CHINA CLASSIFICATION SOCIETY

RULES FOR CONSTRUCTION AND CLASSIFICATION OF SEA-GOING HIGH SPEED CRAFT 2015

Effective date: 1 November, 2015

Beijing

CONTENTS

CHAPTER 1 GENERAL PROVISIONS

Section 1 China Classification Society and Its Main Services

1.1.1 Classification Societies

1.1.1.1 Classification societies are independent and impartial organizations that undertake classification services for ships and offshore installations. Classification societies have no commercial interests related to design, building, ownership, operation, management, maintenance or repairs, financing, insurance or chartering of ships and offshore installations.
1.1.1.2 Classification societies work for the safety of ships and offshore installations and environmental protection, and make a unique contribution to maritime safety and the development of classification rules through technical support, compliance verification and research and development. Classification societies provide classification services, statutory services and other services for clients in accordance with the classification rules published by them.
1.1.1.3 Classification societies furnish reasonable standards – the classification rules, which are generally accepted and recognized, for ships, shipbuilding, marine exploitation and related manufacturing industries as well as insurance, financing and other related sectors, carry out plan approval in ship design and surveys during and after construction so as to ascertain that ships are in compliance with the requirements of the classification rules, and issue classification certificates independently, in accordance with such rules.
1.1.1.4 When authorized by the Government of the flag State, classification societies carry out statutory services in accordance with the requirements of the Government of the flag State with a view to ascertaining the ships' compliance with the requirements of international conventions and/or relevant regulations of the flag State, and issue statutory certificates.

1.1.2 China Classification Society

1.1.2.1 China Classification Society (hereinafter referred to as CCS) is a specialized technical organization, authorized under the relevant laws of China and registered in accordance with the laws for providing classification services and statutory services for ships and offshore installations.
1.1.2.2 CCS mainly undertakes classification services, certification surveys and surveys relating to notarial matters for ships, offshore installations, containers and the related industrial products both at home and abroad, and performs specific services such as statutory services, etc., on behalf of the Chinese Government and the governments of foreign countries or regions when so authorized, and other services approved by the relevant administrations.

1.1.3 Objectives

1.1.3.1 The objectives of CCS are, by furnishing reasonable and reliable technical rules for ships, offshore installations, containers and related industrial products and conducting in an independent, impartial and honest manner classification, certification and technical consultancy services, to provide services for the shipping, marine exploitation and related manufacturing industries as well as marine insurance, for the promotion of safety of life and property on waters and for the protection of marine environment and other environments.

1.1.4 Main services

1.1.4.1 The services of CCS are mainly as follows:

(1) Classification services for ships, offshore installations and related industrial products (including containers): development and maintenance of rules, plan approval, surveys and certification;

(2) Statutory services for ships, offshore installations and related industrial products, when so authorized: development of technical regulations for statutory surveys, plan approval, surveys and certification;

(3) Surveys and certification delegated by other ship survey organizations, surveys related to notarial matters and safety assessment as well as verification surveys and certification of ships and offshore installations , and investigation of major maritime safety accidents;

(4) Verification, surveys and certification of related industrial facilities and products used on land, and surveys and certification delegated by foreign ship survey organizations for marine facilities and products as well as related industrial facilities and products used on land;

(5) ISM audit and certification;

(6) ISPS audit and certification;

(7) Survey and assessment of ship's technical conditions;

(8) Certification of quality management systems and environmental management systems in accordance with ISO 9000 and ISO 14000 series standards;

(9) Technical research for classification of ships and offshore installations, safety on waters and environmental protection, survey of marine facilities and products as well as related industrial facilities and products used on land, and research on the application of information technology;

(10) Other services.

Section 2 Council and Committees

1.2.1 Council

1.2.1.1 The Council of CCS is composed of the representatives from Government departments concerned, CCS, shipping, shipbuilding, marine exploitation and related manufacturing industries as well as insurance, financing and other related sectors.

1.2.1.2 The Council is entitled to:

(1) develop and update the Articles of Association of CCS;

(2) consider the work report of CCS;

(3) decide on other major issues of CCS.

1.2.2 Technical committee

1.2.2.1 The Technical Committee of CCS is composed of the persons in charge of technical work from Government departments concerned, CCS, shipping, shipbuilding and marine exploitation industries, design institutes, universities, research institutes and related manufacturing industries. Specialized subcommittees may be set up as appropriate.

1.2.2.2 The Technical Committee is entitled to:

(1) make comments or recommendations on CCS technical policy and development plan for rules and research;

(2) review and approve the main technical rules developed by CCS for ships and offshore installations;

(3) organize technical analysis and investigation of major accidents of the ships and offshore installations classed with CCS;

(4) make recommendations on developing and amending the rules based on experience in application, market demand and development in science and technology;

(5) examine the major research achievements intended to be incorporated into CCS rules for ships and offshore installations, and make recommendations on such incorporation.

1.2.3 Class committee

1.2.3.1 The Class Committee of CCS is composed of the representatives from Government departments concerned, CCS, owners, oil companies, administrations as well as insurance, financing, law and other related sectors.

1.2.3.2 The Class Committee is entitled to:

(1) examine and adopt the working procedure of the Committee and the procedure for CCS classification management;

(2) examine the relevant provisions of CCS for classification of ships and offshore installations and make recommendations on modifications and additions in light of the latest development in science and technology;

(3) accept and confirm the reports submitted by CCS on assignment, suspension, cancel or reinstatement of characters of classification and class notations of ships and offshore installations;

(4) make comments on the certificates and various survey documents of ships and offshore installations.

CHAPTER 2 SCOPE AND CONDITIONS OF CLASSIFICATION

Section 1 General Requirements

2.1.1 Principle of classification

2.1.1.1 Classification is a representation by CCS, in accordance with its rules, that the structural strength and integrity of essential parts of the ship's hull and its appendages, and the reliability and the function of the propulsion and steering systems, power generation and those other features and auxiliary systems which have been built into the ship, identified by various characters and notations, are sufficient for maintaining essential services on board.

2.1.2 Process of classification

2.1.2.1 The process of classification consists of:
(1) the development of rules;
(2) the plan approval and survey during construction to verify compliance with such rules;
(3) the assignment of class and issuance of a classification certificate when such compliance has been verified;
(4) the endorsement or issuance of a classification certificate by survey after construction to verify compliance with such rules; and
(5) the application of information.

2.1.3 Definitions

2.1.3.1 Unless expressly provided otherwise, for the purpose of Rules for Construction and Classification of Sea-going High Speed Craft (hereinafter referred to as the Rules):
(1) Classification means the technical service provided by a classification society to clients in accordance with the rules published by it.
(2) A classed craft means a craft to which a classification society issues classification certificates according to its rules.
(3) A non-classed craft means a craft which is not a classed craft.
(4) Greater coastal service restriction means the service in the sea area within 200 nautical miles off the shore, and a passenger craft does not proceed in the course of its voyage more than 4 h, or a cargo craft 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.
(5) Coastal service restriction means the service in the sea area within 20 nautical miles off the shore, and a passenger craft does not proceed in the course of its voyage more than 4 h, or a cargo craft 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.

(6) Sheltered water service restriction means the service in the sea area between the island and the shore and between island with a distance of less than 10 nautical miles in between, which form a comparatively good sheltered condition with a little wave, or within 10 nautical miles off the shore, and a craft 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 2.0 m in sea state.

(7) Calm water service restriction means the service in the sea area within 5 nautical miles off the shore and a craft 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 1.0 m in sea state.

(8) A passenger is every person other than:

the master and the members of the crew or other persons employed or engaged in any capacity on board a craft on the business of that craft; and a child under one year of age.

(9) A passenger craft is a craft which carries more than twelve passengers.

(10) A ro-ro passenger craft means a passenger craft with ro-ro cargo spaces or special category spaces.

(11) A cargo craft is any high speed craft other than passenger craft, and which is capable of maintaining the main functions and safety systems of unaffected spaces, after damage in any one compartment on board.

(12) A Catamaran is a craft with twin hulls.

(13) A wave piercer craft is a particular type of catamaran with a large breadth/length ratio and a relatively small waterplane area. This type of catamaran is of good seakeeping characteristics, and fitted with a wedgelike structure, capable of reducing rolling, near forward centerplane below twin hull cross deck structure.

(14) A hover craft is a craft such that the whole or significant part of its weight can be supported, whether at rest or in motion, by a continuously generated air-cushion.

(15) An air-cushion vehicle (ACV) is a kind of hover craft such that the whole of its weight can be supported by air cushion which can be maintained with flexible skirts.

(16) A surface effect ship (SES) is an air-cushion vehicle whose cushion is totally or partially retained by permanently immersed hard structures, e.g. air cushion catamarans and side wall hovercraft.

(17) A hydrofoil craft is a craft which is supported above the water surface in non-displacement mode by hydrodynamic forces generated on foils.

(18) A Category A passenger craft is any high speed passenger craft:

① operating on a route where it has been demonstrated that there is a high probability that, in the event of an evacuation at any point of the route, all passengers and crew can be rescued safely within the least of:

— the time to prevent persons in survival craft from exposure causing hypothermia in worst intended conditions;

— the time appropriate with respect to environmental conditions and geographical features of the route; or

— 4 h.; and

② carrying not more than 450 passengers.

(19) A Category B passenger craft is any high-speed passenger craft other than a Category A passenger craft, with machinery and safety systems arranged such that, in the event of any essential machinery and safety systems in any one compartment being disabled, the craft retains the capability to navigate safely.

(20) Maximum operational weight (t) means the overall weight up to which operation in the intended mode is permitted.

(21) Design waterline means the waterline corresponding to the maximum operational weight or the full load displacement of the craft with no lift or propulsion machinery active.

(22) Length L (m) means the overall length of the underwater watertight envelope of the rigid hull, excluding appendages at or below the design waterline in the displacement mode with no lift or propulsion machinery active.

(23) Breadth B (m) means breadth of the broadest part of the moulded watertight envelope of the rigid hull, excluding appendages at or below the design waterline in the displacement mode with no lift or propulsion machinery active.

(24) Waterline breadth B_{WL} (m) means the maximum moulded breath measured from the design waterline with no lift or propulsion machinery active; and for multihull craft (e.g. catamaran, wave-piercing catamaran, SES, etc.) means the sum of maximum moulded breadths of each hull at the design waterline.

(25) Moulded depth D (m) means the vertical distance measured at midcraft from the base line to the top of freeboard deck beam at side.

(26) Draught d (m) means the moulded draught of the rigid watertight hull at midcraft measured along the design waterline with no lift or propulsion machinery active.

(27) Full load displacement Δ(t) means the weight of sea water displaced by a craft with no lift or propulsion machinery active under a full loaded departure condition, usually equal to the maximum operational weight.

(28) Block coefficient C_b means a ship form coefficient calculated according to the following:

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

(29) Bulkhead deck/freeboard deck means the highest continued deck to which all transverse watertight bulkheads extend.

(30) Service speed is 90% of the maximum speed defined in 2.2.4.1.

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

(32) Special category spaces are those enclosed ro-ro spaces to which passengers have access. Special category spaces may be accommodated on more than one deck provided that the total overall clearheight for vehicles does not exceed 10 m.

(33) Ro-ro spaces are spaces not normally subdivided in any way and normally extending to either a substantial length or the entire length of the craft in which motor vehicles with fuel in their tanks for their own propulsion and/or goods (packaged or in bulk, in or on rail or road cars, vehicles (including road or rail tankers), trailers, containers, pallets, demountable tanks or in or on similar stowage units or other receptacles) can be loaded and unloaded, normally in a horizontal direction.

(34) Machinery spaces are spaces containing internal combustion engines with aggregate total power output of more than 110 kW, generators, oil fuel units, propulsion machinery, major

electrical machinery and similar spaces and trunks to such spaces.
(35) Cargo spaces are all spaces other than special category spaces and ro-ro spaces used for cargo and trunks to such spaces.
(36) Operating compartment means the enclosed area from which the navigation and control of the craft is exercised.
(37) Operating station means a confined area of the operating compartment equipped with necessary means for navigation, manoeuvring and communication, and from where the functions of navigating, manoeuvring, communication, commanding, conning and lookout are carried out.
(38) Weathertight means that in any sea conditions water will not penetrate into the ship.
(39) Watertight means capable of preventing the passage of water through the structure in either direction with a proper margin of resistance under the pressure due to the maximum head of water which it might have to sustain.
(40) International voyage means a voyage from a Chinese port to a port of another country outside China, or conversely.
(41) Non-international voyage means any voyage, which is not an international voyage.

Section 2 Rules for Classification

2.2.1 Bases for classification

2.2.1.1 “Classification rules” are such provisions that have entire content comprising conditions and scope of classification and supporting technical requirements. The aim of the rules is to ensure the safety and quality to be controlled to an appropriate level, and to be generally acknowledged.

2.2.1.2 The rules published by CCS are the basis and sole criteria for classification.

2.2.1.3 CCS rules stipulate the scantlings of hull structures and essential machinery, the quality and structure of material employed, the standards of machinery manufacturing, requirements for classification and tests as well as maintenance conditions.

2.2.1.4 “Special rules” are such provisions that have special content and will be used in combination with the classification rules.

2.2.1.5 For those not covered in CCS present rules, or the principled requirements therein which need to be further defined in details, or where specific applicability of the rules is needed, or for novel ships or equipment or systems, CCS will develop appropriate guidelines to facilitate classification. Where any “guidelines” are referred to in the rules, the paragraphs related to classification in such “guidelines” constitute requirements of the rules.

