2.3 The following phenomena is not allowed for solar photovoltaic modules:
(1) cracked, bent, unregulated or damaged external surface;
(2) broken or cracked cells;
(3) the interconnection line or joint is not reliable;
(4) the batteries are in contact with each other or with the frame;
(5) failure of sealing material;
(6) bubbles or delamination forming a continuous channel between the frame of the module and the battery;
(7) sticky dirt on the surface of plastic material;
(8) failure of lead wire end and live parts exposed;
(9) any other circumstances that may affect the performance of the module.
5.9.2.4 The solar photovoltaic module is to be installed as far as possible in a less vibration space of the boat, and to be equipped with shock absorbers if necessary.
5.9.2.5 When the solar photovoltaic module is installed, the mounting bracket is to be strong

enough to withstand the external force that the solar photovoltaic module may suffer.
5.9.2.6 After the installation of the solar photovoltaic module, appropriate protection measures are to be taken for the exposed live parts.
5.9.2.7 During replacement or maintenance of solar photovoltaic modules, the surface of modules are to be covered with cloth or other materials with poor light transmittance to prevent the modules from generating high voltage hazards under sunlight.

5.9.3 Controllers
5.9.3.1 The controller are to have the following functions:
(1) battery overcharge protection with input full disconnection and restore connection functions;
(2) battery overdischarge protection;
(3) short circuit protection;
(4) overload protection.
5.9.3.2 The controller is to be installed as far as possible in a less vibration space of the boat, and to be equipped with shock absorbers if necessary.

Section 10 Supplementary Requirements for Shore Connection Systems of Boats

5.10.1 General requirements
5.10.1.1 This Section applies to boats fitted with shipside installations of shore connection systems.
5.10.1.2 Boats fitted with shipside installations of shore connection systems are to comply with the requirements of this Section.
5.10.1.3 Shipside installations of shore connection systems are to be furnished with marine product certificates.
5.10.1.4 Procedures for operations of shore connection are to be developed and implemented for boats to ensure operational safety for shore connection.

5.10.2 Shipside installations of shore connection systems of boats
5.10.2.1 A connection box is to be installed in a position in the boat suitable for the convenient reception of flexible cables from the shore supply. Suitable cables having adequate ratings, permanently fixed, are to be provided for connection between the shore connection box and the main switchboard or emergency switchboard. The connection box is to be provided with:
(1) suitable terminals for connecting the flexible cables;
(2) an earth terminal for connecting the hull to the shore;
(3) a circuit-breaker or an isolating switch and fuses for protection;
(4) a lamp or voltmeter to indicate the terminal voltage;
(5) means for checking the polarity (for direct current) or the phase sequence (for three-phase AC) of the shore supply in relation to the ship's system (if applicable);
(6) means to prevent the imposing of excessive mechanical forces on cable terminals;
(7) a nameplate giving full information on the system of supply, the rated voltage and frequency (for AC) of the ship's system.
5.10.2.2 When a three-phase AC system with neutral earthed is adopted for shore supply and/or ship power, an earth terminal is to be provided for connecting the ship's hull to the earth of the shore supply. In the case of DC systems with hull return, the negative terminal of the shore power must be connected to hull.
5.10.2.3 The shore connection is to be provided with an indicator at the main switchboard or emergency switchboard in order to show when the shore connection cables are energized. At the same time, at least one shore ammeter and one shore voltmeter are to be provided.
5.10.2.4 Boats are to be equipped with shore supply plugs with rated current of 16A/32A (Series I) and voltage rating of 220V[①]/380V[②].

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① They are to be electrical accessories with 3 contacts (2P+E) as specified in "Plugs, socket-outlets and couplers for industrial purposes—Part 2: Dimensional compatibility and interchangeability requirements for pin and contact-tube accessories" (GB/T 11918.2-2014).
② They are to be electrical accessories with 4 contacts (3P+E) as specified in "Plugs, socket-outlets and couplers

5.10.2.5 Boats are to be equipped with shore connection cables suitable for their current carrying capacity. The cables are to be flexible cables with sufficient current rating, oil resistance and flame retarding sheath.

5.10.3 Load transfer

5.10.3.1 Load transfer between the shore supply and the shipboard generator may be executed via blackout or temporary parallel running.

5.10.3.2 Where load transfer is executed via blackout, means are to be provided to prevent simultaneous supply from the ship's generators (if fitted, including emergency ones) and the shore supply.

5.10.3.3 Where load transfer is executed via temporary parallel running of the shipboard generator and the shore supply, the following requirements are to be complied with:

(1) Means are to be provided for automatic synchronization of the shipboard generator and the shore supply;

(2) Load transfer is to be conducted both automatically and manually;

(3) The duration of the temporary parallel running is to be as short a period as practicable allowing for the safe transfer of the load;

(4) If the defined transfer time limit for load transfer is exceeded, the transfer is to be stopped, shore connection circuit breakers are to be opened, and an audible and visual alarm is to be activated at a manned location;

(5) Reverse power is to be avoided during load transfer.

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for industrial purposes—Part 2: Dimensional compatibility and interchangeability requirements for pin and contact-tube accessories" (GB/T 11918.2-2014).

Chapter 6 ADDITIONAL REQUIREMENTS FOR LPG POWER-DRIVEN BOATS

Section 1 General Provisions

6.1.1 General requirements

6.1.1.1 This Chapter specifies additional requirements for boats with Liquefied Petroleum Gas (LPG) engine as their main power.
6.1.1.2 Passenger boats are not to be provided with LPG engines.
6.1.1.3 For boats to which this Chapter is applicable, the use of dual fuel is prohibited.
6.1.1.4 Special requirements for outboard LPG engines may be referred to in Chapter 4 of the Rules.

6.1.2 Definitions

6.1.2.1 For the purpose of this Chapter, the relevant definitions are as follows:
(1) **LPG** means mixture of light hydrocarbon which is in a gaseous state under normal temperature and atmospheric pressure and may be kept in a liquid state by pressurization and cool-down, the basic composed are propane, propylene, butane and butylenes. It may also be composed of commercial butane or commercial propane or the mixture of both.
(2) **Gas tank** means a special steel cylinder for storage of LPG.
(3) **Gas tank space** means a space for storage of gas tanks.
(4) **Enclosed space** means a space enclosed by bulkheads and decks but may have windows and doors.
(5) **Semi-enclosed space** means a space having structures such as top plating, deck so that its natural ventilation condition is different from that on open deck and it is so arranged that gases cannot diffuse.
(6) **Open space** means an open deck space.

Section 2 LPG Engine

6.2.1 General requirements

6.2.1.1 The design and manufacture of LPG engine (hereinafter called the engine) are to comply with the provisions of the relevant standards① accepted by CCS and the engine is to have marine product certificate.
6.2.1.2 Where the engine is used as a main engine, reliable governors are to be provided to prevent the engine from exceeding 115% of its rated speed. Governors are to be provided for prime motors where used as generators and their performances are to be as follows.
(1) For governors, where the rated load is suddenly taken off or applied, the momentary variation in speed and permanent variation in speed are not to exceed 10% and 5% of the rated speed. Where the rated load is suddenly applied, the recovery time for the engine speed is not to exceed 5s.
(2) For the rated power of diesel engine greater than 220 kW, overspeed protective devices are to be provided independently from the governors to prevent the speed of diesel engines exceeding 115% of the rated speed.
6.2.1.3 Engines are to be provided with emergency shut-down devices which may cut-off the fuel manifold on LPG supply main and it may be remotely controlled in the bridge room.
6.2.1.4 Heating installation is to be provided in cooling water system of engine in order to ensure that the engine can be normally started in winter.
6.2.1.5 The exhaust piping of engine is to comply with the following requirements:

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① Refer to "Medium and small power internal combustion engines -- Part 1: General technical conditions" (GB/T 1147.1) and "Medium and small power internal combustion engines -- Part 2: Test methods" (GB/T1147.2).

(1) Suitable insulation is to be used for exhaust pipe to prevent the surface temperature from exceeding 220℃.
(2) Spark arrester or equivalent means is to be provided in the outlet of exhaust pipe which is as far as possible apart from those for ventilation of engine room and gas tank space.

Section 3 LPG Supply System

6.3.1 Gas Tanks and Accessories

6.3.1.1 The gas tanks are to be installed in an independent gas tank space with permanent fixing means to ensure they cannot fall during the sea voyages and can be easily dismantled and exchanged. The collision rubber or wood packing is to be provided between gas tank and fixed seating.
6.3.1.2 Effective and reliable working of gaseous and liquid phase joint elements and liquidometer are to be taken into consideration for the installation direction and location of gas tanks.
6.3.1.3 Gas tanks are as far as possible apart from heat sources to avoid direct sunlight. In general, the temperature of gas tank special holds or gas tank compartments is not to be more than 45℃, and suitable cooling means is to be provided in summer.
6.3.1.4 The metering valve of gas tank is to automatically stop charging when the LPG charging capacity achieves 80% volume of gas tank.
6.3.1.5 The safety valve of gas tank is to ensure the pressure not exceeding its design pressure.
6.3.1.6 The sealed protective box is to seal the opening of gas tank and its accessories reliably and vent pipe is to be provided to lead the leakage gases to safe spaces outboard.
6.3.1.7 The gas tanks and accessories are to comply with the provisions of the relevant standard① accepted by CCS and are to have marine product certificate.

6.3.2 LPG Control Equipment

6.3.2.1 Each LPG supply system is to be provided with an evaporation pressure regulator, which is to be capable of supplying suitable and rated working pressure for each gas-driven engine. The pressure within the pipelines after LPG passes through the evaporation pressure regulator is not to be more than 0.1 MPa.
6.3.2.2 Each outlet of gas tank is to be provided with flow-limiting valve which is automatically closed when the pressure deficiency between two ends of the valve is 0.35 MPa.
6.3.2.3 Automatic stop valve is to be provided in way of inlet of evaporation pressure regulator for LPG supply pipe main, and it can automatically cut off LPG supply in the following cases:
(1) ignition switch is not on;
(2) engine is not operated;
(3) exhaust blower is not operated.
6.3.2.4 For the LPG supply system with more than one gas tank, stop valve is to be provided in supply pipe branch of each gas tank for use when gas tanks are exchanged. The stop valve is to be installed in a readily accessible and easily operable location.
6.3.2.5 For supply system simultaneously supplying for more than one engine, stop valve is to be provided in way of inlet pipe of each engine. The stop valve is to be installed in a readily accessible and easily operable location.
6.3.2.6 The gas tank is to be provided with capacity measuring means, pressure sensor and capacity indicator so as to show its present capacity in the bridge room.

6.3.3 LPG Supply Piping

6.3.3.1 The rigid drawn copper tube or drawn stainless tube is to be used for rigid supply pipe. For the pipelines with outer diameter of 12 mm and below, the thickness is not to be less than 0.8 mm, for those more than 12 mm, the thickness is not to be less than 1.5 mm. The approved rubber hose② may be to use for low pressure pipelines after the evaporation pressure regulator, however,

① Refer to "LPG cylinders for motor vehicles" (GB17259).
② Refer to "LPG automotive rubber pipeline" (QC/T745).

plastic hose is not to be used.
6.3.3.2 The high pressure supply pipelines from gas tank to evaporation pressure regulator are to be installed within enclosed or semi-closed gas tank spaces. Where it is installed in an open space, protective members are to be used for fixing and sheltering so as to prevent from stepping on or collision. It is strictly forbidden to install the evaporation pressure regulator inside the LPG engine.
6.3.3.3 LPG supply pipelines are not to penetrate passenger cabins, service spaces and control stations.
6.3.3.4 The approved rubber hoses are to be used for connection between LPG engine and any permanently installed metal pipelines so as to avoid failure caused by vibration.
6.3.3.5 Where hose is used partially in supply pipeline, double clamps are used for the joint at both ends of hose and the clamps are to have a certain contacting length, no pinch-cock clamps are permitted to use and the clamps are to be so fitted as to be accessible.
6.3.3.6 The partial pipelines which gas may possibly leak in LPG supply pipelines are to be apart from electrical equipment as far as possible.
6.3.3.7 The LPG supply pipe is not to contact directly with bulkhead or deck and avoid contacting in way of the intersection of other pipelines.

6.3.4 Test

6.3.4.1 Hydraulic and tightness tests are to be carried out for LPG piping. The test pressure is in accordance with the requirements of Table 6.3.4.1.

Test pressure **Table 6.3.4.1**

LPG piping	Test pressure	
	Hydraulic test (in workshop) (MPa)	Tightness test (onboard) (MPa)
Pipeline from gas tank to pressure regulator	3.3	2.2
Pipeline from pressure regulator to engine	0.2	0.1

6.3.4.2 Effectiveness test is to be carried out after the installation of LPG supply system and no gas leakage exists. The tightness test mentioned in Table 6.3.4.1 may also be carried out together with effectiveness test.

Section 4 Arrangement and Ventilation

6.4.1 Arrangement

6.4.1.1 Engine room and gas tank space are to be independent from each other and it is prohibited to arrange them with passenger cabins. The gas tank space is to be as far as possible arranged in a place with good ventilation above deck by a semi-enclosed way. The gas tank space is to be capable of being locked to prevent persons other than the staff from touching and removing. No holes and stairway openings leading to the holds below are permitted to provide in the gas tank spaces. The distance from the gas tank and high pressure pipeline on deck to the outline edge of the boat (excluding fenders) is not to be less than 100 mm.
When gas tank boxes (shelves) are used as the gas tank space in open area onboard the ship, the ventilation conditions of such boxes (shelves) are to comply with the provisions of 6.4.2.2 of this Section.
6.4.1.2 The engine rooms and gas tank spaces are to be provided with independent drainage systems and the drainage systems are to be separated from those in other compartments.
6.4.1.3 The bottom structures of engine rooms and gas tank spaces are to keep gastight and platforms are to be provided as far as possible. For bottoms with strengthening stiffeners, the arrangement is not to impair the drainage of combustible gases.
6.4.1.4 The bulkheads between engine room, gas tank space and passenger cabins and the bulkheads between gas tank space and engine room are to keep gastight, and in general, openings are not to be provided. Where it is necessary for the pipelines or cables are to penetrate the bulkheads, airtight is to be kept in way of the penetration and structural fire integrity is to be ensured. Ships with outboard motors and passenger space of which is open area may be exempted from this requirement.

6.4.1.5 For open boat with windows and doors of non-weathertight type in passenger cabins, drainage groove and bilge well are to be provided in the bottom plating of passenger cabins.
6.4.1.6 In order to prevent electrostatic hazards, the gas tank and its pipe system are to have necessary grounding arrangements. If non-conductive material gaskets are used between pipe segments connected by flanges, a good conductive lap piece is to be added.
6.4.1.7 When gas tank boxes (shelves) are used as the gas tank space in open area onboard the ship, the ventilation conditions of such boxes (shelves) are to comply with the provisions of 6.4.2.2 of this Section.

6.4.2 Ventilation

6.4.2.1 Mechanical ventilation system having sufficient capacity is to be provided in enclosed or semi-enclosed engine rooms or gas tank spaces with the air charge ratio not less than 30 times/h and 20 times/h respectively. The mechanical ventilation in engine room is to be realized by interlocking start/operation with the main engine, i.e. after the blower is operated at least 4 min, the engine is started, where the blower is stopped caused by some reasons, the engine can be automatically stopped and the following requirements are to be complied with:
(1) In general, mechanical ventilation system is to be used in enclosed engine room and gas tank space. Each intake duct for an exhaust blower is to be under 1/3 height of the compartment and above the normal level of accumulated bilge water. The exhaust outlet is to be so arranged as to discharge the air in compartments to outboard and as far apart from the outlet of exhaust pipe for engine as possible. Where the exhaust outlet is near waterline, means to prevent water flooding is to be provided.
(2) Where mechanical blast is used for ventilation system, in general, the exhaust outlet is to be under 1/3 height of compartment and above the normal level of accumulated bilge water. The exhaust outlet is to be so arranged as to discharge the air in compartments to outboard and as far apart from the outlet of exhaust pipe for engine as possible. Where the exhaust outlet is near waterline, means to prevent water flooding is to be provided.
(3) The blower is to be of the non-spark type.
6.4.2.2 In general, natural ventilation is also to be provided in the engine room and gas tank space mentioned in 6.4.2.1 above. The inlet is to be as far apart from the outlet as possible. The exhaust outlet is to be under 1/3 height of compartment and above the normal level of accumulated bilge water. The exhaust outlet is generally of shutter type. The cross-sectional area of the exhaust outlet is to be such that there is at least $0.3m^2$ opening for every $1m^3$ of net space.

Section 5 Detection and Alarm System

6.5.1 LPG combustible fume detector

6.5.1.1 The LPG combustible fume detection system is to be subject to approval by CCS.
6.5.1.2 Fixed LPG combustible fume detector are to be provided in enclosed and semi-enclosed gas tank spaces and enclosed engine room. The LPG combustible fume detection system is capable of continuous monitoring.
6.5.1.3 LPG combustible fume detectors are to be so arranged to meet the following requirements:
(1) Probes are to be provided in a position where LPG combustible fume leaks and accumulates easily.
(2) Where the concentration of LPG combustible achieves 30% lower limit of explosion, visual and audible alarm is to be given in the bridge; where it achieves 60% lower limit of explosion, manifold on LPG supply main may be automatically cut-off or remotely cut-off in the bridge.
6.5.1.4 Each ship is to be at least provided with one portable LPG combustible fume detector, which is available for use by crew.

Section 6 Fire-fighting

6.6.1 General requirements

6.6.1.1 LPG-powered ships are to comply with the requirements of this Section in addition to the fire-fighting requirements for ordinary ships.

6.6.1.2 Coating and insulation which may set fire easily and emit large amount of smoke or noxious gases during burning cannot be used in engine room and gas tank space.

6.6.1.3 Prominent “No Smoking” signs are to be posted in engine room and gas tank spaces.

6.6.2 Provision of fire extinguishers

6.6.2.1 Engine room is to be provided with fire extinguishers as required in Table 6.6.2.1.

Provision of fire extinguishers in engine room Table 6.6.2.1

Total power in engine room P (kW)	Provision of fire extinguishers
$P \leqslant 37.5$	One dry powder fire extinguisher with a capacity not less than 2 kg
$37.5 < P \leqslant 150$	Two dry powder fire extinguisher with a capacity not less than 2 kg each
$150 < P \leqslant 300$	Two dry powder fire extinguisher with a capacity not less than 3 kg each
$300 < P \leqslant 450$	Two dry powder fire extinguisher with a capacity not less than 4 kg each

6.6.2.2 At least two dry powder fire extinguishers with a capacity not less than 2 kg each are to be provided in a gas tank space.

Section 7 Miscellaneous

6.7.1 Electrical equipment

6.7.1.1 The power distribution system of the ship is to be insulated.

6.7.1.2 Electrical equipment is not to be installed in gas tank space as far as possible. Where it is needed, electrical equipment preventing LPG combustible fume from igniting is to be provided. Where it is necessary, one portable explosion-proof light with batteries may be provided for emergency use onboard each boat.

6.7.2 Operation Requirements

6.7.2.1. Boat’s certificate and/or operation manual of LPG power-driven system, etc. required in the Rules are to be provided onboard the boat.

6.7.2.2 The crew is to be trained for normal operation and management of LPG power-driven system.

6.7.2.3 The crew is to be trained for emergency procedures in order to deal with the emergency cases such as LPG leakage or fire.