2.2.1.6 CCS COMPASS computer software system covers structural calculation and evaluation, ship characteristics, calculation of shafting vibration and strength and calculation of short-circuit current. The computer software plays an essential role in plan approval and surveys during and after construction.

2.2.2 Rules development

2.2.2.1 The main input for development of the rules is as follows:
(1) experience in application;
(2) relevant scientific theories and research findings;
(3) the applicable part of the relevant conventions, codes and resolutions adopted by IMO (International Maritime Organization), and unified requirements by IACS (International Association of Classification Societies).

2.2.2.2 The drafts of CCS rules or their amendments will be distributed to the Administration, designers, shipbuilders and manufacturers, survey units, owners, research institutes and universities related to ships and marine products for comments.

2.2.2.3 The drafts of CCS rules or their amendments are to be further supplemented and improved based on analysis of the expert comments or recommendations from the above-mentioned sources, followed by a final review by CCS Technical Committee or its subcommittee(s), and then issued after being approved and signed by CCS President.

2.2.2.4 Where any part of CCS rules related to the classification needs to be amended, as shown by experience in application, safety aspects covered by investigation of accidents, or due to entry into force of relevant resolutions, codes, etc., of IMO, or upon acceptance of unified requirements adopted by IACS, CCS will directly publish amendments thereto.

2.2.3 Entry into force of rules

2.2.3.1 Unless stated otherwise, the rules (including their amendments) will generally come into force in 6 months after being published. The effective date will be indicated on the first page of the corresponding PART or on the title page of the publication.

2.2.3.2 Unless stated specially, the rules are applicable to newbuildings and new marine products.

2.2.3.3 With the consent of the shipyard and the Owner, the requirements of the new rules may be adopted for the ship under construction; and where the requirements in the new rules are reasonable and practicable, CCS may agree that these requirements be adopted for the ship under construction. In any case, this is to be indicated in the corresponding technical documents.

2.2.3.4 The date of entry into force of the rules is subject only to the date of approval for publishing the rules, not to the date of entry into force of any other statutory requirements.

2.2.4 Application

2.2.4.1 The Rules apply to the craft with the maximum speed V equal to or exceeding:

$$V \geq 3.7\ \nabla^{0.1667} \quad \text{m/s}$$

where: ∇ – displacement corresponding to the design waterline, in m^3;

V – speed achieved at the maximum continuous propulsion power for which the craft is certified at maximum operational weight and in smooth water.

CCS Rules for Construction of Coastal Boats may be applicable to where high speed craft are less than 20 m in length.

2.2.4.2 The craft above mentioned in 2.2.4.1 include:

(1) high speed passenger craft (including high speed ro-ro passenger craft) which do not proceed in the course of their voyage more than 4 h at operational speed from a place of refuge when fully laden;

(2) high speed cargo craft of 500 gross tonnage and upwards which do not proceed in the course of their voyage more than 8 h at operational speed from a place of refuge when fully laden; and

(3) high speed cargo craft of less than 500 gross tonnage which do not proceed in the course of their voyage more than 8 h at operational speed from a place of refuge when fully laden, reference may be made to the provisions of the Rules.

2.2.4.3 Except as specified in 2.2.4.1 and 2.2.4.2, the Rules do not apply to:

(1) craft of war;

(2) pleasure craft not engaged in trade;

(3) craft not propelled by mechanical means;

(4) fishing craft; and

(5) wooden craft.

2.2.4.4 Buoyancy, stability and subdivision, fire safety, life-saving, radio communications, etc., of classed craft are to comply with the relevant requirements of the Administration.

2.2.4.5 For craft classed according to the Rules, where there is difficulty in practical application of or it is proved to be unnecessary by experience in application of provisions of International Code of Safety for High-speed Craft and IACS requirements covered by the Rules, necessary background material are to be submitted, and such provisions/requirements may not be applied subject to agreement of the Headquarters of CCS.

2.2.4.6 In addition to meeting the Rules, the materials and construction technology for craft are to comply with the relevant requirements of CCS Rules for Materials and Welding.

2.2.5 Equivalent and exemption

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

2.2.5.2 Any fitting, material, appliance or apparatus, other than that required in CCS rules, may be allowed to be fitted in a craft, 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 CCS rules.

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

Section 3 Characters of Classification and Class Notations

2.3.1 Characters of classification

2.3.1.1 Characters of classification are indicative of main features of craft, and mandatory.

2.3.1.2 The hull (including equipment) and machinery (including electrical installations) of a craft complying with the Rules will be assigned appropriate characters of classification and class notations by CCS.

2.3.1.3 The characters of classification for craft to which the Rules apply are:
For craft engaged on international/non-international voyages:

★CSA
★CSM
or
★CSA
★CSM
or
★CSA
★CSM

For craft only engaged on domestic voyages in China:

★CSAD
★CSMD
or
★CSAD
★CSMD
or
★CSAD
★CSMD

The meanings of the characters of classification are:

★CSA — indicating that the structure and equipment of the craft have been constructed with plan approval by and under the supervision of CCS, and found to be in full compliance with CCS rules and to comply with the requirements of the International Code of Safety for High-speed Craft.

★CSA — indicating that the structure and equipment of the craft have not been constructed with plan approval by and under the supervision of CCS, but they have been found after classification survey by CCS to be in compliance with CCS rules and to comply with the requirements of the International Code of Safety for High-speed Craft.

★CSM — indicating that the product surveys for craft's propulsion and essential auxiliary machinery have been carried out by CCS, the craft's machinery and electrical installations have been constructed with plan approval by and under the supervision of CCS, and found to be in compliance with CCS rules and to comply with the requirements of the International Code of Safety for High-speed Craft.

★CSM — indicating that the product surveys for craft's propulsion and essential auxiliary machinery have not been carried out by CCS, but the craft's machinery and electrical installations have been constructed with plan approval by and under the supervision of CCS, and found to be in compliance with CCS rules and to comply with the requirements of the International Code of Safety for High-speed Craft.

★CSM — indicating that the craft's machinery and electrical installations have not been constructed with plan approval by and under the supervision of CCS, but they have been found after classification survey by CCS to be in compliance with CCS rules and to comply with the requirements of the International Code of Safety for High-speed Craft.

★CSAD — indicating that the structure and equipment of the craft have been constructed with plan approval by and under the supervision of CCS, and found to be in full compliance with CCS rules.

★CSAD — indicating that the structure and equipment of the craft have not been constructed with plan approval by and under the supervision of CCS, but they have been found after classification survey by CCS to be in compliance with CCS rules.

★CSMD — indicating that the product surveys for craft's propulsion and essential auxiliary machinery have been carried out by CCS, the craft's machinery and electrical installations have been constructed with plan approval by and under the supervision of CCS, and found to be in compliance with CCS rules.

★CSMD — indicating that the product surveys for craft's propulsion and essential auxiliary machinery have not been carried out by CCS, but the craft's machinery and electrical installations have been constructed with plan approval by and under the supervision of CCS, and found to be in compliance with CCS rules.

★CSMD — indicating that the craft's machinery and electrical installations have not been constructed with plan approval by and under the supervision of CCS, but they have been found after classification survey by CCS to be in compliance with CCS rules.

2.3.2 Class notations

2.3.2.1 Class notations indicate different features of a craft in sequence, and will be appended to the characters of classification, including class notations for hull and machinery.

2.3.2.2 CCS will assign class notations after satisfied with compliance with the relevant requirements of the Rules by carrying out plan approval and survey, at the request of the owners.

2.3.2.3 Class notations for hull consist of following type, category and service restriction notations.

(1) Refer to Table 2.3.2.3(1) for type notations:

Table 2.3.2.3(1)

No.	Type Notations	
	Chinese	English
1	高速单体船	Mono-Hull HSC
2	高速双体船	Catamaran HSC
3	穿浪双体船	Wave Piercer Craft
4	高速水面效应船（侧壁气垫船）	Surface Effect Ship
5	全垫升气垫船	Air Cushion Vehicle
6	水翼船	Hydrofoil Craft

(2) Refer to Table 2.3.2.3(2) for category notations:

Table 2.3.2.3(2)

No.	Category Notations	
	Chinese	English
1	A类客船	Passenger A
2	B类客船	Passenger B
3	A类客滚船	Ro/Ro Passenger A
4	B类客滚船	Ro/Ro Passenger B
5	货船	Cargo

(3) Refer to Table 2.3.2.3(3) for service restriction notations:

Table 2.3.2.3(3)

No.	Service Restriction Notations	
	Chinese	English
1	近海营运限制	Greater Coastal Service Restriction
2	沿海营运限制	Coastal Service Restriction
3	遮蔽营运限制	Sheltered Water Service Restriction
4	平静水域营运限制	Calm Water Service Restriction

2.3.2.4 Class notations for machinery (including electrical installations) include:

(1) Refer to Table 2.3.2.4(1) for Class notations for machinery (including electrical installations):

Table 2.3.2.4(1)

Special Survey Notations	
Chinese	English
机械计划保养系统	PMS (Planned Maintenance System)

(2) For craft’s machinery classed with CCS, if prime movers of main engine and generator are subject to planned maintenance system approved by CCS and in compliance with the requirements

of the Rules, the above-mentioned class notations for machinery (Planned Maintenance System) will be affixed to its characters of classification.

2.3.2.5 For ships and machinery installations constructed in accordance with the relevant rules issued by CCS or other accepted standards, CCS will assign corresponding class notations case by case upon the application of owners and subject to agreement of CCS. Example for category notations:

救助船 Rescue

Section 4 Application and Fees

2.4.1 Application

2.4.1.1 Applicants requesting services from CCS are to submit a written application or a completed application form to CCS or one of its local branches or the units designated by it, and/or sign a contract/agreement with CCS.

2.4.1.2 The responsibilities of both parties, characters of classification and class notations, craft's particulars, etc., are to be clearly specified in the application or contract/agreement.

2.4.1.3 Applicants are to submit plans and technical documents necessary for the requested services.

2.4.1.4 Applicants are to provide safe and appropriate survey conditions for the Surveyors to CCS, including the convenience for access to locations, workshops, manufactories and craft for carrying out timely and efficient surveys.

2.4.2 Fees

2.4.2.1 Applicants are to pay survey fees, traffic fees and other necessary expenses occurred in accordance with the Provisions of Survey Fees of CCS and/or contract/agreement.

2.4.2.2 For any service provided beyond the contract/agreement or any service provided anew due to the reasons on the part of the party receiving such service, CCS has the right to charge additional fees from the applicant.

Section 5 Submission and Examination of Plans and Surveys

2.5.1 Examination of plans and documents

2.5.1.1 Prior to commencement of construction of craft, the plans and documents as defined in Section 1 of Chapter 3 are to be submitted in triplicate to the designated plan approval location(s) of CCS for examination. Copies of the plans to be submitted for approval to sister craft or craft additionally constructed within one year in accordance with the approved plans may be reduced or such submission exempted according to the specific conditions.

2.5.1.2 The craft's list of survey and test items, as well as the technical documents, such as construction technology, welding specifications, NDT diagrams, installation procedure of machinery (excluding reasonable alignment of shafting), inclination testing programme, and mooring trial and sea trial programme are to be submitted to the attending Surveyors to CCS for examination.

2.5.1.3 Necessary scantlings and relevant data as required by the Rules are to be indicated on the plans and documents submitted.

2.5.1.4 The term "approval" means that the plans or documents have been examined and found in compliance with CCS rules. The approval of plans and documents by CCS covers only the items as required by CCS rules, excluding any items not required by CCS rules. Where CCS undertakes statutory surveys at the same time, the "approval" by CCS is to cover the items related to the statutory requirements.

2.5.1.5 The plans and documents as deemed to comply with the Rules upon examination, are to be stamped with APPROVED seal. The approval conditions and restrictions may be written on the plans and documents, or stated in the plan approval letters with appropriate notes being added on the plans and documents.

2.5.2 Validity of approved plans

2.5.2.1 The approved plans are valid only for construction in the designated shipyard, the construction project number or the number of craft to be constructed as specified in the application or contract/agreement for plan approval.

2.5.2.2 The approved plans for craft classification will be invalid automatically in one of the following cases:
(1) the new rules (including their amendments) with major revisions have come into force. For craft of which the plans for cross section and midcraft section have been approved, the previous rules may be applicable to such craft within one year;
(2) the construction of the craft with the project number or within the number as specified in the application or contract/agreement for plan approval has been completed;
(3) after 4 years since the approval date of plans;
(4) the approved shipyard or construction project number has been changed, or the number of craft constructed has been exceeded;
(5) the craft is not constructed under the supervision of CCS.

2.5.2.3 Where the statutory requirements of the flag State or the international conventions, codes accepted by it and the entry into force of the amendments thereto affect the validity of the approved plans, the approved statutory plans will be invalid automatically.

2.5.3 Surveys

2.5.3.1 For a craft applying for class of CCS and at the same time CCS is authorized by the flag State for statutory surveys of the same craft, CCS may carry out classification survey in conjunction with statutory surveys.

2.5.3.2 Classification surveys include survey during construction, survey after construction, classification survey for first entry of existing craft, survey of major conversion, etc.

2.5.3.3 Statutory surveys for craft applicable to the Rules are to comply with the corresponding provisions in Section 12 of this Chapter. Classification surveys and marine products inspections are to be in compliance with the corresponding provisions in Chapter 3.

Section 6 Approval of Suppliers

2.6.1 General requirements

2.6.1.1 Suppliers providing services on behalf of the owner to CCS, such as measurements, tests or maintenance of safety systems and equipment, the results of which will be used by CCS Surveyors as the basis for surveys, are subject to approval by CCS as evidence for their capabilities to provide the approved services.