6.7.3 Accessing spaces

6.7.3.1 When the crew accesses a compartment, void space or other enclosed spaces where LPG is likely to accumulate, one of the following means is to be taken:

(1) fixed or portable LPG detecting device is to be used to confirm that no dangerous concentration of LPG combustible fume exists in the air of the above-mentioned spaces;

(2) respirators and other necessary protective equipment are to be provided for personnel.

6.7.3.2 Where personnel access the above-mentioned spaces, any potential fire source can not be brought in, unless it is verified that free gas is carried out for the space and it is still kept in such a condition.

6.7.4 Operation Manual of LPG Power-Driven System

6.7.4.1 Operation Manual of LPG Power-driven system approved by the Society is to be readily available onboard, and it is used as safe operation guidance in normal conditions and in emergency.

6.7.4.2 The Operation Manual is to contain those specified in 6.7.4.3 to 6.7.4.7 below.

6.7.4.3 The starting procedures of LPG engine is to comply with the following requirements:

(1) to switch on detection and alarm system to confirm no LPG leakage; where LPG leakage is detected in engine room (sometimes) and gas tank space by the probe, examination is to be made immediately to find the leakage reason and handle with it;
(2) to switch on blowers in engine room and gas tank space;
(3) in order to prevent mal-operation, interlocking device is to be provided between blower and engine. After the blower is operated more than 4 min, the engine can be started; where the blower is stopped caused by some reasons, the engine can be automatically stopped.

6.7.4.4 During the boat's service period (including embarkation, disembarkation or temporary laid-up), mechanical ventilation is to be kept in the enclosed or semi-enclosed engine room and gas tank spaces and blower can not be stopped.

6.7.4.5 Fixed LPG combustible fume probe is to be provided onboard the boat. Where the concentration of LPG combustible fume achieves 30% lower limit of explosion, visual and audible alarm is to be given in the bridge; where it achieves 60% lower limit of explosion, manifold on LPG supply main may be automatically cut-off. If it fails, the navigating officer must cut-off the LPG supply main immediately in the bridge.

6.7.4.6 Changing of gas tanks

(1) After recharged, the gas tank and its accessories are to be examined to see whether it leaks or not. If damage and leakage is found, the gas tank can not be taken onboard.
(2) After it is installed onboard, the connection between outlet valve and quick connection of gas tank is to be examined, and leakage is not to be found there.

6.7.4.7 Other requirements

(1) Where it is found that the LPG supply system leaks, it can not be used before the cause is determined and repair is made. Means are to be taken to cut off LPG supply source and start the blower. Various fire sources are prohibited and electrical equipment is not to be used.
(2) It is prohibited to discharge, store or deal with the LPG residual liquid in gas tanks onboard.
(3) All supply valves of LPG engine are to be closed during boat's laid-up.
(4) Where fire takes place onboard, the gas tanks are to be dismantled and thrown outboard quickly to protect the safety of boat and passengers.
(5) Special-assigned persons are to be responsible for the management, maintenance and service of LPG equipment.

Chapter 7 ADDITIONAL REQUIREMENTS FOR SAILING BOATS

Section 1 General Provisions

7.1.1 General requirements

7.1.1.1 The provisions of this chapter apply to sailing boats carrying passengers① for the purpose of sightseeing.

7.1.1.2 Unless otherwise specified by this Chapter, survey and certification, machinery and electrical installations (excluding main propulsion), outfitting, materials and construction procedure of sailing boats are to comply with relevant provisions of Chapter 1, Chapters 3 to 5 of the Rules.

7.1.1.3 The design of a sailing boat's rudder is to comply with the relevant provisions of the ISO standard②.

7.1.2 Definitions

7.1.2.1 For the purpose of this Chapter, the following definitions apply (other definitions are same as those in Chapter 1 of the Rules):

(1) **Beam between centers of buoyancy B_{CB}** (m) is the transverse distance between centers of buoyancy of two hulls of the catamaran at full load displacement.

(2) **Maximum draught T_{max} (m)** is the vertical distance measured in way of the cross section in half-length of full load waterline L_{WL} from the lowest point of keel (including the ballast keel) to the full load waterline.

(3) **Maximum moulded depth D_{max} (m)** is the vertical distance measured at the cross section in half-length of full load waterline L_{WL} from the lowest point of keel (including the ballast keel) to the main deck beam at side.

Section 2 Hull Structure

7.2.1 General requirements

7.2.1.1 The provisions of this Section apply to monohull sailing boats and catamaran sailing boats with the hull structure made of fabric reinforced plastics (FRP) or aluminium alloy. Special consideration will be given by CCS for boats made of other materials provided with relevant information. CCS accepts other standards③ as the equivalent requirements of this Section.

7.2.1.2 The definitions and symbols of this Section are as follows:

(1) b **(mm)** means length of the short side of the panel. For the panel fitted with FRP top-hat stiffener, the width of stiffener bottom is to be deduced for the calculation.

(2) l **(mm)** means length of the long side of the panel. For the panel fitted with FRP top-hat stiffener, the width of stiffener bottom is to be deduced for the calculation.

(3) s **(mm)** means the spacing between centerlines of adjacent stiffeners (hereinafter referred to as spacing of stiffeners).

(4) l_u **(mm)** means the span of unsupported length of stiffener, see Figure 7.2.1.2(4)a (hereinafter referred to as span of stiffener). For FRP top-hat stiffener, it is to be taken as the spacing of centerline of adjacent top-hat stiffeners. See Figure 7.2.1.2(4)b.

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① Sailing boat carrying passengers: a sailing boat that carries one or more passengers.

② Refer to Small craft - Hull construction and scantlings - Part 8: Rudders (ISO 12215-8).

③ Refer to Small craft - Hull construction and scantlings (ISO 12215).

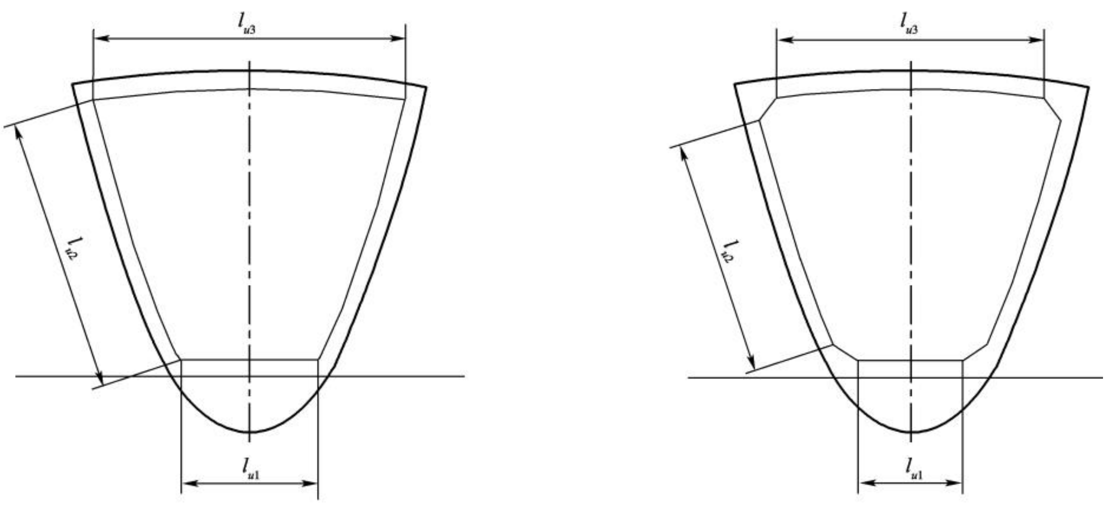

Figure 7.2.1.2(4)a

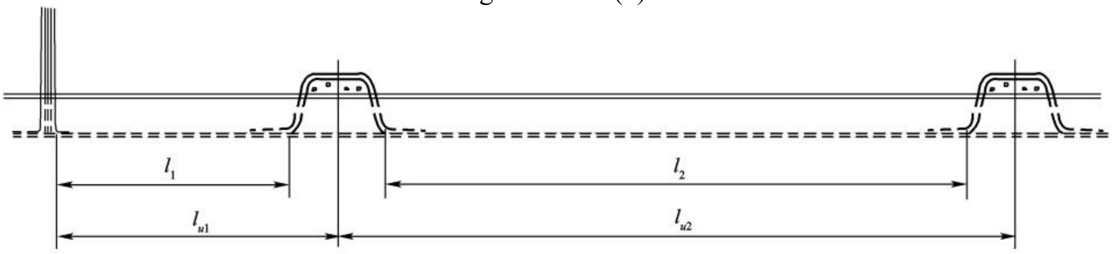

Figure 7.2.1.2(4)b

(5) $\boldsymbol{b_e}$ **(mm)** means the effective breadth of attached plate for stiffener, to be calculated according to the following, but not more than the spacing of stiffeners:

$b_e = 60t$ for attached plate of aluminium alloy stiffener, where t is the thickness of attached plate;

$b_e = 20t+w$ for single skin attached plate of FRP top-hat stiffener, where t is the thickness of attached plate, w is the bottom width of top-hat stiffener, see Figure 7.2.1.2(5);

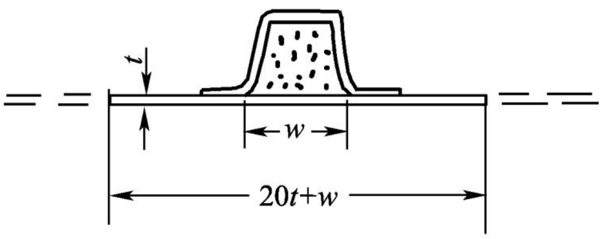

Figure 7.2.1.2(5)

$b_e = 20\ (t_o + t_i)$ for sandwich laminate attached plate of FRP top-hat stiffener, where t_o and t_i are the thicknesses of outer skin① and inner skin② of sandwich laminate, respectively.

(6) Relative coordinate system OXYZ: taking the intersection between the aft perpendicular of full load waterline at longitudinal middle plane and moulded baseline as the origin, the x coordinate along the forward direction being positive, the y coordinate along the left direction being positive and the z coordinate along the upper direction being positive.

7.2.1.3 Selection of load points

(1) For plate panel, the center of plate panel is to be taken as the calculated load point. For vertical plate panel, the load point is to be taken at the one-third height of the plate panel above its lower edge.

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① Outer skin means the side of sandwich laminate which is subject to the effects of static and dynamic loads of liquid or impact loads constantly.

② Inner skin means the other side of sandwich laminate which is not subject to the effects of loads.

(2) For stiffener, the middle of stiffener span is to be taken as the calculated load point. For vertical stiffener, the calculated load point it to be taken at the one-third span of stiffener l_u above its lower edge.

7.2.1.4 Division of bottom area and side shell area

(1) The bottom area is the part of the shell located below the full load waterline.

(2) The side shell area is the part of the shell located above the full load waterline, other than the deck. The side shell area for catamaran also includes the cross-deck bottom.

7.2.1.5 Plate panel dimension for large side shell without stiffener is determined as follows: Where the side shell plate is not fitted with stiffeners, natural stiffeners are normally the ones where the angle between two adjacent panels at hull cross section is < 130° with a hard angle (e.g. angled bottom centerline, deck/hull angles, knuckles at sides) and sufficient strength and rigidity, and in way of the intersections between the double bottom structures, fixed tanks, isolating plates, continuous small platforms, etc., and the shell plate of hull. Where a curved plate thickness in way is calculated, the shorter dimension b is to be taken as the chord length of curvature.

7.2.2 Local strength

7.2.2.1 Local design loads

(1) The design pressure load P_b of monohull sailing boat bottom is determined by the following formula:

$$P_b = 10C_n\left(\frac{C_W}{C_{L1}} + d\right) + 27C_n d\left(\frac{50-\beta_x}{50-\beta}\right)\left(1 + C_K\frac{x - x_K}{L - x_K}\right) \quad \text{kN/m}^2$$

where:

C_n— coefficient of service restriction, to be obtained according to the service restriction:

C_n= 1.0 for sailing boat with greater coastal service restriction;

C_n= 0.85 for sailing boat with coastal service restriction;

C_n= 0.76 for sailing boat with sheltered water service restriction;

C_n= 0.70 for sailing boat with calm water service restriction;

C_W —wave coefficient, $C_W = 10\lg(\frac{L+L_{oa}}{2}) - 10$, but not to be less than 3.0;

C_{L1} —longitudinal distribution coefficient of monohull sailing boat bottom pressure, to be obtained according to the longitudinal coordinate x of load point:

C_{L1}= 1.4 for $5/6 \leqslant x/L \leqslant 1$;

C_{L1}= 1.7 for $2/3 \leqslant x/L < 5/6$;

C_{L1}= 1.9 for $1/3 \leqslant x/L < 2/3$;

C_{L1}= 2.2 for $0 \leqslant x/L < 1/3$;

d — full load draft, in m, see 1.1.2.1(4) of Chapter 1;

β, β_x— deadrise angle in way of center of gravity of sailing boat and deadrise angle of load point at the cross section of coordinate x, respectively, in (°). If β_x> 50°, it should be taken as 50°. The deadrise angle β_x is to be so measured to draw a reference line connecting the intersection of bottom line at x cross section and half-height of draught (T/2) with the origin of coordinate, then to take the angle between the reference line and horizontal axis (see Figure 7.2.2.1(1));

C_K — coefficient of ballast keel, to be obtained according to the type of keel:

C_K= 1.0 for lifting ballast keel;

C_K= 1.5 for bar ballast keel;

C_K= 2.1 for bulb ballast keel;

x_K — longitudinal coordinate of centroid for ballast keel, in m;

x— longitudinal coordinate of load point, in m.

where: $x - x_K = 0$ for $x - x_K < 0$.

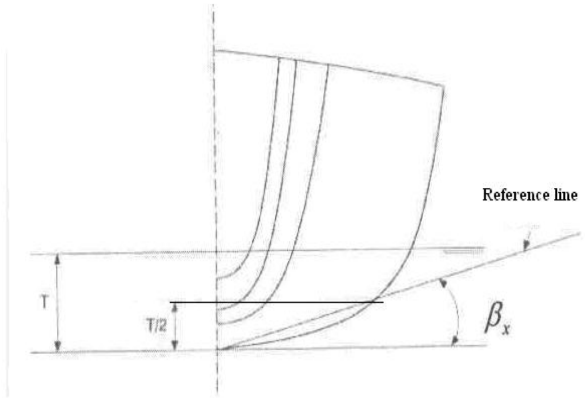

Figure 7.2.2.1(1)

(2) The design pressure of catamaran sailing boat bottom P_b is to be determined by the following formula:

$$P_b = 10C_n\left(\frac{C_W}{C_{L2}} + h\right) \quad \text{kN/m}^2$$

where:

C_{L2} — longitudinal distribution coefficient of catamaran sailing boat bottom pressure, to be obtained according to the longitudinal coordinate x of load point:

C_{L2}= 1.1 for $5/6 \leqslant x / L \leqslant 1.0$;

C_{L2}= 1.7 for $2/3 \leqslant x / L < 5/6$;

C_{L2}= 2.2 for $1/3 \leqslant x / L < 2/3$;

C_{L2}= 2.5 for $0 \leqslant x / L < 1/3$;

h — vertical distance of bottom load point below the full load waterline, in m;

C_n and C_W — same as 7.2.2.1(1).

(3) The design pressure of side shell for monohull sailing boat P_S is to be taken as follows, whichever is the greater:

$$P_1 = 10C_n\left(\frac{C_W}{C_{L1}} + d - h\right) \quad \text{kN/m}^2$$

$$P_2 = 40C_n \quad \text{kN/m}^2$$

where:

C_n, C_W, C_{L1} and d—same as 7.2.2.1(1);

h —vertical distance of side shell load point above the full load waterline, in m.

(4) The design pressure of side shell for catamaran sailing boat P_S is to be taken as follows, whichever is the greater:

$$P_1 = 10C_n\left[(1+0.3C_b)\frac{C_W}{C_{L2}} + 0.3C_b d - h\right] \quad \text{kN/m}^2$$

$$P_2 = 40C_nC_S \quad \text{kN/m}^2$$

where:

C_S — position coefficient of side shell, to be determined according to where the load point is located:

within the external side shell area of catamaran: C_S= 1.0 for 2/3≤x/L≤1.0;

C_S= 0.65 for 0≤x/L＜2/3;

cross-deck bottom and internal side shell within forward 1/3 length of cross-deck: C_S= 1.5;

other areas of cross-deck bottom and internal side shell: C_S= 1.0.

C_n, C_W, h and d— same as 7.2.2.1(3);

C_{L2} — same as 7.2.2.1(2).

C_b — block coefficient.

(5) The design pressure of deck P_D is to be determined by the following:

① Weather deck: $P_{D0} = C_n C_{L3}\left[0.5\left(\Delta\times10^3\right)^{0.33}+12\right]$ kN/m², and not to be less than 5 kN/m².

where:

C_n —same as 7.2.2.1(3);

C_{L3} — longitudinal distribution coefficient of weather deck pressure, to be obtained according to the longitudinal coordinate x of load point:

C_{L3}=0.5 for $x / L = 0$;

C_{L3}=1.0 for $x / L = 0.6 \sim 1.0$;

C_{L3} is to be obtained by linear interpolation for $x / L = 0 \sim 0.6$.

△ — full load displacement, in t, see 1.1.2.1(3) of Chapter 1.

② For deck in walking areas less than 0.8 m above weather deck: $P_{D1} = 0.5P_{D0}$ kN/m².

③ For deck in walking areas more than 0.8 m above weather deck: $P_{D2} = 0.35P_{D0}$ kN/m².

④ For cabin deck located in common spaces: $P_{D3} = 5$ kN/m².

⑤ For cabin deck located in machinery spaces: $P_{D4} = 10$ kN/m².

(6) The design pressures of end and side bulkheads for superstructure/deck houses P_{SUP} are to be determined by the following formula:

$$P_{SUP} = C_n C_{SUP}\left[0.5(\Delta\times10^3)^{0.33}+12\right] \qquad \text{kN/m}^2$$

where:

C_n—coefficient of service restriction, see 7.2.2.1(1);

C_{SUP} —coefficient, C_{SUP} = 1.0 for fore end bulkhead and C_{SUP} = 0.5 for side and after end bulkheads.

△ — full load displacement, in t, see 1.1.2.1(3) of Chapter 1.

The minimum design pressures of fore end and after end bulkheads and side bulkhead of the first tier superstructure/deck houses are to be of 20 kN/m², 10 kN/m² and 14 kN/m², respectively.

(7) The design pressure P_{BUL} of bulkheads is to be determined by the following:

① For the design pressure of watertight bulkhead: $P_{BUL} = 7\ h_B$ kN/m², where h_B is the height measured from the load point calculated to the top of bulkhead, in m.

② For the design pressure of bulkhead in tank: $P_{BUL} = 10\ h_B$ kN/m², where h_B is the height of the load point calculated to the top of vent pipe, in m.

7.2.2.2 Scantling of FRP hull structures are to be determined as follows:

(1) The minimum thickness t_{min} of plating for single skin hull structure and the minimum content w_{min} of fiber per unit are to be determined by the following formulae according to where the plating is located:

$w_{min} = 0.43k_5\left(A+2.36k_7\sqrt{L}+A\Delta^{0.33}\right)$ kg/m² for bottom plate, side plate and transom plate;

$t_{min} = k_5\left(0.14L+1.45\right)$ mm for main weather deck.

where:

△ — full load displacement, in t, see 1.1.2.1(3) of Chapter 1.