2.6.1.2 Where such services are used by CCS in making decisions affecting statutory certificates, the suppliers are subject to approval by CCS. In addition, CCS may accept the suppliers recognized by the flag Administration or an organization authorized by it.

2.6.1.3 Suppliers do not act on behalf of CCS and are responsible for the services provided by them and the results thereof.

2.6.2 Requirements for approval

2.6.2.1 Any supplier requesting approval is to meet the following conditions:
(1) sufficient competent technicians, operators, inspectors and supervisors are available for providing approved services;
(2) necessary and appropriate equipment and facilities are in place;
(3) an effective and documented quality assurance system has been established and is being maintained.

2.6.2.2 The scope and procedure of approval of suppliers are to be in compliance with Appendix 8 — Procedural Requirements for Approval of Service Suppliers to Chapter 5 of PART ONE of CCS Rules for Classification of Sea-going Steel Ships.

2.6.3 List of approved suppliers

2.6.3.1 CCS publishes and maintains a list of suppliers approved by CCS.

Section 7 Assignment, Maintenance, Suspension, Cancellation and Reinstatement of Class

2.7.1 Assignment and maintenance of class

2.7.1.1 Where the hull (including equipment) and machinery (including electrical installations) are found in compliance with the relevant provisions of CCS rules after plan approval and surveys, the characters of classification and corresponding class notations will be assigned, and the classification certificate will be issued by CCS.

2.7.1.2 Owners are to ensure proper maintenance of the craft and to operate according to the conditions specified in the classification certificate.

2.7.1.3 The CCS class assigned to a ship which is found to comply with the Rules upon surveys after construction will continue to be valid, and CCS will endorse or renew the classification certificate.

2.7.2 Suspension and cancel of class

2.7.2.1 Suspension of class

(1) When a craft is operating beyond the service limitation defined by its characters of classification and class notations or any other additional condition as approved, its class will be suspended and its classification certificate invalidated.

(2) Any damage, defect, failure or grounding that may affect the validity of the assigned class may, if not reported to CCS without inappropriate delay or prior agreement of CCS to foreseen repairs not obtained, lead to suspension of the class and invalidation of the classification certificate.

(3) One of the following cases will lead to suspension of the class and invalidation of the classification certificate, unless the craft is attended by the Surveyor for completion of the overdue surveys:

① when any outstanding recommendation or condition of class specified by CCS is overdue, and no extension is granted by CCS;

② when continuous survey item(s) due or overdue at time of annual survey have not been dealt with, and no extension is granted by CCS;

③ when surveys after construction other than annual, intermediate or special surveys are overdue, and no extension is granted by CCS;

④ when repairs of any damage, defect, failure or grounding have not been completed and surveyed as specified.

(4) The class of a craft will be automatically suspended and the classification certificates will become invalid in any one of the following cases:

① when an annual survey has not been completed within 3 months of the due date of the annual survey, unless the craft is under attendance for completion of the annual survey;

② when an intermediate survey has not been completed within 3 months of the due date of the third annual survey in each special survey period (5 years), unless the craft is under attendance for completion of the intermediate survey;

③ when a special survey has not been completed within the period of time specified by CCS and no extension is granted by CCS, unless the craft has been under attendance for completion of the special survey prior to resuming trading, by the due date.

a. Under "exceptional circumstances", CCS may grant an extension not exceeding 3 months to allow for completion of the special survey, provided that the craft is attended and the attending Surveyor so recommends upon satisfactory survey to the following extent:

(a) annual survey;

(b) re-check of outstanding recommendations/conditions of class;

(c) progression of the special survey as far as practicable;

(d) dry docking survey is to be extended together with the special survey, an underwater examination is to be carried out by an approved diving company. Such underwater examination may be dispensed with in the case of extension of docking survey not exceeding 36 months provided the craft is without any outstanding recommendation/condition of class regarding underwater parts.

b. In the case that the class certificate will expire when the craft is expected to be at sea, an extension to allow for completion of the special survey may be granted provided there is documented agreement to such an extension prior to the expiry date of the certificate, and provided that positive arrangements have been made for attendance of the Surveyor at the first port of call, and provided that CCS is satisfied that there is technical justification for such an extension. However, if owing to "exceptional circumstances" the special survey cannot be completed at the first port of call, the subparagraph a. above may be followed, but the total period of extension shall in no case be longer than 3 months after the original due date of the special survey.

(5) If, due to circumstances reasonably beyond the owner's or CCS control a craft is not in a port where the overdue surveys can be completed at the expiry of the periods allowed above, CCS may allow the craft to sail, in class, directly to a discharge port, and if necessary, hence, in ballast, to a port at which the survey will be completed, at request of the owner and provided that:

① relevant records are to be reviewed;

② the due and/or overdue surveys and examination of outstanding recommendations/ class conditions are carried out by CCS at the next port of call when there is an unforeseen inability of CCS to attend the craft in the present port;

③ upon review of the craft's history and survey at the present port, the attending Surveyor is satisfied that the craft is in condition to sail for one trip to a discharge port and if necessary, hence, in ballast to a repair facility, and this is to be confirmed by the Headquarters of CCS. Where there is unforeseen inability of CCS to attend the craft in the present port, the master is to confirm that his craft is in condition to sail to the nearest port of call.

If class has already been automatically suspended in such cases, it may be reinstated subject to the conditions prescribed above.

2.7.2.2 Cancel of class

(1) The class of a craft will be cancelled in any one of the following cases:

① at the request of the owner;

② the circumstances leading to suspension of class are not corrected within the time specified;

③ the craft's class will be cancelled immediately when the craft proceeds to sea without having completed recommendations or conditions of class which were required to be dealt with before leaving port;

④ when the class has been suspended for a period of 6 months due to overdue annual, intermediate, special surveys or other surveys after construction as required by the Rules and/or overdue outstanding recommendations/conditions of class.

A longer suspension period may be granted for craft which are either laid up, awaiting disposition of a casualty or under attendance for reinstatement;

⑤ where hull, equipment or machinery (including electrical installations) is so badly damaged or in other conditions (e.g. sinking, scrapping, etc.) that continuing operation of the ship is confirmed as not possible;

⑥ when the payment of survey fees is not made in time.

2.7.2.3 If survey requirements related to maintenance of special class notations are not specified to be carried out, the suspension or cancellation is to be limited to those special class notations only.

2.7.2.4 Notification of suspension or cancellation of class

(1) Cancellation of class of a craft will be indicated correspondingly in CCS Register of Ships or its supplements.

(2) When the class of a craft is suspended or cancelled, CCS will send written notification to the owner and the Administration of the flag State, and make an announcement on CCS website available to the underwriters and other interested parties concerned.

2.7.3 Reinstatement of class

2.7.3.1 The class of a craft may be reinstated in any one of the following cases:

(1) class will be reinstated upon satisfactory completion of the overdue surveys. Such surveys are to be credited as of the original due date. However, the craft is disclassed from the date of suspension until the date class is reinstated;

(2) class will be reinstated upon verification that due or overdue continuous survey items have been satisfactorily dealt with;

(3) class will be reinstated upon verification that due or overdue outstanding recommendations have been satisfactorily dealt with.

2.7.3.2 When the class of a craft is reinstated, CCS will send written notification to the owner and the Administration of the flag State, and make an announcement on CCS website available to the underwriters and other interested parties concerned.

Section 8 Certificates and Reports

2.8.1 Certificates

2.8.1.1 A classification certificate indicates only that craft, structure, material, equipment, machinery, electrical installations stated in the certificate or other items covered by it, as verified during plan approval, construction and survey after construction, are in compliance with CCS rules and fit for their intended purposes.

2.8.1.2 The equipment record attached to the classification certificate is part of the classification certificate.

2.8.1.3 The classification certificates and related reports are to be issued by CCS independently. The validity, applicability and interpretations of the classification certificate issued based on contracts/agreements are only to be in accordance with CCS rules, and CCS reserves one and only judgment.

2.8.1.4 The classification certificate is to contain the terms and conditions as agreed between both parties.

2.8.2 Duration and validity of certificates

2.8.2.1 The period of validity of classification certificates of craft is not to exceed 5 years.

2.8.2.2 The period of validity of interim classification certificates is not to exceed 5 months.

2.8.2.3 The period of validity of classification certificates is to be harmonized with that of statutory certificates of the craft as possible.

2.8.3 Issue and endorsement of classification certificates

2.8.3.1 An interim classification certificate is to be issued by the survey unit on completion of initial surveys.

2.8.3.2 Upon issue of an interim classification certificate, the survey unit is to submit the interim classification certificate together with records, reports and other technical documents to the related department of CCS Headquarters for review and then submitted by the department to the Class Committee and upon approval by the Committee, a classification certificate will be issued by the President of CCS or person(s) authorized by him.

2.8.3.3 The classification certificates are to be endorsed by the Surveyor(s) as required after completion of the survey after construction as specified in Section 4, Chapter 3 of the Rules.

2.8.3.4 Where a new classification certificate cannot be issued before the expiry date of the existing classification certificates after completion of the special survey, the existing classification certificate may be endorsed by the Surveyor, which is to be valid within 5 months from its expiry date.

2.8.3.5 Upon completion of the special survey, the survey unit is to submit a report and other technical documents to the related department of CCS Headquarters or another designated survey unit for review, and a new classification certificate will be issued by the President of CCS or person(s) authorized by him.

Section 9 Register of Ships and Lists of Approved Marine Products

2.9.1 Register of ships

2.9.1.1 CCS will enter main characteristic particulars and details of all ships classed with CCS, after they are assigned characters of classification and class notations, into the Register of Ships periodically published by CCS to provide information for those related to ships, such as builders, owners, underwriters, shippers and charterers.

2.9.1.2 Subsequently, in case changes concerning ships or their characteristic particulars are made, CCS will publish renewed editions of the Register of Ships or supplements thereto in time.

2.9.2 Lists of approved marine products

2.9.2.1 CCS will enter the names, main characteristic particulars and details of related products as well as detailed information on their manufacturers in respect to those factories and plants and their marine products approved by CCS into the Lists of Approved Marine Products periodically published by CCS to provide information for ship-designing institutes, builders, owners, traders and exporters.

2.9.2.2 Subsequently, in case changes concerning performance of the approved products are made or their scope is extended, CCS will publish renewed Lists of Approved Marine Products or supplements thereto in time.

Section 10 Liability, Disagreement and Arbitration

2.10.1 Liability of each party

2.10.1.1 CCS rules are the basis for the design, building, manufacturing and testing of ships and related products, but not the sole basis for the design. The rules can neither replace the control of technological process and quality by builders or manufacturers, nor diminish their liability in this respect or absolve them therefrom.

2.10.1.2 CCS rules do not cover every piece of structure or item of equipment on board a ship, nor do they cover operational elements, or activities which fall outside the scope of classification and include such items as design and manufacturing processes, choice of type and power of machinery and certain equipment, number and qualification of crew or operating personnel, form and cargo-carrying capacity of the ship and manoeuvring performance, cargo securing, hull and equipment vibrations, noises, spare parts, life-saving appliances and maintenance equipment.

2.10.1.3 CCS will not be liable for any loss of any result of applying CCS rules by any third party without plan approved or ship surveyed by CCS.

2.10.1.4 The classification of ships undertaken by CCS is carried out on the basis that the designers, builders, owners, manufacturers, sellers, suppliers, repairers, operators and other parties fulfill their respective responsibilities. The contents of any reports, documents and certificates issued by CCS do not mean to diminish any liability of any party mentioned above or absolve it therefrom.

2.10.1.5 Any survey-related document issued by CCS only reflects the status at the time when the survey is carried out.

2.10.1.6 The classification certificate (characters of classification and class notations) is only an attestation that the ship is in compliance with the relevant requirements of classification rules published by CCS. If the ship is not in compliance with such requirements, CCS has the right to prevent, suspend or cancel the characters of classification and class notations assigned.

2.10.1.7 Except as required by CCS rules, CCS will make no representations beyond the relevant reports, statements, plan approval, surveys, certification or other services. The application of the information supplied by CCS in documents other than classification certificates and reports is at the discretion of the users, and CCS is not liable for the results of such actions.

2.10.1.8 CCS is to provide service(s) based on the contract only, in no case shall CCS be liable for any loss of any party who has no direct contractual relations with CCS.

2.10.2 Disagreement

2.10.2.1 The right of interpretations of the rules published by CCS is to be left solely to the Headquarters of CCS. The rules are translated by CCS into English. In case of any different understanding to the English version, the currently effective Chinese version of the rules is to be considered as solely authoritative.

2.10.2.2 Where there is disagreement between the Surveyor and the interested party during survey, which affects the project schedule, the latter is to promptly appeal in writing to the unit where the Surveyor serves. Where the handling of the appeal by the unit is not considered satisfactory by the interested party, it may appeal in writing to the Headquarters of CCS along with detailed background materials. The Headquarters will decide on the matter, and this ruling will be final.

2.10.2.3 The costs arising from any examinations carried out by the Headquarters on request are to be paid by the appellant, except for those cases in which the appeal proves justified.

2.10.3 Arbitration

2.10.3.1 CCS will be liable only for the loss or damage resulting directly from its negligent act.

In no event shall CCS be liable for any indirect or consequential losses or damages.