A, k_5 and k_7 — factors, may be obtained from Table 7.2.2.2(1).

Factors Table7.2.2.2(1)

	Position	A	k_5	k_7
FRP hull structure	Bottom	1.5	1.0(1)	0.03
	Side/transom	1.5		0
	Main weather deck	-		-

Note: (1) k_5 = 1.0 for alkali free glass fiber reinforced plastics containing up to 50% of chopped strand mat by mass; k_5 = 0.9 for bidirectional glass fiber cloth reinforced plastics.

(2) The minimum mass w_{min} of fiber of inner and outer skins for sandwich hull structure plating per unit area is to be determined by the following formulae:

Outer skin $w_{1\min} = C_n k_4 k_5\left(0.1L+0.15\right)$ kg/m²

Inner skin $w_{2\min} = 0.7w_{1\min}$ kg/m²

where:

C_n— coefficient of service restriction, see 7.2.2.2(1);
k_4—factor of position, to be obtained according to where the sandwich laminate is located:
k_4= 1.0 for sandwich laminate located at bottom area of boat;
k_4= 0.9 for sandwich laminate located at side shell area of boat;
k_4= 0.7 for sandwich laminate located at deck area of boat;
k_5—to be obtained from Table 7.2.2.2(1).

(3) The thickness t of single skin laminate is not to be less than:

$$t = k_C b\sqrt{\frac{k_2 P}{500\sigma_{fnu}}} \quad \text{mm}$$

where:

k_C— reduction factor for curved plates, to be determined by Table 7.2.2.2(3) according to camber c of curved plates:

Reduction factor Table 7.2.2.2(3)

c/b	k_C
0 ~ 0.03	1.0
0.03 ~ 0.18.	1.1—3.33 c/b
> 0.18	0.5

Note: c in the Table is the camber of arc line for lath beam measured by taking the length of short side of panel b as the span.

k_2— correction factor for aspect ratio of panel (l/b); if $l/b > 2$, k_2= 0.5; if $l/b \leqslant 2$, to be taken as:

$$k_2 = \frac{0.271(l/b)^2 + 0.91(l/b) - 0.554}{(l/b)^2 - 0.313(l/b) + 1.351}$$

P— design load determined according to 7.2.2.1, in kN/m^2;
σ_{fnu} —ultimate bending strength of laminate, in N/mm^2.

(4) The total effective thickness of FRP sandwich laminate t_S is not to be less than the value calculated by the following formula:

$$t_S = \sqrt{k_C}\, b \frac{k_{2S} P}{1000\tau_d} \quad \text{mm}$$

where:

t_S — effective total thickness of sandwich laminate, i.e. distance between mid-thickness of outer and inner skins, in mm, $t_S = t_C + 0.5(t_1 + t_2)$;
where: t_C—thickness of sandwich core, in mm;
t_1—thickness of outer skin of sandwich laminate (excluding gel coat), in mm;
t_2—thickness of inner skin of sandwich laminate, in mm;

k_C and P— same as 7.2.2.2(3);
k_{2S}— correction factor for aspect ratio of panel (l/b) of sandwich laminate panel, to be obtained from Table 7.2.2.2(4)a:

Correction factor Table 7.2.2.2(4)a

l/b	≥4	3.0	2.0	1.9	1.8	1.7	1.6	1.5	1.4	1.3	1.2	1.1	1.0
k_{2S}	0.5	0.493	0.463	0.459	0.453	0.445	0.435	0.424	0.410	0.395	0.378	0.360	0.339

τ_d —allowable shear strength of sandwich core, in N/mm^2, to be obtained according to the type of cores:

$\tau_d = 0.5\,\tau_u$ for balsa wood or honeycomb core;

$\tau_d = 0.55\,\tau_u$ for cross-linked PVC core;

$\tau_d = 0.65\,\tau_u$ for linear PVC or SAN core;

where: τ_u —ultimate shear strength of core, in N/mm^2. The minimum value of ultimate shear strength is not to be less than that specified in Table 7.2.2.2(4)b:

Minimum ultimate shear strength   Table 7.2.2.2(4)b

L_{oa} (m)	$L_{oa} < 10$	$10 \le L_{oa} \le 15$	$15 < L_{oa}$
$\tau_{u\min}$ (N/mm^2)	0.25	$0.25 + 0.03(L_{oa} - 10)$	0.40

(5) Due to the different laminates of three parts of top-hat stiffener made of FRP single skin panel (top plate, web plate and attached plate with effective width), the mechanical performance of them are also different. In general, the difference of performances is not to exceed 25%. The section modulus *W,* moment of inertia *I* and web plate area *A* of the top-hat stiffener are not to be less than the values calculated by the following formulae respectively. However, additional consideration is to be taken for such top-hat stiffener if the difference of mechanical performance for these three parts exceeds 25%.

$$W = 167 \frac{k_{CS} P s l_u^2}{\sigma_{ut}} \times 10^{-9} \quad \text{cm}^3;$$

$$I = 52 \frac{k_{CS}^{1.5} P s l_u^3}{E} \times 10^{-10} \quad \text{cm}^4;$$

$$A = 10 \frac{P s l_u}{\tau_u} \times 10^{-6} \quad \text{cm}^2.$$

where:

P—design load as determined by 7.2.2.1, in kN/m^2;

l_u— span of stiffener, in mm, see 7.2.1.2(4). For bending stiffener, chord length of the arc is to be taken;

k_{CS}—reduction factor of bending stiffener, to be determined by Table 7.2.2.2(5) according to the ratio of camber *c* and span l_u:

Table 7.2.2.2(5)

c/l_u	k_{CS}
0 ~ 0.03	1.0
0.03 ~ 0.18.	1.1 ~ 3.33 c/l_u
> 0.18	0.5

Note: *c* in the Table means the camber value measured by taking the span of bending stiffener l_u as the chord, in mm.

σ_{ut} — ultimate tensile strength of top plate of top-hat stiffener made of FRP single skin panel, in N/mm^2;

τ_u — ultimate shear strength of web plate of top-hat stiffener made of FRP single skin panel, in N/mm^2;

E— elastic modulus of top-hat stiffener made of FRP single skin panel or that of its attached plate, whichever is the less, in N/mm^2.

(6) The main transverse bulkhead of FRP hull is generally made of unstiffened plywood. The thickness of such plywood bulkhead t_b is not to be less than the value calculated according to the following formula:

$$t_b = 7D \quad \text{mm}$$

where: D— moulded depth, in m, see 1.1.2.1(6) of Chapter 1.

(7) Where the unstiffened FRP sandwich laminate structure is used for main transverse bulkheads of hull, the following three conditions are also to be met:

① The ultimate shear strength τ_u of sandwich laminate core, in N/mm^2, is not to be less than the values list in Table 7.2.2.2(4)b.

② The thickness of sandwich laminate core t_C is not to be less than five times the thickness of the thinner skin.

③ The total effective thickness of sandwich laminate t_S and thickness of core t_C are also to meet the following two conditions:

$$t_S \times t_C \geq \frac{t_b^2}{6}\left(\frac{50}{\sigma_{fnu}}\right)$$

$$t_S \times \frac{t_C^2}{2} \geq \frac{t_b^3}{12}\left(\frac{4000}{E}\right)$$

where:

t_S —effective total thickness of sandwich laminate, in mm, see 7.2.2.2(4);

t_C — thickness of sandwich laminate core, in mm;

t_b — thickness of bulkhead as required by 7.2.2.2(6), in mm;

σ_{fnu} — ultimate bending strength of sandwich laminate skin, in N/mm^2;

E —elastic modulus of sandwich laminate skin, in N/mm^2.

7.2.2.3 Scantling of aluminium alloy hull structure

(1) The minimum thickness of aluminium alloy hull structure $t_{\min}$ is to be determined by the following formulae:

$t_{\min} = k_5 (A + 2.36 k_7 \sqrt{L} + A\Delta^{0.33})$ mm, for bottom plate, side plate and transom plate;

$t_{\min} = 0.06L + 1.35$ mm, for weather deck.

where:

△ — full load displacement, in t, see 1.1.2.1(3) of Chapter 1.

A, k_5 and k_7 — factors, may be obtained from Table 7.2.2.3.

Factors Table 7.2.2.3

	Position	A	k_5	k_7
Aluminium alloy hull structure	Bottom	1.0	$\sqrt{125/R_{P0.2W}}$	0.02
	Side/transom	1.0		0

Note: $R_{P0.2W}$ — the specified non-proportionality tensile strength of aluminium alloy section under annealing condition, in N/mm^2, see the relevant provisions of CCS Rules for Materials and Welding.

(2) The thickness of plating for aluminium alloy hull t is not to be less than the following calculated value:

$$t = k_C b \sqrt{\frac{k_2 P}{900 R_{P0.2W}}} \quad \text{mm}$$

where:

k_C— reduction factor for curved plates, to be determined by the following Table according to camber c of curved plates, see Table 7.2.2.2(3);

k_2— correction factor for aspect ratio of panel (l/b), if $l/b > 2$, $k_2 = 0.5$; if $l/b \leqslant 2$, to be taken as:

$$k_2 = \frac{0.271(l/b)^2 + 0.91(l/b) - 0.554}{(l/b)^2 - 0.313(l/b) + 1.351}$$

P— design load to be determined according to 7.2.2.1, in kN/m^2;

$R_{P0.2W}$ — the specified non-proportionality tensile strength of aluminium alloy section under annealing condition, in N/mm^2, see the relevant provisions of CCS Rules for Materials and Welding.

(3) The section modulus W of aluminium alloy stiffener (including attached plate with effective breadth) and its web plate area A are to be not less than the value calculated by the following formulae:

$$W = 119 \frac{k_{CS} P s l_u^2}{R_{P0.2W}} \times 10^{-9} \quad \text{cm}^3;$$

$$A = 12.5 \frac{P s l_u}{R_{P0.2W}} \times 10^{-6} \quad \text{cm}^2;$$

where:

P—design load to be determined according to 7.2.2.1, in kN/m^2;

k_{CS}— reduction factor of bending stiffener, to be determined by camber c of stiffener, see Table 7.2.2.2(5);

$R_{P0.2W}$ — the specified non-proportionality tensile strength of aluminium alloy section under annealing condition, in N/mm^2, see the relevant provisions of CCS Rules for Materials and Welding.

7.2.3 Longitudinal strength of monohull sailing boat

7.2.3.1 For monohull boat with any one of the following conditions, in addition to compliance with the requirements for local strength of its scantling, longitudinal strength of hull is to be checked:

① transversely framed hull;

② large opening on strength deck within 0.4L amidships the width of which is more than half the width of the strength deck

③ $L / D_{max} > 12$.

7.2.3.2 Where longitudinal strength of hull girder for monohull boat is checked, the check may only be done to ensure that the weather deck at amidboat section will keep stability under the maximum design bending moment M_V of sagging specified in 7.2.3.2(1).

(1) The maximum design bending moment of sagging M_V is to be calculated as follows:

$$M_V = 2.7 C_n L \Delta \times 10^3 \quad \text{Nm}$$

where:

△ — full load displacement, in t, see 1.1.2.1(3) of Chapter 1.

C_n—coefficient of service restriction, see 7.2.2.1(1).

(2) The weather deck compressive stress σ at amidboat section under the maximum design bending moment of sagging M_V is to be determined as the following formula:

$$\sigma = \frac{M_V}{W_d} \quad \text{N/mm}^2$$

where: W_d—amidboat section modulus at weather deck, in cm^3.

(3) Where the weather deck of FRP hull is made of sandwich laminate, and the core material is cellular plastic (with very less compressive elastic modulus), the core materials of all sandwich laminate members at amidboat section may be negligible when the amidboat section modulus W_d at weather deck is calculated.

(4) It is to be ensured that each longitudinal member of weather deck at amidboat section which is used for calculation of longitudinal bending strength for hull girder will keep stability under the compressive stress σ specified in 7.2.3.2(2).

(5) The stability of the structural members at amidboat section may be checked in accordance with the relevant requirements of CCS Rules for Construction and Classification of Sea-going High Speed Craft. However, when the critical yield stress σ_{cr} of aluminium alloy deck panel is determined, the specified non-proportionality tensile strength of aluminium panel under annealing condition $R_{P0.2W}$ is to be used for yield strength of deck material, in N/mm^2, see the relevant provisions of CCS Rules for Materials and Welding.

7.**2.4 Overall strength of catamaran**

7.2.4.1 General provisions

(1) For catamaran navigating in diagonal swell, in the direct calculation, the normal stress and shear stress of the hull connection structure and area adjacent to the structure are to comply with the criteria in Table 7.2.4.3.

(2) For catamaran with $L / D_{max} > 12$, the bending normal stress of bottom and deck at amidboat section in hogging and sagging conditions are to be calculated respectively and are to comply with the criteria in Table 7.2.4.3.

(3) To check the longitudinal strength and torsional strength, please refer to relevant provisions of CCS Rules for Construction and Classification of Sea-Going High Speed Craft.

7.2.4.2 Design loads for overall strength

(1) The design torque M_T of diagonal swell for catamaran when navigating in diagonal swell is to be determined by the following formula:

$$M_T = 1.5 L \Delta \times 10^3 \quad \text{Nm}$$

where: △ — full load displacement, in t, see 1.1.2.1(3) of Chapter 1.

(2) For catamaran with $L/D > 12$, the vertical design bending moment M_V on each hull is to be determined by the following formula:

$$M_V = 0.5L\Delta \times 10^3 \quad \text{Nm}$$

where: △ — full load displacement, in t, see 1.1.2.1(3) of Chapter 1.

7.2.4.3 See Table 7.2.4.3 for criteria for overall strength check:

Permissible Stress **Table 7.2.4.3**

	Permissible normal stress	Permissible shear stress
FRP	$\sigma_d = 0.33\sigma_{ut}$ ①	$\tau_d = 0.33\tau_u$ ②
Aluminium	$\sigma_d = 0.5R_{p0.2W}$ ③	$\tau_d = 0.3R_{p0.2W}$ ④

Notes: ① σ_{ut} is the ultimate tensile strength of the laminated plate material. The permissible compressive stress of components made of FRP laminated plate is taken as $\sigma_d = 0.33\sigma_{uc}$, where σ_{uc} is the ultimate compressive strength of the laminated plate material.

② τ_u is the ultimate shear strength of the laminated plate material.

③ $R_{p0.2W}$ is the specified non-proportionality tensile strength of aluminium alloy section under annealing condition. Where the aluminium alloy section at the place where the checking is carried out is unwelded, the value may be taken as $\sigma_d = 0.5R_{p0.2}$, where $R_{p0.2}$ is the specified non-proportionality tensile strength of aluminium alloy section.

④ $R_{p0.2W}$ is the specified non-proportionality tensile strength of aluminium alloy section under annealing condition. Where the aluminium alloy section at the place where the checking is carried out is unwelded, the value may be taken as $\tau_d = 0.3R_{p0.2}$, where $R_{p0.2}$ is the specified non-proportionality tensile strength of aluminium alloy section.

Section 3 Ballast Keel, Chainplates and Masts

7.3.1 Ballast keel

7.3.1.1 General provisions

(1) This Section applies to sailing boat fitted with fin-shaped ballast keel at bottom centerplane. The ballast keel is generally to be of fixed-type, and made of lead, cast iron, steel or other heavy materials. Lifting ballast keel may be used for some certain small sailing boat.

(2) In addition to ensuring its own strength, the connection strength between ballast keel and hull bottom structure is to be checked.

7.3.1.2 Strength check for ballast keel

(1) The ballast keel is to be capable of withstanding the bending moment M_K induced by its weight as it is assumed that the sailing boat heels at 90°. M_K is to be calculated by the following formula:

$$M_K = 18C_{nK}Qa \quad \text{Nm}$$

where:

C_{nK}—coefficient of service restriction for appendage/sail, to be obtained by:

$C_{nK} = 1.0$ for sailing boat with greater coastal service restriction;

$C_{nK} = 0.75$ for sailing boat with coastal, sheltered water and calm water service restrictions;

Q— mass of ballast keel, in kg;

a— distance between cross-section which is the furthest from center of gravity of ballast keel and with least strength (usually being the connection section between ballast keel and boat bottom) and the center of gravity of ballast keel, in m, see Figure 7.3.1.2(1).

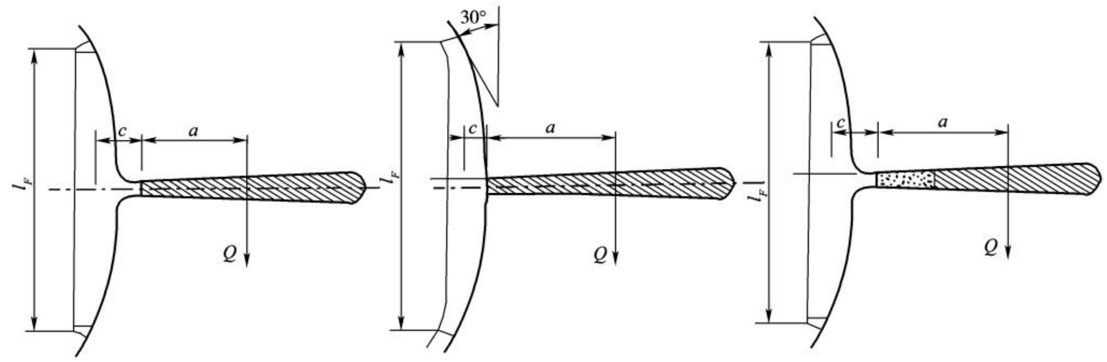

Figure 7.3.1.2(1)

(2) The strength of ballast keel is to meet the following formula:

$$\frac{M_K}{W_a} \le \sigma_{dk} \qquad \text{N/mm}^2$$

where:

M_K— design bending moment of ballast keel calculated according to 7.3.1.2(1), in Nm;

W_a— modulus of cross-section of ballast keel distanced a from its center of gravity, in cm^3;

σ_{dk} — allowable stress of ballast keel material, in N/mm^2, to be obtained according to material category, to be obtained according to material category:

σ_{dk} = 0.9 σ_S for tough metals, such as steel, stainless steel, etc., σ_S is the yield strength of tough metals;

σ_{dk} = 0.6 σ_S for brittle metals, such as cast iron, σ_S is the yield strength of brittle metals;

σ_{dk} = 0.5 σ_u for FRP, σ_u is the ultimate bending strength of FRP.

7.3.1.3 Strength check for connection between ballast keel and hull bottom structure

(1) The fixed-type ballast keel is usually supported by several frames at boat bottom. Strength check is to be carried out for frames supporting ballast keel, to ensure they are capable of effectively supporting the ballast keel.

(2) The design bending moment M_f of n_f frames effectively supporting the ballast keel is to be calculated by the following formula:

$$M_f = 9C_{nK}Q(a+c) \qquad \text{Nm}$$

where:

C_{nK}, Q and a— same as 7.3.1.2(1);

c — distance between center of gravity of frame supporting ballast keel and section connecting ballast keel with boat bottom, in m, see Figure 7.3.1.2(1).