2.10.3.2 Notwithstanding the previous paragraph, CCS will be liable for the loss or damage due to negligent act judicially attributed exclusively to CCS or its employees, agents or other parties acting on behalf of CCS. And in no case shall the amount of this liability exceed five times the fee(s) charged by CCS in respect of the service(s) in question or 2,000,000 RMB in maximum. CCS liability for the loss or damage is specially excluded when such loss or damage arises out of an act:

(1) by an employee of CCS acting outside the terms or scope of his/her employment; or

(2) by any agent or other party acting on behalf of CCS, when such act exceeds the authority granted in writing by CCS to such agent or party.

2.10.3.3 Any claim for any loss or damage set forth above is to be made in writing within six months of the date the damage first discovered or the loss occurred; failure of doing so will be deemed as an absolute waiver of this right.

2.10.3.4 Unless otherwise agreed with CCS, any dispute of whatsoever nature in respect to the Rules or the service(s) provided in accordance with the Rules shall be referred to China Maritime Arbitration Commission and arbitrated in accordance with its arbitration rules effective at the time of request for arbitration. The arbitration award shall be final and binding upon both interested parties.

2.10.4 Applicable laws

2.10.4.1 The laws of the People's Republic of China shall apply.

Section 11 Availability and Disclosure of Information

2.11.1 Availability of information

2.11.1.1 The party who makes any information available to CCS as required for classification of the ship shall be responsible for the authenticity, timeliness and completeness of such information.

2.11.2 Disclosure of information

2.11.2.1 CCS will not disclose any information obtained for the purpose of classification of the ship to any other party not specified in the contract, except in the following cases:

(1) when the class of the ship is transferred from CCS to another member society of IACS, the relevant class information together with survey reports for the ship are to be made available to that society;

(2) as required by IACS, the updated data related to the Register of Ships and the data of class suspension and survey status are to be communicated to IACS;

(3) the IACS quality system auditor(s) or the representative(s) of the Government of the flag State may, during their audit of CCS, have access to the certificates, documents and information related to the ships classed with CCS;

(4) the flag State has special legal provisions for the disclosure, or the court having jurisdiction or

the owner agrees in writing to the disclosure.

Section 12 Statutory Surveys

2.12.1 General requirements

2.12.1.1 Upon the authorization by the Government of the flag State, and at the request of the owner or designer or shipyard or upon contract/agreement with them, CCS will undertake a part of or all statutory surveys for craft.

2.12.1.2 For craft requesting to be classed with CCS, CCS will carry out the classification survey in conjunction with the statutory survey when so authorized.

2.12.1.3 CCS will issue relevant statutory certificates and/or reports, upon completion of plan approval, survey during construction and survey after construction, and confirmation that the craft is in compliance with the corresponding statutory requirements.

2.12.1.4 For craft receiving both classification and statutory services by CCS, where the classification certificate is invalidated and this will affect the conditions for issuance of the relevant statutory certificates, the relevant statutory certificates or documents of compliance (e.g. for safety and load lines) will be invalidated simultaneously.

2.12.2 Basis for statutory surveys

2.12.2.1 For high speed craft engaged on international voyages, the statutory requirements are referred to the international conventions or codes, mainly including:
(1) International Code of Safety for High-speed Craft;
(2) International Convention on Tonnage Measurement of Ships, 1969;
(3) International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto;
(4) International Regulations for Preventing Collisions at Sea, 1972, etc.

2.12.2.2 For high speed craft on non-international voyages, the statutory requirements are referred to the relevant statutory regulations of the Government of the flag State.

2.12.2.3 The applicable statutory requirements are to be clearly specified in the application form or contract/agreement.

2.12.3 Responsibilities of parties concerned

2.12.3.1 The right to interpret the statutory requirements rests with the Administration of the flag State.

2.12.3.2 The Administration of the flag State is responsible for the equivalence and exemption covered by the statutory requirements.

2.12.3.3 In carrying out statutory services, CCS will not be liable for any modification costs of any craft or any loss caused by traceability of the statutory requirements of the Administration of the flag State to existing craft.

Section 13 Audit

2.13.1 Vertical contract audit

2.13.1.1 The owners, shipyards and marine product manufactories concerned are to assist the representative(s) of third-party independent audit organizations, e.g. representative(s) of an Accredited Certification Body (ACB), IACS observer(s), etc., and the representative(s) of the European Commission (EC) in their vertical contract audit of CCS, when they are accompanied by CCS representative(s), so as to facilitate their work.

2.13.1.2 Where the auditor(s) or the representative(s) request access to relevant information during the audit, the owners, shipyards and manufacturers concerned are to make such information available to them provided that it is ensured that they will not in any form reproduce such information or transmit it to any other party.

CHAPTER 3 MARINE PRODUCTS INSPECTIONS AND CRAFT'S SURVEYS

Section 1 Plan Approval

3.1.1 General Requirements

3.1.1.1 Before a classed craft is built, the plans and documents as specified in this Section are to be submitted to CCS for approval in accordance with the requirements in Section 5 of Chapter 2.

3.1.1.2 When any major modifications or additions are made to the craft construction, the related plans and documents are also to be submitted to CCS for approval.

3.1.2 Plans and documents

3.1.2.1 The following hull plans and documents are to be submitted to CCS for approval:

(1) Strength calculations or scantling calculations according to the Rules, including hull girder strength, hull transverse strength and local strength;

(2) Structure direct calculations (if any);

(3) Principal transverse structure sections;

(4) Construction profile;

(5) Details for typical joints;

(6) Superstructures and deckhouse construction;

(7) Main bulkhead construction;

(8) Shell expansion;

(9) Fibre reinforced plastics laminate design (if any);

(10) Main engine seating and thrust seating;

(11) Propeller bracket construction and strength calculations, as well as aerial propeller (if any) seating construction;

(12) Vehicle ramp and stern door constructions (if any);

(13) Hydrofoil construction (if any);

(14) Hydrofoil strength calculations (if any);

(15) Skirt arrangement and construction (if any);

(16) Skirt connection (if any);

(17) Speed limit curve when craft navigating in waves;

(18) Arrangement, constructions and materials of exposed doors, windows and covers, including thickness calculations and joint calculations of window glass, diagram for joints, etc.;

(19) Configuration, construction and strength calculations of rudder, including rudder blade, rudder stock, rudder carrier and connections;

(20) Calculations of equipment number;

(21) Arrangement of anchoring and mooring equipment;

(22) Constructions of embedded parts in any places under heavier stress where anchoring and mooring equipment and passenger's seats are sited (if any).

3.1.2.2 The following hull plans and documents are to be submitted to CCS for information:

(1) Hull specifications;
(2) General arrangement;
(3) Lines;
(4) Hydrostatic curves;
(5) Arrangement of fresh water tank and oil tank, including capacity plans;
(6) Calculations of weight and gravity center;
(7) Calculations of local vibration of hull (if any);
(8) List of hull materials and their test reports of mechanical property (including glue for window glass).

3.1.2.3 The following machinery plans and documents are to be submitted to CCS for approval:
(1) Engine room arrangement;
(2) Bilge piping;
(3) Ballast piping;
(4) Air, sounding, overflow and filling pipes;
(5) Discharge and deck drain pipes;
(6) Lubricating oil pipes;
(7) Cooling water pipes;
(8) Fuel oil pipes;
(9) Hydraulic transmission system;
(10) Compressed air piping;
(11) Exhaust piping;
(12) Ventilation piping in machinery space;
(13) Arrangement of shafting;
(14) Parts of shafting;
(15) General arrangement of stern tube, including oil sealing gland and tube shaft bearings;
(16) Propeller, including water-propeller, air-propeller or waterjet and other equivalent equipment;
(17) Strength calculations of shafting;
(18) Torsional vibration calculations of propelling shafting;
(19) Whirling vibration calculations of propeller shafting;
(20) Torsional vibration calculations of lifting shafting;
(21) Whirling vibration calculations of lifting shafting;
(22) Strength calculations of propeller;
(23) Calculations of prefastening force when blades of air-propeller are fastened;
(24) Oil shrink fitting of propeller with calculations;
(25) General arrangements of steering gear;
(26) Control systems of rudder equipment;
(27) Rudder, rudder stock and rudder tiller together with strength calculations.

3.1.2.4 The following machinery plans and documents are to be submitted to CCS for approval:
(1) Machinery specifications;
(2) Technology specifications and on board arrangement of stabilization device (if any);
(3) Machinery list.

3.1.2.5 The following plans and documents of electrical installations are to be submitted to CCS for approval:
(1) Electrical loading calculations;
(2) Battery capacity calculations;
(3) Calculations for short-circuit currents (apply to craft whose generator capacity is more than 250 kVA);
(4) Arrangement of main electric power equipment;
(5) Electric power system;
(6) Schematic diagrams and arrangement of main lighting and emergency lighting;
(7) Arrangement of main cable runs (apply to passenger craft);
(8) Internal communication system with arrangement;
(9) Schematic diagrams and arrangement of safety system for craft and persons on board;
(10) Single line of main switchboard or battery’s charge and discharge switchboard;
(11) Single line of emergency switchboard or battery’s charge and discharge switchboard;
(12) List of alarm items (indicating position and alarm mode of these items covered in Chapter 8);
(13) Schematic diagrams for power supplies of remote control, alarm and safety systems.

3.1.2.6 The following plans and documents of electrical installations are to be submitted to CCS for information:
(1) Specifications for all electrical equipment;
(2) List of all electrical equipment.

3.1.2.7 Additional plans and documents may be required if considered necessary by CCS.

Section 2 Inspections of Marine Products

3.2.1 General Requirements

3.2.1.1 In addition to the requirements in 3.2.1.2 of this Section, the inspections of marine products for high speed craft are to be carried out in accordance with the relevant requirements in Chapter 3, PART ONE of CCS Rules for Classification of Sea-going Steel Ships by.

3.2.1.2 The following marine products are to be surveyed by CCS. Before installation on board, the relevant certificates are to be examined by the Surveyor(s).
(1) The following products are to be installed on high speed craft:
① engine with power less than 135 kW;
② aviation oil pump and oil motor;
③ aviation hydraulic element and device;
④ aviation pipes and tubes;
(2) The following products are to be installed on ACV:
① main diesel engine;
② centrifugal clutch;
③ flexible shaft coupling;

④ air propeller;
⑤ aviation oil filter;
⑥ aviation cables.

3.2.1.3 Applicable certificates of marine products submitted by the manufacturers may be accepted by the Surveyor where the requirements in 3.2.1.2 cannot be implemented, subject to agreement of CCS.

Section 3 Surveys during Construction

3.3.1 General requirements

3.3.1.1 Designers are to establish the appropriate quality assurance systems, so as to ensure the quality in design of craft and products. In addition, designers are to submit list of suppliers and general documents and information.

3.3.1.2 Manufacturers are to establish the appropriate quality assurance systems, so as to ensure the quality in fabrication of craft and products. In addition, manufacturers are to submit list of suppliers and general documents and information (such as brief introduction to manufacturer and information on quality management system).

3.3.1.3 Factories manufacturing marine products such as materials, equipment, systems, etc., required by the Rules are to apply to CCS for marine products inspections. The requirements of marine products inspections are referred to in Section 2 of this Chapter.

3.3.1.4 Firms providing services such as measurements and tests of essential safety systems and equipment, the results of which are used as the basis for survey, are to be subject to approval by CCS; otherwise, such services are to be carried out under the supervision of the Surveyor(s).

3.3.2 Assessment and examination prior to commencement of construction

3.3.2.1 Prior to commencement of construction of a craft, CCS will appoint the Surveyor(s) to make assessment on the capability and quality assurance system of the builder and/or to carry out examination prior to commencement of construction.

3.3.2.2 The Surveyors are to examine or verify the list of craft's survey and test items and the technological documents such as welding procedure, welding specifications, NDT diagrams, procedure for installation of machinery (except reasonable shafting alignment), inclination test programme, and mooring and sea trial programme, etc.

3.3.2.3 The Surveyors are to confirm that the essential materials, equipment and systems as required by the Rules are in compliance with the approved plans, calculations and other technical documents, and furnished with the marine products certificates from CCS.

3.3.2.4 The Surveyors are to carry out the examination in accordance with the approved plans and documents and to confirm the implementation of the approval condition and restriction (comments and replies concerning plan approval).

3.3.3 Survey items

3.3.3.1 The survey items for hull are to be as follows:
(1) review of materials and confirmation of assigned relevant products certificates from CCS;
(2) block/assembly inspections and erection inspections (including installation of hydrofoils and skirts, etc.). When the monolithic construction survey is adopted, proper consideration is to be given to the nodes by the Surveyors;
(3) integration inspections of structures and compartments;
(4) pressure test and tightness test;
(5) testing for means of closing hatches and openings, including remote controls;
(6) survey for steering gear, windlass and mooring equipment after installed;
(7) determination of rudder centreline, propulsion shafting centerline and baseline;
(8) retractable test of vehicle ramps (if applicable);
(9) determination of craft's main dimensions, load line marks and draft scale;
(10) lightweight survey;
(11) inclining test, including confirmation of craft's condition before testing;
(12) survey items required for class notations;
(13) mooring and sea trials;
(14) other items considered necessary to be inspected by CCS.

3.3.3.2 The survey items for machinery are to be as follows:
(1) confirmation that the essential machineries as specified in the Rules are all furnished with the marine products certificates from CCS;
(2) confirmation of the materials for main machinery components, including partial material tests;
(3) workshop test of partial machineries;
(4) piping tests, including strength test in workshop and tightness test after installation on board the ship;
(5) inspections and tests of essential machineries after installed, such as main engine, shafting, propeller, gear boxes, generating sets, water jet lift devices, important pumps, steering gear, windlasses, air compressors, heat exchangers, sea chests, scupper valves, etc.;
(6) inspections and tests of systems, such as those of fuel oil, lubricating oil, bilge, ballasting, fire fighting, ventilating, measuring, heating, cooling, venting and valve remote control, etc.;
(7) inspections and tests of mechanical automatic and remote control systems;
(8) inspections and tests of remote control means of closing, such as quick-closing valves of oil tanks, ventilation system cut-off and closing, etc.;
(9) survey items required for class notations;
(10) mooring and sea trials;
(11) other items considered necessary to be inspected by CCS.

3.3.3.3 The survey items for electrical installations are to be as follows:
(1) confirmation that the electrical installations for essential services as specified in the Rules are all furnished with marine products certificates;
(2) inspections and tests of main switchboards, emergency switchboards and bus bars after installed;
(3) check of cable specifications and inspection of the installation;
(4) test of internal communication on board;
(5) mechanical remote control and automation — inspections and tests of main and auxiliary engines, boilers, steering systems (including control, safety and alarm systems);
(6) inspections and tests of installation of electrical equipment in ro-ro spaces;
(7) inspections and tests of emergency power supply (including charging devices);
(8) survey items required for class notations;
(9) mooring and sea trials;
(10) other items considered necessary to be inspected by CCS.

3.3.4 Requirements for tests

3.3.4.1 Tightness test for hull structure
(1) The following items are to be hose tested:
① watertight bulkheads, flats and tunnels;
② bulkhead watertight doors and flow channels for lift fans of ACV;
③ weathertight doors, windows and hatch covers;
④ reveting joints of aluminum alloys' superstructure and deckhouse.
During hose tests, the water-pressure of nozzle is not to be less than 0.05 MPa, the nozzle size is not to be less than 16 mm, and the nozzle is to be placed at a distance of not greater than 3 m from the item under test. The moving speed of water column is not to be more than 0.1 m/s.
(2) The following places are to be subjected to the appropriate waterhead test:
① fore and after peak tanks used as cofferdams, heading up to the highest damage water-line;
② water tanks, oil tanks, ballast tanks and peak tanks, heading up to 1.5 m above the tank top or the top of the overflow, whichever is the greater;
③ buoyancy tanks for ACV, heading up to the highest damage water-line;
④ where testing using water is undesirable in drydock or on the building berth, water pressure testing may be carried out afloat. However the underwater body of the hull and those portions of the hull which are unable to be inspected after launching, are to be inspected with appropriate means prior to launching.
(3) The water head test required by (2) above may be substituted by air test. The air pressure is raised to 0.02 MPa, and this pressure is to be maintained for 1 h to stable condition, then lower the air pressure to not less than 0.015 MPa test pressure. After that, soapy water solution is to be applied to the welds for detecting leakage.
(4) Walls for pantry, toilet, washroom and battery room are to be subjected to the filling water test whose heading is up to the top of their sills.

3.3.4.2 Tightness test for machineries
(1) Tightness test for machineries, pressure vessels and piping is to be carried out after installation.

The duration of test is in general to be 3 to 5 min, with the test pressure as required in Chapter 6 of the Rules.

3.3.4.3 Inclining test

(1) When construction is finished, each craft is to undergo an inclining test to determine the elements of its stability, and the information thereon is to be provided to the master of the craft, which will enable him to assess with ease the stability of his craft in different service conditions. The conditions and requirements for the inclining test and the assessment of test results are to comply with the requirements of the Administration of the flag State. Where no requirements are made by the Administration of the flag State, the requirements of the guidelines formulated by CCS in accordance with the relevant provisions of IMO are to be complied with.

(2) The inclining test of a craft may be dispensed with by CCS subject to agreement of the flag State Administration where the craft's basic stability data are available from the inclining test of a craft of the same type or reference to existing data for similar craft clearly indicates that due to the craft's proportions and arrangements more than sufficient metacentric height will be available, or the craft is of special type that more than sufficient metacentric height will be available in all probable loading conditions, or it is impracticable to carry out an accurate inclining test. In such a case, the lightship displacement and center of gravity are to be determined by lightship weight survey and accurate calculation.

3.3.4.4 Mooring and sea trials are to be carried out in accordance with the approved test programme.

3.3.5 Documents and reports

3.3.5.1 Manufacturers are to submit relevant inspection, testing, measuring reports and records to the Surveyors and the owners.

3.3.5.2 The Surveyors are to prepare various survey reports, records, data and relevant certificates for the craft's hull and equipment, machinery, electrical installations, on completion of inspection, testing and examination of the reports and records submitted by the manufacturers, in the forms specified by CCS.

3.3.5.3 The plans and data, specifications, operation manual, certificates, reports, records, loading manual, stability information and other guidelines related to the craft are to be kept on board the craft.

3.3.5.4 In general, the date of completion for surveys is to be recorded as that for construction. The other important dates for the craft, e.g. the signing date of construction contract, the date of the keel laid, the date of launching and the date of delivery are also to be recorded.

Section 4 Surveys after Construction

3.4.1 General requirements

3.4.1.1 For the purpose of maintaining the validity of certificates, craft which have been classed with CCS are to be subject to various surveys as specified in this Section, as appropriate.

3.4.1.2 If any damage or defect affecting the validity of certificates is found at any of the surveys mentioned above, the Surveyor is to inform the owner or his representative of the recommendations in time when he deems necessary. When such recommendations are not dealt with, the Surveyor is to report to the Headquarters of CCS immediately.

3.4.1.3 It is the responsibility of the owners to ensure that they are to apply for all surveys to CCS necessary for the maintenance of the validity of certificates and to provide preparations and means of safety for surveys in accordance with the requirements of the Rules.

3.4.1.4 Reclassification

(1) When reclassification is requested by the owner for a craft for which class previously assigned by CCS has been withdrawn, CCS will carry out a survey as required for an initial classification survey. If at such a survey the craft is found in a good and efficient condition, CCS will reassign such class to it. The date of reclassification will be recorded in the Register of Ships.

3.4.1.5 Reinstatement of class

(2) When reinstatement of class is desired for a craft for which the class previously assigned by CCS has been suspended, CCS will carry out a survey appropriate to the circumstances of the case. If at such a survey the craft is found in a good and efficient condition, CCS will reinstate the original class. After reinstatement of class, such surveys are to be credited from the date originally due. However, the craft is disclassed from the date of suspension until the date class is reinstated.

3.4.1.6 Damage and repair surveys

(1) Any damage to hull, equipment or machinery (including electrical installations), which could invalidate the conditions for which a class has been assigned, is to be reported to CCS without delay. CCS will appoint the Surveyor(s) boarding a craft in time to carry out damage surveys at a suitable port where the craft arrives on its voyage. And scope of the survey is to be that considered by the Surveyor(s) necessary for ascertaining the extent and cause of the damage.

(2) All repairs to hull, equipment or machinery (including electrical installations) involving the craft's class are to be made under the supervision of the Surveyor(s). If repairs are effected at a place where services of a Surveyor to CCS are not available, CCS is to be informed in time by the owner/company.

3.4.1.7 Alteration or modification surveys

(1) Plans and particulars of any proposed alternations or modifications to the approved scantlings and arrangements of hull, equipment or machinery (including electrical installations) are to be submitted to CCS for approval. Such alterations or modifications and related items are in general to comply with the provisions of the present rules of CCS or at least the requirements of previously applicable rules.

3.4.1.8 Statutory surveys as authorized

(1) For a craft applying for class of CCS and at the same time CCS is authorized for statutory surveys of the same craft, CCS may carry out classification survey in conjunction with statutory surveys.

(2) The survey requirements for stability, fire safety and its associated portable equipment are to comply with the provisions of the Administration of the flag State.

3.4.2 Type and interval of surveys

3.4.2.1 Annual surveys

(1) Annual surveys are to be carried out on all high speed craft within 3 months before or after each anniversary date of the date of completion, commissioning or the expiry date of certificate issued after special survey, as appropriate.

3.4.2.2 Intermediate surveys

(1) Intermediate surveys are to be carried out on all high speed craft at either the 2nd or 3rd annual survey after the date of completion, commissioning or special survey, as appropriate. If an intermediate survey is carried out to coincide with an annual survey, such an intermediate survey may replace this annual survey.

3.4.2.3 Examinations of the outside of the craft’s bottom (hereinafter referred to as docking surveys)

(1) Docking surveys of high speed craft are to be carried out once a year, and within 3 months before or after the due date of the docking survey. The next survey is to be dated from the craft’s undocking date. If an up-to-slipway examination of the outside of the craft’s bottom is carried out, the next survey is to be dated from the date of completion of the examination. The docking survey may be carried out in conjunction with an annual survey.

(2) For the intervals of docking surveys of high speed craft, attention is also to be paid that the Administration of the flag States may have additional requirements.

(3) The interval of docking surveys may be shortened depending on the condition of the underwater portion of the hull and the interval of special surveys.

3.4.2.4 Special surveys

(1) Unless expressly provided otherwise，special surveys of hull and machinery (including electrical installations) are to be carried out at an interval not exceeding 5 years after completion, commissioning or the previous special survey of the craft.

(2) The special survey may be commenced at the annual survey prior to its expiry date and be progressed during the succeeding year with a view to completion by its expiry date. However minor defects of individual items may be removed within 3 months after the expiry date of certificate. In such a case, the date of next special survey is to start from the expiry date of the previous special survey.

(3) Where the owner is not able to arrange the special survey by its expiry date, CCS may grant an extension not exceeding 3 months upon the owner’s request, provided that a written application is

received before the expiry date and that the statutory certificate and examination of the outside of craft's bottom allow such an extension. In such a case, the date of next special survey for class is to start from the expiry date of the previous special survey before the extension was granted.

3.4.2.5 Surveys of screwshaft, tube shaft and waterjet units

(1) Unless expressly provided otherwise, surveys of screwshaft, tube shaft and waterjet units of all craft to be carried out and the interval between the surveys are to be in accordance with the requirements in 3.4.7 of this Section.

3.4.2.6 Continuous surveys

(1) At the request of the owner and with the consent of CCS, all examination and test items of the special survey of the machinery (including electrical installations) may be carried out on the continuous survey basis.

(2) When the continuous surveys are carried out, the various items for special survey of the machinery (including electrical installations) are to be examined in rotation, evenly distributed within the cycle of the special survey (5 years).

(3) The longest interval between consecutive examinations of each item is not to exceed 5 years. All items to be inspected are to be submitted to CCS for examination after opening and cleaning, as in the special survey. Control, alarm and safety systems, in general, are to be checked only by operation test or simulation test.

(4) At the request of the owner, the chief engineer of the craft with authorization from CCS may examine the items as authorized by CCS. On completion of the examination, the chief engineer is to make an entry in continuous survey report about the items examined by him and a confirmatory survey is to be applied for at the next port of call where the Surveyors to CCS are available and also a report in writing in this regard is to be submitted.

(5) CCS at its discretion, or the owner in view of the implementation of the continuous survey system, may terminate this system and apply special survey.

3.4.2.7 Survey of planned maintenance scheme (PMS) for machinery

(1) For machinery and installations which are subject to planned maintenance and with the consent of CCS, the survey of planned maintenance scheme may be introduced to replace the special or continuous survey, provided that:

① a maintenance plan for all machineries, installations and equipment on board the craft is approved by CCS;

② crew members implementing the plan are to follow the approved maintenance plan, carry out planned maintenance and make relevant records;

③ the records for implementing planned maintenance are to be examined once every year to confirm that the plan is well implemented.

(2) When it is found upon examination of the records that the planned maintenance is not able to fully meet the requirements for survey after construction, the implementation will be canceled. Special surveys or continuous surveys will then be carried out in this regard.

(3) For details of the survey of planned maintenance scheme (PMS) for machinery, see Appendix 16 to Chapter 5 of CCS Rules for Classification of Sea-going Steel Ships and Appendix 10 to Chapter 5 of CCS Rules for Classification of Sea-going Ships Engaged on Domestic Voyages.

3.4.2.8 Occasional surveys

(1) Occasional survey means any surveys other than the periodical surveys. This type of survey may be defined as occasional surveys for hull, machinery, electrical installations and automatic and remote control systems according to the different parts of a craft to be surveyed.

(2) The Owner or his representative is to apply for an occasional survey in either of the following conditions:

① changes of a craft's name, port of registry, flag and owner or manager;

② an accident of sea damage or mechanical damage to a craft which affects its classification;

③ alteration of a craft's intended purpose or service area;

④ any repairs or modifications or replacements involved in the classification of a craft;

⑤ postponement of surveys or outstanding recommendations.

(3) Occasional survey may be overall or partial on basis of conditions to ensure that maintenance and any renewal have been efficiently carried out and the craft and its equipment are continuously fit for the service for which the craft is intended.

(4) After completion of occasional survey, the craft's classification certificate is to be endorsed correspondingly.

3.4.2.9 Miscellaneous

(1) Craft laid up for 12 months and above without annual survey are to be subject to an annual survey prior to recommissioning. And in addition, the machinery installations are to be subject to a sea trial.

(2) Craft are to be subject to an annual survey during the laid-up period.

(3) Where the special survey is due during the laid-up period exceeding 12 months, a new special survey is to be carried out prior to recommissioning, the period of which is to start from the completion date of the survey.