(3) In order to simplify the calculation, it is assumed that the scantlings of these frames supporting ballast keel are similar, the section modulus W_f of each supporting frame is not to be less than the value calculated according to the following formula:

$$W_f = \frac{M_f}{n_f \sigma_{df}} \qquad \text{cm}^3$$

where:

M_f—design bending moment of n_f bottom frames effectively supporting ballast keel, in Nm, see 7.3.1.3(2);

n_f— number of bottom frames effectively supporting ballast keel;

σ_{df} — allowable stress of frames, in N/mm^2, to be obtained according to material categories of frames:

σ_{dk} = 0.5 σ_u for FRP, where σ_u is the ultimate bending strength of FRP material;

σ_{dk} = 0.9 $R_{P0.2}$ for aluminium alloy, where $R_{P0.2}$ is the yield strength of aluminium alloy.

(4) The section of each supporting frame span end is also to be capable of withstanding of the following shearing force Q_f:

$$Q_f = \frac{M_f}{n_f \ell_F} \qquad \text{N}$$

where:

M_f— design bending moment of n_f bottom frames effectively supporting ballast keel, in Nm, see 7.3.1.3(2);

n_f — number of bottom frames effectively supporting ballast keel;

ℓ_F — span of bottom frame effectively supporting ballast keel, in m, may be measured according to Figure 7.3.1.2(1). If there are no longitudinal supporting members at the both ends of frame, the frame extends to the both sides in way of a point with an angle of 30° between shell plating tangent and horizontal, which may be regarded as the span point of that frame, see Figure 7.3.1.2(1).

(5) Where a series of bolts with same diameter is used to connect ballast keel with bottom structure at a connecting plane (see Figure 7.3.1.3(5)), the connecting surface is to be flat and sealed. The longitudinal coordinate of centroid of connecting bolt group is to be in consistent with that of ballast keel centroid basically. The diameter d of thread root for connecting bolt is not to be less than the value calculated by the following formula:

$$d = 140\sqrt{\frac{C_{nK} Q a b_{\max}}{R_{eH} \sum b_i^2}} \qquad \text{mm}$$

where:

C_{nK}, Q and a— see 7.3.1.2(1);

b_i— scantling width at each pair of connecting bolts, in mm, to be calculated by:

$b_i = 0.5 b_{bi} + 0.4 b_{ki}$, where b_{bi} and b_{ki} are shown Figure 7.3.1.3(5);

$b_{\max}$ — maximum value of b_i, in mm;

R_{eH} — yield stress of connecting bolt, in N/mm^2, to be obtained according to material categories of blots.

Where the general low carbon steel is used as material of connecting bolts, $R_{p0.2}$ = 235 N/mm^2, the diameter of thread root of connection bolt is not to be less than 12 mm.

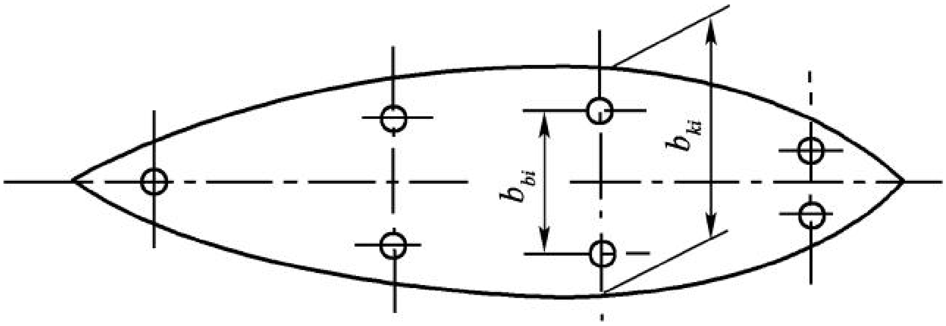

Figure 7.3.1.3(5)

(6) The thickness of bottom plate within 0.2 maximum draught $d_{\max}$ (see the definition in 7.1.2.1(2) of this Chapter) beyond the root contour line of ballast keel of boat bottom is to be properly increased. The thickness of bottom plate within this range may still be determined according to 7.2.2.2(3) and 7.2.2.3(2), however, the design load of the thickness formula is to be 1.8 times of the design bottom pressure P_b defined in 7.2.2.1.

7.3.2 Chainplates

7.3.2.1 General provisions

(1) Most rigs are fixed on different positions of hull structure for sailing boat by their individual chainplates. In general, chainplate is a metal plating with pin hole, see Figure 7.3.2.1(1). The end of chainplate with pin hole is usually used to fix one or two shrouds while another end is fixed on the hull structure. The force withstood by shrouds is transmitted to hull structure by chainplates.

(2) The chainplate is generally made of stainless steel for FRP sailing boat or aluminium alloy for aluminium alloy sailing boat.
(3) In addition to complying with the scantling requirements specified in 7.3.2.2, the chainplates are to be firmly fixed on the hull structure.
7.3.2.2 Scantling of chainplates
(1) The design load F_S of chainplates is to be determined by the following formulae:

$F_S = F_b$, in N if only one shroud on chainplate;

$F_S = F_{bs} + 0.5F_{bw}$, in N if two shrouds on chainplate.

where:

F_b— breaking load of one shroud, in N;

F_{bs}— breaking load of two shrouds, whichever is the greater, in N;

F_{bw}— breaking load of two shrouds, whichever is the less, in N.

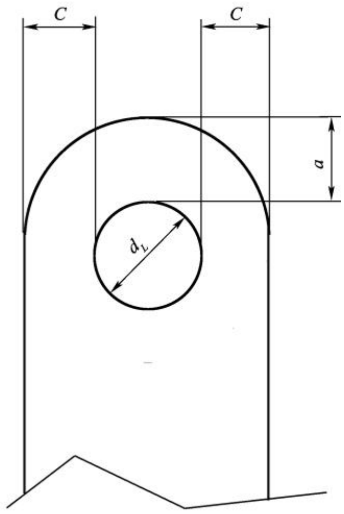

Figure 7.3.2.1(1)

(2) For the metal chainplate with pin hole, the edge distances a and c (see Figure 7.3.2.1(1)) of circular pin hole are not to be less than the values calculated by the following formulae:

$$a = \frac{F_S}{2tR_{eH}} + \frac{2}{3}d_L \quad \text{mm;}$$

$$c = \frac{F_S}{2tR_{eH}} + \frac{1}{3}d_L \quad \text{mm.}$$

where:

F_S— design load of chainplate, in N, to be calculated according to 7.3.2.2(1);

t— thickness of chainplate, in mm;

d_L— diameter of pin hole for chainplate, in mm;

R_{eH} — yield strength of metal chainplate, in N/mm^2.

7.3.3 Masts

7.3.3.1 General provisions
(1) The masts are to have sufficient strength and to be capable of withstanding the sail loads. Masts are to be made of aluminium alloy or carbon fiber reinforced composite materials.
(2) The masts are to be firmly connected with hull, able to effectively withstand and transmit corresponding loads. The following three ways are usually to be adopted:
① mast step is supported on certain transverse bulkhead of the hull;
② mast step is supported on hull deck or superstructure deck sustained by pillar below;
③ mast penetrates deck and extends to the boat bottom with its step being supported by bottom structure.
7.3.3.2 Strength check for connection of mast with hull structure is to be as follows:

(1) Where the mast is supported by transverse bulkhead, when the transverse bulkhead where the mast is supported is made of aluminium alloy or FRP veneer, the thickness of bulkhead t_b where the mast is supported is not to be less than the value calculated by the following formula:

$$t_b = 1.3\sqrt[3]{\frac{K_{SU} b_m M_{HD}}{b_C E}} \quad \text{mm}$$

where:

K_{SU}— safety factor, to be obtained by:

K_{SU}= 5.92 for monohull sailing boat;

K_{SU}= 5.44 for catamaran;

b_m — breadth of cross-section of mast supported by transverse bulkhead, in mm;

b_C — horizontal distance from chainplate of left/right shroud to centerline of boat, in m, see Figure 7.3.3.2(1)a;

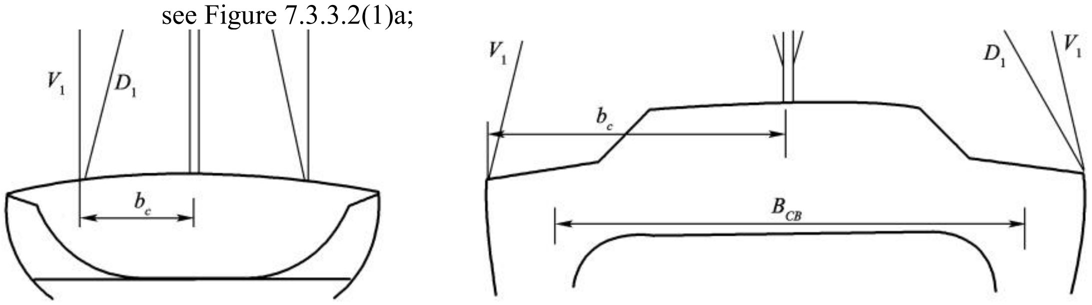

Figure 7.3.3.2(1)a

E— elastic modulus of compression for transverse bulkhead material, in N/mm^2;

M_{HD}— design righting moment of transverse stability for sailing boat, in Nm, to be obtained by:

for monohull sailing boat, M_{HD} is the maximum righting moment of transverse stability at full load displacement △, in Nm, may be obtained from transverse stability curve;

for catamaran, M_{HD} may be M_{HD1} or M_{HD2}, whichever is the less:

$$M_{HD1} = 5C_{nK} K_{VS} B_{CB} \Delta \quad \text{Nm}$$

$$M_{HD2} = 0.16 C_{nK} K_{VS} A_S V_{AWK}^2 \left(h_{CE} + h_{LP}\right) \quad \text{Nm}$$

where: C_{nK}— coefficient of service restriction for appendage/rig of sailing boat, to be obtained according to 7.3.1.2(1);

K_{VS}— factor, to be calculated by:

for sailing boat with greater coastal service restriction, K_{VS}= 1.0;

for sailing boat with coastal, sheltered water and calm water service restrictions,

K_{VS}= 1.0, if $\Delta \geq 4.3L^3$;

$K_{VS} = \frac{2.65L^2}{\sqrt[3]{\Delta^2}}$, but not greater than 2, if $\Delta < 4.3L^3$;

△ — full load displacement, in t, see 1.1.2.1(3) of Chapter 1.