3.4.3 Surveys for hull

3.4.3.1 Annual surveys. The following applicable items for hull and equipment are to be examined by the Surveyor to confirm that they are in an efficient technical condition:

(1) main hull above design waterline, and superstructures, deckhouses, companionways, and all openings and hatchways and their weathertight closing appliances, confirming the effectiveness of closing of stern doors (if applicable);

(2) watertight integrity of watertight bulkheads in main hull and their watertight doors, indicators for closing of watertight doors;

(3) side scuttles, windows and deadlights;

(4) freeing ports, bulwarks, guard rails and other means for the protection of the crew;

(5) ventilators and air pipes and their closing appliances;

(6) the portions acted by larger slamming pressure of the main hull, and the structural integrity of cross deck bottom and joints between each hull and cross deck for multihull craft;

(7) watertightness of buoyancy tanks for ACV;

(8) integrity of fore/aft skirts of ACV, and their connection with the hull;

(9) integrity of flow channels for lift fans of ACV;

(10) riveting quality, whether there are relaxation and seepage.

3.4.3.2 Intermediate surveys. In addition to the annual survey items listed in 3.4.3.1, the Surveyors are to examine the following applicable items and to confirm that they are in an efficient technical condition.

(1) For craft not exceeding 5 years of age:

① general examination of sea water ballast tanks, sea suctions in engine room, etc.;

② examination of anchoring and mooring equipment, partial test of slipping and hauling anchors by windlass.

(2) For craft exceeding 5 years of age

① survey items listed in (1) above;

② for high speed craft with metal hull, the thickness measurement for hull plating may be required as deemed necessary by the Surveyor. When necessary, the renewal of plating is to be carried out, and recorded.

3.4.3.3 Special surveys. In addition to the items listed in 3.4.3.1 and 3.4.6, the following applicable items are to be examined by the Surveyor.

(1) Special survey No.1 (for craft not exceeding 5 years of age):

① Engine room, cargo holds, passenger spaces and other spaces, including superstructures and deckhouses, are to be carefully examined after cleaning. Special attention is to be paid in positions likely to sustain corrosion, impact, wear, etc.

② Special attention is to be paid to discontinuities of structures, or to openings in strength deck and side walls of superstructures, especially high stress areas in way of connection between catamaran hulls and cross-deck, as well as stress concentration at the front mouth of hulls of wave piercer craft.

③ Tanks for carriage of fresh water, sea water, fuel oil and lubricating oil are to be pressure tested with the maximum water head which they might have to sustain under service conditions.

④ Anchors and chain cables or anchor ropes are to be inspected, and the chain cables are to be drawn out for examination.

⑤ Mooring lines are to be examined.

⑥ The connection of the passenger's seats to the deck is to be examined, especially for the hull structure made of F.R.P.

(2) Special survey No.2 and subsequent special surveys (for craft exceeding 5 years of age):

① Survey items listed in (1) above.

② Chain locker and all cofferdams are to be internally examined.

③ Anchors and chain cables or anchor ropes are to be examined, when the diameter of a link is reduced by 12% or more from its nominal diameter required in the Rules, the link is to be renewed, and when necessary, anchor ropes are to be renewed.

④ For steel high speed craft, thickness measurement is to be taken of the following positions: suspect areas and at least one (at special survey No.2) or two (at subsequent special surveys after special survey No.2) transverse sections within 0.5*L* amidcraft; for aluminum high speed craft, thickness measurement is to be carried out as deemed necessary by the Surveyor, and according to the results of thickness measurement, the renewal of plating is to be carried out when necessary, and recorded.

⑤ The lightweight of a high speed passenger craft is to be verified, and the passenger craft is to be re-inclined whenever, in comparison with the approved stability information, a deviation from the lightweight displacement exceeding 2% of that recorded previously, or a deviation of the longitudinal center of gravity exceeding 1% of *L* is found.

3.4.4 Surveys for machinery

3.4.4.1 Annual surveys

(1) For the interval of annual surveys, see the relevant provisions in 3.4.2.1 of this Section.

(2) At each annual survey, the Surveyor is to confirm that the following items are in an efficient technical condition:

① propulsion machinery, shafting, lift device, stabilization device and auxiliary engines for essential services are to be generally examined, and when considered necessary by the Surveyor, certain items may be required to be opened for examination;

② a general examination is to be carried out for confirming that there is no existence of any fire and explosion hazards in machinery spaces;

③ escape routes for machinery spaces are to be free from obstruction;

④ directional control system and stabilization system are to be examined under working condition.

⑤ all means of communication between the navigation bridge and machinery space, steering gear compartment and fire control station are to be tested;

⑥ bilge pumping systems and bilge wells including operation of pumps, extended spindles and level alarms, where fitted, are to be examined as far as practicable;

⑦ thermal oil unit, pressure vessels and their safety devices are to be externally inspected;

⑧ quick-closing valves of oil tanks are to be operating tested;

⑨ a general examination of fixed fire-extinguishing system (including CO_2, dry powder, etc.) is to be carried out as follows:

a. examination of piping system, control system, marking and operation instructions;
b. examination of ventilation, lighting, communication, instruments, etc., in station;
c. external examination of fire-extinguishing medium containers, valves, etc.;
d. measurement of remaining quantity of fire-extinguishing medium and test of piping system at two-yearly intervals.

3.4.4.2 Intermediate surveys

(1) For the interval of intermediate surveys, see the relevant provisions in 3.4.2.2 of this Section.

(2) At each intermediate survey, the requirements of the annual survey as specified in 3.4.4.1 of this Section is to be carried out.

3.4.4.3 Special surveys

(1) For the interval of special surveys, see the relevant provisions in 3.4.2.4 of this Section.

(2) The requirements for annual survey as specified in 3.4.2.1 of this Section are to be complied with.

(3) In addition, the following items are to be completed at each special survey:

① Diesel engine

a. Cylinders, cylinder covers, valves and their transmitting gear, pistons, connecting rods, crankshaft and all bearings, crankcases, bedplates, entablatures, crankcase door fastenings and explosion relief devices, superchargers and their associated coolers, fuel pumps and fittings, camshafts and their transmitting gear together with balance weights, torsional vibration dampers or detuners, flexible couplings, clutches, reverse gears, attached pumps and cooling arrangements are to be opened for examination.

b. Selected portion of pipes in the starting air system is to be removed down for internal examination.

② Gas turbine

a. The following parts are to be opened up for examination:

impellers or blading, rotors and casings of the air compressors, the combustion chambers, burners, intercoolers, heat exchangers, gas pipes and air pipes with attachments, starting and reversing arrangements.

③ Intermediate shaft, thrust shaft and their all bearings

Where the alignment of shafting and wear clearances of bearings are found in normal condition, the lower half bushes of the bearings are not to be turned out for examination.

④ Reduction gears are to be opened up for examination, including their wheels, pinions, racks, shafts, bearings, thrust bearings and clutches.

⑤ Auxiliary engines, including air compressors and their intercoolers and safety devices, and all pumps for essential service are to be opened up for examination.

⑥ Air receivers and other pressure vessels for essential service together with their mountings, valves and safety devices are to be internally and externally examined after cleaning. Safety valves are to be adjusted. Where air receivers cannot be internally examined, the hydraulic test with the pressure 1.3 times the working pressure is to be carried out.

⑦ Directional control system and stabilization system, including associated equipment and control system, are to be examined for confirming that they are in good working condition.

⑧ Windlass and its driving unit are to be examined and operating tested.

⑨ Bilge system is to be examined and tested under working condition. Valves, valve chests or cocks, strainers and mud boxes are to be opened for examination as deemed necessary by the Surveyor.

⑩ Ballast system is to be examined and tested under working condition. Valves, valve chests or cocks are to be opened for examination as deemed necessary by the Surveyor. Attention is to be paid to blanking arrangements on deep tanks used for both cargo and ballast.

⑪ Fuel oil, lubricating oil and cooling water systems together with pressure filters, heaters and coolers are to be opened up for examination or test.

⑫ Propulsion machinery is to be tested under working condition. Control systems of essential machineries are to be tested for confirming that they are in good working condition.

⑬ Fuel oil tanks constructed not forming part of hull structure are to be internally and externally examined. Internal examination may be dispensed with where external examination is satisfactorily carried out at special survey No.1.

3.4.4.4 Other methods in lieu of surveys

(1) For craft implementing the planned maintenance scheme (PMS) specified in 3.4.2.7 and approved by CCS, the survey of planned maintenance scheme may be introduced to replace the survey items for machinery.

3.4.5 Surveys for electrical installations

3.4.5.1 Annual surveys

(1) For the interval of annual surveys, see the relevant provisions in 3.4.2.1 of this Section.

(2) At each annual survey, the Surveyor is to confirm that the following items are in an efficient technical condition:

① All means of communication between the navigation bridge and machinery space and where fitted, emergency steering positions are to be tested.

② Electric machineries, switchboards, switchgear and other electrical equipment are to be generally examined. They are to be examined under operating condition as practicable.

③ Examining, in general, that the precautions provided against shock, fire and other hazards of electrical origin are being maintained.

④ All emergency power sources (including temporary emergency power sources) are to be function tested, and integrity of emergency lighting or temporary emergency lighting is to be checked. Where emergency power sources are provided with automatic power supply, the test is to be carried out in automatic mode;

⑤ Main and auxiliary steering gears are to be running tested, and the reliability of alarms indicating failures of power supply, A.C. phase supply, etc., of steering gears are to be verified.

⑥ Navigation lights are to be tested under working condition to verify correct indication and alarm on failure of power supply or of the lights.

⑦ Fire (or smoke) detection system is to be tested.

⑧ General alarm system is to be function tested.

⑨ Remote controls for stopping fans and for shutting off fuel oil supplies in machinery spaces are to be examined as far as practicable.

⑩ Electrical equipment in dangerous spaces such as paint room, battery room, etc., are to be examined to confirm that they are suitable for such spaces, are in good condition and are being properly maintained.

⑪ Remote control, alarm monitoring and safety systems are to be generally examined.

⑫ All cables are to be examined as far as practicable, and electrical installations or protective casings are to be examined to verify that they are without improper breakage. The insulation resistance of cables and main electrical equipment (such as switches, generators, heaters, lighting fixtures, etc.) is to be measured, and the measurement of insulation resistance may be carried out section after section.

3.4.5.2 Intermediate surveys

(1) For the interval of intermediate surveys, refer to the relevant provisions in 3.4.2.2 of this Section.

(2) The relevant requirements in 3.4.5.1 (2) of this Section are to be complied with.

3.4.5.3 Special surveys

(1) For the interval of special surveys, refer to the relevant provisions in 3.4.2.4 of this Section.

(2) The relevant requirements in 3.4.5.1(2) of this Section are to be complied with.

(3) In addition, the following items are to be dealt with at each special survey:

① The fittings on main and emergency switchboards, section boards and shunt fuse panels are to be examined and over-current protective devices and fuses verified to confirm the proper protection respectively.

② Air circuit breakers of generators are to be tested to verify satisfactory operation of protective devices.

③ Main generators are to be running tested separately and in parallel under work load conditions, and prime mover governors and load sharing are to be examined.

④ Motors and their controls for essential services are to be examined and if considered necessary, to be operated under working conditions in so far as practicable.

⑤ The clearance in the electromagnetic clutches (if fitted) is to be examined and recorded, and where excessive off-center is found, calibration is to be made. The clutches and controls are to be examined and tested.

3.4.6 Docking or up-to-slipway surveys

3.4.6.1 At time of survey, the craft's shell is to be cleaned, and necessary conditions for execution of the survey are to be provided. At docking survey, the following items are to be examined:

(1) shell plating, especially corrosion of shell plating at stern above propeller and close to rudder, is to be carefully examined, and extensive areas of wastage are to have thickness measurement taken, and when necessary, the renewal of plating is to be carried out, and recorded;

(2) corrosion of propeller and rudder blades, especially cavitation corrosion;

(3) inner shell plating at top of twin hull (or side wall) cross deck of catamaran and SES;

(4) sea valves, sea valve chest, discharges and their connections to the shell including fastening and the gratings at the sea inlets;

(5) examination of rudders, measuring the clearances in the rudder bearings, and examination of tightening nuts, pins and bolts for rudder blades and rudder stock; examination of horizontal flange for connecting rudder stock to rudder blades with welding and the connection of flat plate rudder to rudder stock with welding by effective means of detection.

(6) examination of propeller, waterjet unit and other auxiliary propulsion arrangements, measuring the clearance in the propeller bearings, and inspecting the effectiveness of the oil gland, and examination of the skip bucket of waterjet unit and the gratings at the sea inlets;

(7) examination of shell corrosion protection system and coating including sacrificial anode-zinc slab fixing and corrosion condition;

(8) examination of earthing;

(9) general examination of damage status of skirts and their connection with the hull for ACV;

(10) examination of hydrofoils, pillars and their connections with the hull for hydrofoil craft;

(11) careful examination of leakage of fiberglass reinforced plastic (FRP) shell plating due to chafing and breaking for high speed craft with hull made of FRP, and examination of the forebody side and bow impacted by sea waves;
(12) examination of fins (if any);
(13) verification of damage or crack of shell plating in the connections of the bottom of propeller shaft bracket to the hull.

3.4.7 Surveys of screwshaft, tube shaft and waterjet unit

3.4.7.1 Interval of surveys
(1) Shafts with keyed propeller attachment and fitted with continuous liners or approved oil glands, or made of approved corrosion-resisting materials, are to be surveyed at an interval of 5 years provided that the keyway complies with the present Rules.
(2) Shafts with keyless propeller attachment are to be surveyed at an interval of 5 years provided that they are fitted with approved oil glands or are made of approved corrosion-resisting materials.
(3) Shafts having solid coupling flanges at the after end are to be surveyed at an interval of 5 years provided that they are fitted with approved oil glands or continuous liners or are made of approved corrosion-resisting materials.
(4) Shafts other than those prescribed in (1) to (3) above are to be surveyed at least twice within 5 years with an interval not exceeding 3 years.
(5) Side thrusters are to be surveyed at an interval not exceeding 5 years.
(6) Water jet propulsion arrangements for main propulsion purpose are to be surveyed at an interval not exceeding 5 years provided that they are of approved type.

3.4.7.2 Extent of surveys
(1) The following items are to be carefully examined with withdrawal of the screwshaft:
① shafts, liners (especially for butt joints and ends), keyways, shaft cones, fillets of flanges;
② crack detection method is to be made in way of the after end of cylindrical portion of screwshaft, forward portion 1/3 length of shaft cone or keyways;
③ non-destructive examination is to be made in way of fillets of flanges where a solid coupling flange is connected to the after end of the shaft;
④ sterntube and oil gland are to be examined;
⑤ clearance and wastage of bearings are to be measured before withdrawal and after installation of shafts, and recorded;
⑥ fit condition of the propeller and screwshaft cone is to be examined.
(2) Side thruster is to be generally examined as far as practicable, and tested under working conditions when the craft is under floating condition.
(3) Water jet propulsion arrangements are to be dismantled for examining impeller, shaft, shaft bearing, inlet and outlet channels, guiding nozzles, reversion units and control gear, and measuring the clearance between impeller and guide duct.
(4) Water lubricated bearings are to be examined.
(5) Low level alarm device for oil tank and device for measuring temperature (if fitted) of oil lubricated bearings are to be examined.

Section 5 Classification Survey for First Entry of Existing Craft

3.5.1 General requirements

3.5.1.1 For the purpose of this Chapter, existing craft cover the following craft which have been put in service:

(1) craft which have been surveyed by IACS members before assignment of class;

(2) craft which have been surveyed by the survey organizations accepted by non-IACS members or CCS before assignment of class;

(3) non-classed craft which have been surveyed by CCS before assignment of class.

3.5.2 Initial surveys of craft which have been surveyed by IACS members

3.5.2.1 Plans and documents

(1) When applying for an initial survey, the owner is to submit at least one copy each of following plans and documents to CCS for check:

① Hull:

a. General arrangement;

b. Principal transverse structure sections;

c. Construction profile;

d. Typical structural details;

e. Strength calculations , including hull girder strength and local strength);

f. Direct calculations for hull structure (if any);

g. Superstructure and deckhouse construction;

h. Main bulkhead construction;

i. Vehicle ramp or stern door construction (if any);

j. Arrangement, construction and material of all doors, windows and covers, including the calculations for heights of coaming of exposed doors and covers, and thickness calculations and joint calculations of window glass,

k. Shell expansion;

l. Configuration, construction and strength calculations of rudder, including rudder blade, rudder stock, rudder carrier and connections;

m. Arrangement of anchoring and mooring equipment.

② Machinery (including electrical installations):

a. Engine room arrangement;

b. Bilge piping;

c. Fuel oil pipes;

d. Parts of shafting;

e. Torsional vibration calculations of propelling shafting (for craft less than 2 years of age);

f. Calculations of prefastening force when blades of air-propeller are fastened;

g. Oil shrink fitting of propeller with calculations;

h. General arrangement of steering gear;

i. Control systems of rudder equipment/water-jet propulsion arrangement;
j. Technology specifications and arrangement of stabilization device;
k. Electric power system;
l. Internal alarm system with arrangement;
m. Schematic diagram and arrangement of emergency lighting.

③ Additional plans required for periodically unattended machinery space:
a. Checklist of measuring instruments and alarms;
b. Fire alarms;
c. Diagram of automatic functional tests.

(2) Any other plans and documents required by the Administration of the flag State.

(3) Where the plans and documents can not be submitted according to the above-mentioned requirements, CCS may accept other relevant technical information as equivalent.

3.5.2.2 Extent of surveys

(1) Hull:

① An annual survey is to be carried out.

② The latest dry-dock survey report of the losing classification society may be accepted by CCS if found in compliance with the actual condition.

(2) Machinery (including electrical installations):

① insulation resistance is to be measured, generator circuit breakers, preference tripping relays and generator prime mover governors are to be tested and paralleling and load sharing to be proved;

② navigating lights and indicators are to be examined and their working and alternative sources of power verified;

③ remote controls for bilge pumps, lubricating oil pumps and forced draught fans are to be examined and tested under working conditions;

④ the main and all auxiliary machinery necessary for operation of the craft at sea together with essential controls and steering gear/water-jet propulsion arrangement is to be examined and tested under working conditions. Steering gear/water-jet propulsion arrangements are to be alternatively tested. A sea trial may be held if the craft has been laid up for a long period;

⑤ initial start arrangement s are to be verified.

(3) Any remaining recommendations/conditions of class are to be dealt with by their due dates except not required by the Rules.

(4) After the surveys stated in (1) and (2) above, the interval between surveys is to be corresponding to that of the losing society.

3.5.3 Initial surveys of craft which have been surveyed by non-IACS members

3.5.3.1 Plans and documents: Plans and documents are to be submitted at least one copy each of plans and documents mentioned in 3.5.2.1(1) to CCS for check.

3.5.3.2 The extent of surveys: special survey, docking survey and survey of screwshaft and tube shaft are to be carried out in accordance with the requirements of the Rules for craft of the same type and age.

3.5.4 Initial surveys of non-classed craft which have been surveyed by CCS

3.5.4.1 The classification certificate can be issued after confirming, upon examination, that the requirements relative to assignment of the characters of classification and class notations for which a craft applies have been complied with.

3.5.4.2 When the owner intends to add class notation or alter service area, the corresponding plans and documents are to be submitted for approval, and the classification certificate can be issued after review and confirmation of the plans and documents.

3.5.4.3 If there are outstanding recommendations which affect the classification of a craft, an occasional survey is to be carried out, and the classification certificate can be issued after confirming that the outstanding recommendations have been dealt with.

Section 6 Survey of Craft in Lay-up

3.6.1 General requirements

3.6.1.1 When a craft stops trading and is put out of commission for a certain period, i.e. is laid-up, the normal survey requirements may no longer apply provided that the owner notifies CCS of this fact. The owner is also to submit a lay-up maintenance program to CCS for approval.

3.6.1.2 The lay-up maintenance program includes:
(1) the safety conditions to be kept through the lay-up period;
(2) the measure taken to preserve the maintenance of the craft through the lay-up period;
(3) the survey requirements to be complied with for lay-up, maintenance of class in lay-up and re-commissioning..

3.6.2 Safety conditions

3.6.2.1 Adequate power supply is to be supplied, or readily available, all around the clock, wither from independent means on board the craft or from shore.

3.6.2.2 Watch personnel are to be provided. The number of the watch personnel will depend on the size of the craft, the lay-up site and mooring arrangements, the shore assistance available in case of fire, leakage or flooding, the maintenance required to provide adequate preservation. A necessary craft-to-shore communication installation is also to be available.

3.6.2.3 The following requirements for fire protection and fire fighting are to be complied with:

(1) automatic fire alarm systems, where provided, are to be in working order and in operation;
(2) fire-fighting installations are to be tested regularly and readily available;
(3) fire main is to be readily available and periodically tested under pressure;
(4) ventilation trunks, air inlets and watertight doors are to be kept closed.

3.6.2.4 The following requirements for protection against explosion are to be complied with:
(1) Piping systems are to be cleaned and ventilated to prevent gas from forming any pockets.
(2) All flammable materials, sludges, etc., are to be removed from the craft's bilge wells, tank tops, double bottom tanks, engine room and similar spaces. Hot work is not to be carried out during lay-up, unless special precautionary measures are taken.

3.6.2.5 The following requirements for safety equipment are to be complied with:
(1) all the equipment usually recommended for the safety of the watch personnel is to be provided, kept in working order and tested regularly;
(2) the usual life-saving equipment such as liferafts, life-jackets and distress signals is to be provided and made accessible;
(3) the requirements of the flag State Administration and of the local port authorities of the lay-up site are usually to be applied.

3.6.2.6 Emergency power source, emergency generator and/or emergency air compressor are to be kept in a working condition and to be tested weekly.

3.6.3 Preservation measures for lay-up and maintenance

3.6.3.1 A lay-up log book is to be kept on board, in which the maintenance work and tests carried out during the lay-up period are to be entered with the corresponding dates. The nature and frequency of the maintenance, inspections and tests are also to be defined in the lay-up log book.

3.6.3.2 The appropriate measures for preservation and maintenance during the lay-up period are to be taken by the owners according to the type of craft, hull equipment, machinery installations and the specific cases of lay-up conditions.

3.6.4 Surveys

3.6.4.1 Laying-up survey
(1) At the beginning of the lay-up period, the owner is to apply for a laying-up survey.
(2) The scope of laying-up survey is to verify that the safety conditions, preservation measures, lay-up site and mooring arrangements are in accordance with the program agreed by CCS.
(3) Upon satisfactory completion of this survey, an endorsement to confirm that the craft has been placed in lay-up is entered on the classification certificate.

3.6.4.2 Annual lay-up condition survey
(1) When a craft is in laying-up condition, an annual lay-up condition survey is to be performed in lieu of the normal annual classification surveys to ascertain that the lay-up maintenance program

implemented is continuously complied with.
(2) It is to be checked that the arrangements made for the lay-up are unchanged and that the maintenance work and tests are carried out in accordance with the maintenance manual and recorded in the lay-up log book.
(3) Upon satisfactory completion of the survey, the classification certificate is endorsed.

3.6.5 Recommissioning survey

3.6.5.1 The owners are to apply for occasional survey and make the necessary arrangements to remove the temporary lay-up installations provided for preservation measures and the protective materials and coatings (oil, grease, inhibitors, desiccants) prior to recommissioning.

3.6.5.2 Scope of survey
(1) General requirements
① a general examination of the hull, deck fittings, safety systems, machinery installations and steering gear;
② all periodical surveys due at the date of recommissioning or which became overdue during the lay-up period.
(2) Survey items for hull
① shell plating above the waterline, deck plating and hatch covers;
② function tests of ballast tanks, bilge and ballast systems.
(3) Survey items for machinery installations
① the analysis of lubricating oil of main engines, auxiliary engines, reduction gears, main thrust bearings and sterntube;
② the general condition of crankcase, crankshaft, piston rods and connecting rods of diesel engines;
③ the crankshaft deflections of diesel engines. In addition when engines have been laid-up for more than two years, one piston is to be disconnected and one liner is to be removed for examination. Dismantling is to be extended if deemed necessary;
④ the condition of blades of turbines through the inspection doors;
⑤ the condition of condensers, heat exchangers and expansion arrangements;
⑥ the condition of reduction gears;
⑦ the condition after overhauling of relief valves;
⑧ the test of bilge level alarms, when fitted;
⑨ the examination of fire main under working pressure.
(4) The main and emergency electrical installations are to be tested. The parallel shedding of main generators and main switchboard safety devices are to be checked.
(5) Other survey items required by the Administration.

3.6.5.3 On completion of the above surveys, sea trials are to be performed in the presence of a Surveyor of CCS. The sea trials are to include:
(1) verification of the satisfactory performance of the deck installations, main propulsion system and essential auxiliary machinery, including a test of the safety devices;
(2) an anchoring test;

(3) complete tests of steering gear;
(4) full ahead and full astern tests;
(5) tests of automated machinery systems, where applicable.

3.6.5.4 Upon satisfactory completion of the surveys, an endorsement to confirm the carrying out of all relevant surveys, and the recommissioning of the craft is indicated on the classification certificate.

CHAPTER 4 STRUCTURE OF HULL

Section 1 General Requirements

4.1.1 Application

4.1.1.1 This Chapter applies to hull structures made of aluminum alloy, steel and fiber reinforced plastics for monohull high speed craft, various high speed catamarans (including normal catamaran, wave piercer craft and SES), hydrofoil craft, ACV, etc., except for SWATH and WIG craft.

4.1.1.2 High speed craft of novel structure design are to be specially considered and subject to agreement of CCS.

4.1.1.3 For craft with hull structures of material not covered in 4.1.1.1, its material and hull structural design are to be subjected to the consent of CCS.

4.1.2 Loads

4.1.2.1 The structure is to be capable of withstanding the static and dynamic loads and periodic excited vibration force acting on the craft under the critical design condition, and without being damaged by such loads.

4.1.2.2 Static loads are such as weights of occupants, vehicles, equipment, baggages and dry cargoes, static pressure of liquids in tanks, buoyancy of hull, static pressure of air-cushion, supporting force of slipway and lifting force.

4.1.2.3 Dynamic loads are such as inertial force of a craft motion in waves, slamming pressure, supporting dynamic pressure of air-cushion, lifting force of hydrofoil and impact force during a landing of ACV.

4.1.2.4 Periodic excited vibration force primarily means the force generated by the periodic turning of main engines and propellers.

4.1.3 Definition

4.1.3.1 “Primary member” means the primary supporting members of hull, such as girders, keels, web beams, plate floors, etc.

4.1.3.2 “Secondary member” means the secondary supporting members of hull, such as longitudinals, beams (transverses), etc.

4.1.3.3 “Design load P (kN/m^2)” means the design value of positive pressure withstood at unit area by various strength members in local strength calculation of hull.

4.1.3.4 "Spacing of members s (m)" means the spacing of secondary members for secondary members, and the average breadth of supporting load area for primary members.