B_{CB}— transverse distance between centers of buoyancy for two hulls, see 7.1.2.1(1) of this Chapter;

A_S — sum of full mainsail area and fore triangle sail area for catamaran, in m^2, see Figure 7.3.3.2(1)b;

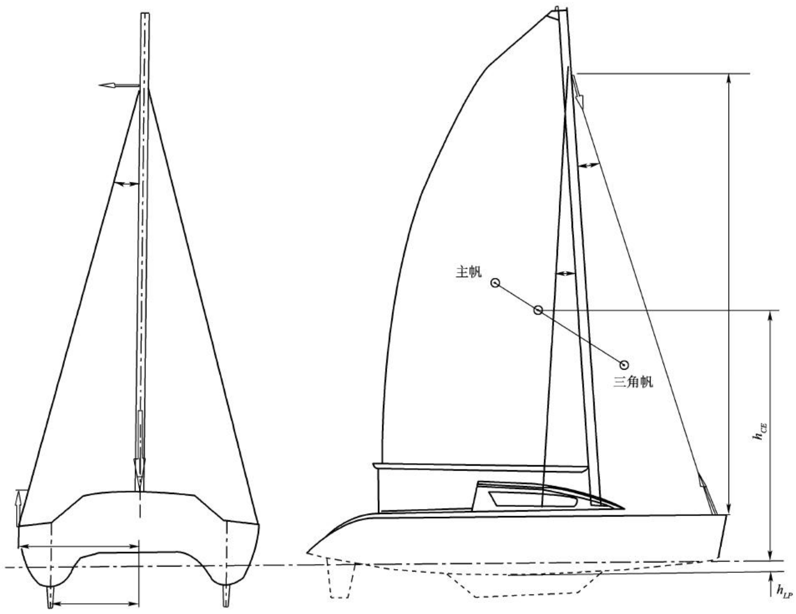

Figure 7.3.3.2(1)b

h_{CE} — height of the centroid of A_S above loaded waterline, in m, see Figure 7.3.3.2(1)b;

h_{LP} — vertical distance from the center of profile area of underwater parts (including appendages) to full-load waterline, in m, see Figure 7.3.3.2(1)b;

V_{AWK} — apparent wind speed for catamaran, in kn,

for sailing boat with greater coastal service restriction, V_{AWK}= 32, if L< 18 m;

V_{AWK} = 30, if 18 m ≤ L < 20 m;

for sailing boat with coastal, sheltered water, calm water service restrictions, V_{AWK} = 25.

When the transverse bulkhead where the mast is supported is made of FRP laminated plate, the effective total thickness t_S and core thickness t_C of the laminated plate are to meet the following two conditions:

$$t_S \times t_C \geq \frac{t_b^2}{6}\left(\frac{50}{\sigma_{fnu}}\right)$$

$$t_S \times \frac{t_C^2}{2} \geq \frac{t_b^3}{12}\left(\frac{4000}{E}\right)$$

where: t_S ——effective total thickness of the laminated plate, in mm, see 7.2.2.2(4);

t_C ——core thickness of the laminated plate, in mm;

t_b ——thickness of the bulkhead plate required in 7.3.3.2(1) above, in mm;

σ_{fnu} ——ultimate bending strength of the face plate of the laminated plate, in N/mm^2 ;

E ——modulus of elasticity of the face plate of the laminated plate, in N/mm^2 .

(2) Where the mast step is supported by metal circular pillar, the cross-sectional area A of pillar is not to be less than the value calculated by the following formula:

$$A = \frac{K_{SU}\left[1 + K_P\left(l/r\right)^2\right]M_{HD}}{90 b_C \sigma_{SW}} \quad \text{cm}^2$$

where:

K_{SU} — safety factor, see 7.3.3.2(1);

K_P — factor, K_P= 1.9 for aluminium alloy pillar; K_P= 1.2 for steel pillar;

〒 — length of pillar in m;

r — minimum radius of inertia of cross section for circular pillar, in cm;

M_{HD} — righting moment of transverse stability for sailing boat, in Nm, to be obtained according to 7.3.3.2(1);

b_C — horizontal distance from chainplate of left/right shroud to centerline of boat, in m, see Figure 7.3.3.2(1);

σ_{SW} — yield strength of postweld metal pillar, in N/mm^2, to be taken as $R_{P0.2W}$ for aluminium alloy pillar, and $\sigma_{SW} = R_{eH}$ for steel pillar.

(3) Where the mast step penetrates deck and extends to bottom structure, the bottom structure is to be capable of withstanding the compression load of mast. The cut-out in the deck is to be collared with resilient material such as rubber or plywood to give suitable horizontal support to the mast and certain freedom.

7.3.4 Movable and fixed rigging

7.3.4.1 The steel wire rope used for fixing rigging is not to be flexible steel wire rope (fiber rope core).

7.3.4.2 The strength of all pulleys, shackles, bolts, lanyard pedestals and the strength of related fittings and joints are to be higher than the corresponding breaking strength of movable and fixed rigging.

Chapter 8 ADDITIONAL REQUIREMENTS FOR WINDFARM SERVICE BOATS

Section 1 General Provisions

8.1.1 General requirements

8.1.1.1 This Chapter applies to boats providing support service for the operation and maintenance of offshore wind farms.

8.1.1.2 Unless expressly provided otherwise, the survey and certification, hull structure, outfitting, electrical and machinery installations are also to comply with the relevant provisions in other Chapters of the Rules.

Section 2 Hull Structure

8.2.1 General requirements

8.2.1.1 The hull structure is to be so designed that its strength can withstand loads in all working conditions in expected service duration.

8.2.2 Structural strength for bow push-up operations

8.2.2.1 When the boat is intended for push up operations to transfer persons or cargo over the bow, fendering arrangements are to be suitably arranged in the push-up area and the bow structure is to be suitably strengthened.

8.2.2.2 The structure in way of main propulsion machinery, shaft bearings, brackets, propellers and rudders is to be suitably strengthened taking into account the possibility of contact shock loading during push-up operation.

8.2.2.3 The structure in way of main propulsion machinery and rudder is to be suitably strengthened to withstand strong local vibration in the push-up operations and minimize any potential for resonance.

8.2.3 Fender

8.2.3.1 The berthing area of the boat is to be equipped with rubber fender or equivalent energy absorbing fender materials or devices that are convenient for installation, replacement and maintenance.

8.2.3.2 Fender is to be suitable for the geometric shape, size, strength of the boat's berthing area and the maneuverability of the boat, so as to ensure the minimum impact on the boat's berthing.

8.2.3.3 Fender is to have the characteristics of high energy absorption, low reaction force, strong friction resistance, etc., and is to be able to effectively absorb the impact and extrusion energy produced by the boat on the foundation when the boat is on or off the foundation.

Section 3 Machinery

8.3.1 General requirements

8.3.1.1 Machinery installations and systems are also to comply with the relevant provisions of Chapter 4 of the Rules in addition to the provisions of this Section.

8.3.1.2 Windfarm maintenance personnel carried onboard the windfarm service boat are considered as passengers onboard. When the number of passengers is more than 12, the bilge system of the windfarm service boat is to comply with the provisions for passenger ships in Section 7, Chapter 4 of the Rules.

8.3.1.3 For the windfarm service boat intended for operations to transfer personnel or cargo from the boat over the bow to windfarm foundation, the propulsion systems are to comply with the requirements of 8.3.1.4 and 8.3.1.5 of this Section. Where other means are used, the propulsion systems may not meet the requirements of 8.3.1.4 and 8.3.1.5 of this Section, provided that there is no relative displacement between the boat and the wind farm foundation during the transfer of personnel or cargo.

8.3.1.4 The windfarm service boat is to be provided with two mutually independent propulsion systems and comply with the following requirements:

(1) at least two propulsion machines, two propulsors and two steering systems are to be provided;

(2) at least two independent auxiliary service systems, including fuel oil service tanks, are to be provided. These two systems may be designed to be completely independent, or with interconnections between them provided that effective means to disconnect or isolate the systems from each other are fitted;

(3) the propulsion machines, shafting, gearing, steering and auxiliary service systems may be located in the same compartment.

(4) each propulsion system is to be provided with independent control and monitoring system. If arranged with common parts, these are to be arranged with redundancy so that any single failure can be effectively isolated.

8.3.1.5 The design of the propulsion system is to ensure that the windfarm service boat can maintain its position and heading in case of a single failure. For the purpose of this Section, a single failure mainly includes the following:

(1) loss of a propulsion machine;

(2) any failure of a non-static component of systems which are necessary for the operation of the propulsion machine or steering gear, including prime movers, controls and monitoring of fuel oil system, lubricating oil system, cooling water system and compressed air system;

(3) any failure of heat exchangers, including heat generators, necessary for propulsion (i.e. auxiliary boilers, fuel oil heaters, lubricating oil coolers, fresh water coolers, reduction gear oil coolers);

(4) any failure of any non-static component of fuel oil and lubricating oil transfer system;

(5) any failure of any of the power generating sets;

(6) any failure of any electric apparatus, including the main switchboard, electric motors, transformers, distribution switchboards, panels;

(7) any failure of the propulsor, including propeller, propeller shaft, intermediate shafts, bearings, couplings, reduction gears.