4.1.3.5 "Span of members l (m)": For secondary members, where there are no end brackets, the span points are to be taken at the ends of the member. Where end brackets are fitted, the span points may be taken at half length of the brackets. Primary members are usually fitted with end brackets, and the span point is to be, as shown in Figure 4.1.3.5a, taken at a point distance, k_e, from the end of the primary member, where:

$$k_e = k_b \left(1 - \frac{d_w}{d_b}\right)$$

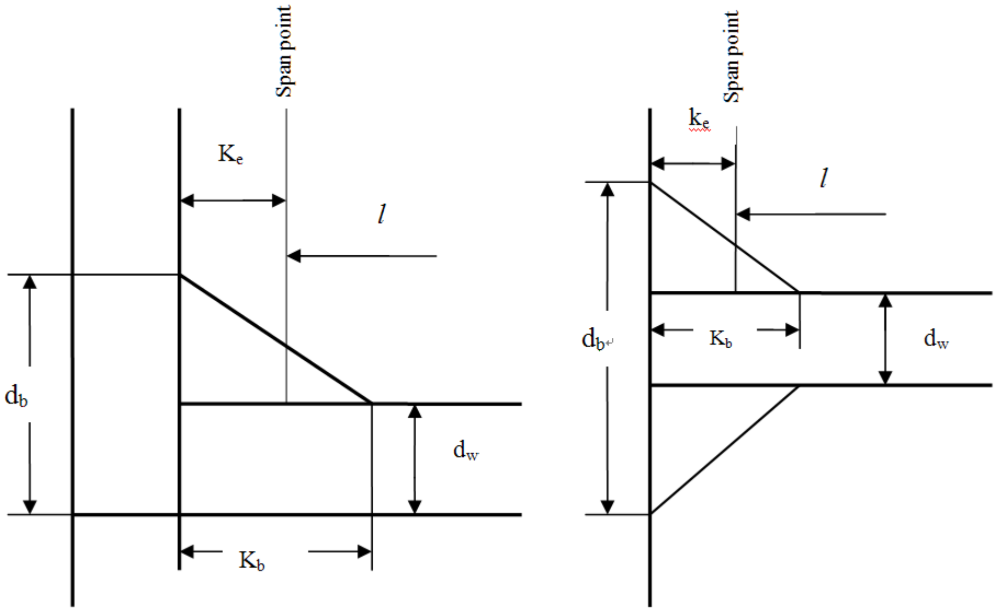


Figure 4.1.3.5a

If primary members are supported by pillars, the supporting points may be taken as the span points of primary members.

4.1.3.6 "Load point" for which the design pressure is to be calculated is defined for various strength members as follows: For vertical plates subject to non-uniformly distributed loading, the point is to be taken at the lower edge of the plate. For secondary members, in general, the point is to be taken at the midpoint of span, and when the pressure on the member varies other than linearly, the design 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, the point is to be taken at midpoint of load area.

Section 2 Structure Design Principles

4.2.1 General requirements

4.2.1.1 Longitudinal framings are generally adopted for hull structures of monohull craft or hydrofoil craft. Mixed framings are generally adopted for hull structures of various catamarans, of which the two hulls are longitudinal framings and cross decks are transverse framings.

4.2.1.2 Spacing of longitudinals for longitudinal framings or of transverse beams for transverse framings is not to be more than 500 mm in general.

4.2.1.3 Longitudinal members of longitudinal framings are to be continuous. Where the longitudinal secondary members are cut in way of bulkheads, connecting brackets are to be provided as to ensure the longitudinal continuity. The longitudinal secondary members and the brackets at both sides of the bulkheads are to be in line.

4.2.1.4 Transverse members of transverse framings are to be continuous as far as practicable. Where the transverse secondary members are cut in way of bulkheads or longitudinal primary members, connecting brackets are also to be provided, and the members and the brackets are to be in line.

4.2.1.5 The plate floors are to be effectively connected with the side web frames and deck transverses in the same section.

4.2.1.6 Where holes for the passage of pipes or cables are cut in primary members, they are to have rounded corners. If holes have a depth greater than 1/3 of web depth of girder or deck transverse, they are to be strengthened. However, openings and holes are not to be cut at ends of the members mentioned above.

4.2.1.7 The scantlings and arrangement of structural members may be determined by the design unit according to the finite element analysis for plane plated grillage or space rigid frame or other theoretical calculations, however the plate thickness is still to comply with the minimum thickness requirements, and the data necessary for calculation are to be submitted to CCS for approval.

4.2.2 Bottom, cross deck, side and deck structures

4.2.2.1 The bottom girders are to comply with the following requirements:
(1) Bottom longitudinal girders taken into account in hull girder strength are to be continuous and to pass through transverse watertight bulkheads.
(2) Holes are not permitted in way of the girder ends within 1.5 times the height of the girders from bulkheads.
(3) Girders under the main engine seatings are to be extended directly from the bottom to the top plate of the engine seating, and suitable measures for strength and tripping are to be taken.
(4) Girders in way of the thrust bearing are to be strengthened.

4.2.2.2 The plate floors are to be fitted on each frame in the engine room, additional strengthening is to be provided in way of the thrust bearing.

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

4.2.2.4 The height of web plates of bottom floors is not to be less than 2.5 times that of the holes which longitudinals pass through; the height of web plates of side frames and deck transverses is not to be less than 2.2 times that of the holes which longitudinals pass through.

4.2.2.5 The shell plating over the propeller and in way of the rudder post is to be suitably strengthened.

4.2.2.6 The passenger's seats are to be efficiently connected to the deck, and the deck is to be capable of withstanding the impact force acted by passenger's seats when the craft encounters in high speed collision.

4.2.2.7 The span of the cross deck between two hulls of the wave piercer craft is relatively large so the transition is to be made by large brackets in the connections of the cross deck to two hulls and the symmetric positions of two hulls, to avoid stress concentration resulting from abrupt change in structure. The plate thickness and scantlings of members in such positions are to be appropriately increased. The scantlings may be determined by direct calculations in Section 10 of this Chapter.

4.2.2.8 Where there are large openings in the strength deck (such as sunken openings in engine room or cabin) and the corners of openings are parabolic or elliptical, the requirements as shown by Figure 4.2.2.8(1) are to be complied with. Where the corners of openings are rounded, insert plates are required, and the radius of the rounded corner is not to be less than 1/20 of the breadth of the opening. The dimensions of the insert plates are to be as shown in Figure 4.2.2.8(2). The thickness of the insert plate is not to be less than 1.5 times the thickness of strength deck plating in way.

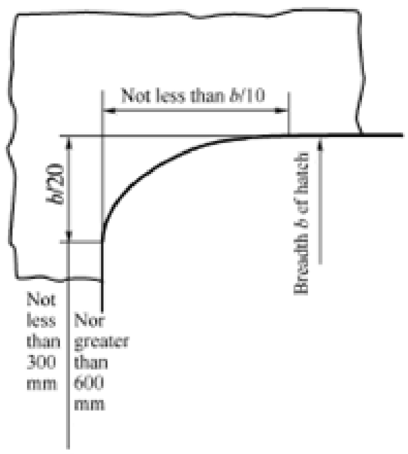


Figure 4.2.2.8(1)

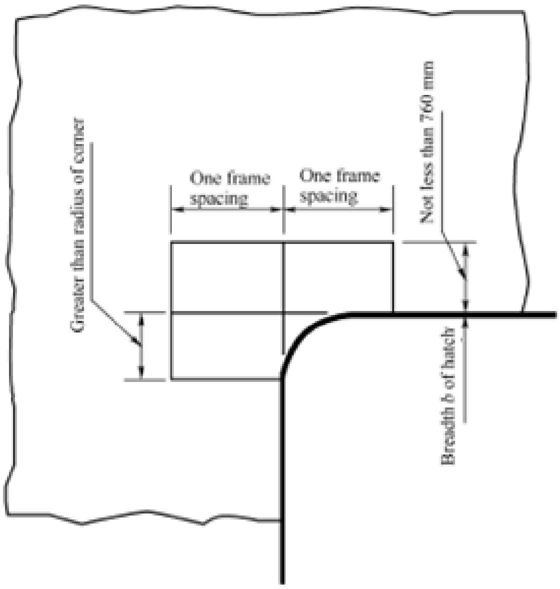


Figure 4.2.2.8(2)

4.2.3 Superstructures and deckhouses

4.2.3.1 In superstructures and deckhouses, the front end bulkheads are to be in line with transverse bulkheads in the hull below or be supported by transverses or pillars if without transverse bulkheads. The exposed sides of the superstructure and the deckhouse which are taken into account in hull girder strength are to be located above longitudinal girders.

4.2.3.2 Sufficient transverse strength is to be provided by means of transverse bulkheads or equivalent major members inside the superstructure or deckhouse.

4.2.3.3 The transition in way of the ends of the superstructure is to be smooth and without local discontinuities.

4.2.3.4 Webs of the deck girders and transverses under front ends and after ends of the deckhouses are not to be provided with any openings for a distance of 0.5 m from each side of the deckhouse corners.

4.2.3.5 In superstructures and deckhouses taken into account in hull girder strength, window openings in side walls are to be provided with well rounded corners. Horizontal stiffeners are to be fitted at the upper and lower edges of the openings. Openings for doors in sides are to be substantially stiffened along the edges.

4.2.4 Bulkheads

4.2.4.1 This provision involves watertight bulkheads for division and liquid tanks and wash bulkheads.

4.2.4.2 The following watertight bulkheads are to be fitted:
(1) a front collision bulkhead, which is to be located within the range of 0.05 L to 0.05 L + 3 m measuring from the F.P. along the design waterline;
(2) a bulkhead at both ends of the engine room;
(3) an after peak bulkhead.
When necessary, other bulkheads are to be fitted to reinforce transverse strength of the hull or to reduce local stresses in addition to the above bulkheads.

4.2.4.3 An isolation space between the fuel tank and fresh water tank is to be fitted.

4.2.4.4 Bulkheads of liquid tanks are to comply with the following requirements:
Where a tank extends from side to side, the width of which exceeds 4 m, a wash bulkhead is to be fitted at the centre line of the tank. Where the width of a tank exceeds 8 m, each half wash bulkhead is to be fitted at the upper half depth of the both half side tanks. Where the width of the fore peak tank exceeds 4 m, a wash bulkhead is to be fitted at the centre line of the tank.

4.2.5 Skirts

4.2.5.1 This provision is applicable to flexible skirts of ACV and fore/aft flexible skirts of SES.

4.2.5.2 For the materials of skirts, reference is to be made to the relevant requirements of CCS Rules for Materials and Welding.

4.2.5.3 The stability, handling, seaworthiness and comfortableness of a hovercraft is to be fully taken into account in skirt design.

4.2.5.4 It is to be considered that the loads applied on each part of skirts around a craft are different. In the structural design of the fore, aft and sides of the skirt, the following requirements are to be considered.
(1) Fore skirt is to be capable of swaying to the interior of the craft when it runs into obstacles.
(2) In the same case, aft skirt is to be capable of swaying to the behind, to ensure that the craft passes through the obstacles safely.
(3) For two sides of skirts, it is to be ensured that their freedom to sway is to be greater.

4.2.5.5 It is to be prevented that water and sand are wrapped up in skirts.

4.2.5.6 Connections of skirts with the hull are to be robust to prevent the skirts from being ripped.

4.2.5.7 When a craft is landing in emergency, its skirts are to be in good condition.

4.2.5.8 Skirts are to be convenient for inspection and maintenance.

4.2.5.9 Any original defects of skirts are not to be permitted.
(1) Openings on skirts are to be circle or elliptical. Any opening with cute angle is not to be permitted.
(2) Openings on skirts and lower edges of skirts are to be strengthened and smooth. Rough edges are not to be permitted.
(3) The fabric is to be homogeneous. When rubber is spread on the fabric for sticking, bubbles and impurities are not to be permitted.
(4) Joints of each part of the skirt are to be sufficiently tight without leakage of air as far as possible.

4.2.5.10 Joints of fingers and pockets of skirts are to be convenient for use and easy for maintenance.

4.2.5.11 The quantity of metal connectors used in skirts is to be as small as possible.

4.2.5.12 Methods of connection of skirts and hull are to be reliable and effective. The connectors such as security strips and bolts are to be with sufficient strength and corrosion resistance.

4.2.5.13 Composition of skirts is to ensure the operation safely when individual part of the skirts suffers damage.

4.2.5.14 Marks to indicate position of a part of skirts are to be made on the skirts in bright colour for assembly.

4.2.5.15 Most severe and dynamic situation, and sufficient safety factors are to be considered in the design of the skirt strength.

4.2.5.16 Vibration status are to be considered in design of skirts. Lower frequency vibrations and higher frequency vibrations are to be prevented, and the former will be transmitted to the hull structure and result in the damage of the structure, the later will make the material of skirts divided separately and striped.

4.2.6 Hydrofoil

4.2.6.1 For a hydrofoil craft, the strength of hydrofoil equipment, including fore and aft hydrofoils and their supports, is to be calculated to check their strength and stability.

4.2.6.2 Hydrodynamic lift force on hydrofoils is related to wave height and craft speed. The maximum speed and allowable wave height in foilborne mode is to be taken as the calculating speed and wave height.

Section 3 Watertight Integrity and Tests

4.3.1 External weathertight integrity

4.3.1.1 The external openings above the freeboard deck (excluding engine room air inlets) are to be fitted with weathertight closing appliances. Additional consideration may be given for tightness of the external doors on sides and behind bulkheads above the first tier superstructure or deckhouse for the craft with sheltered water service restriction and calm water service restriction.

4.3.2 Internal watertight and weathertight integrity

4.3.2.1 All openings, including doors, tubes and cables, situated on watertight bulkheads below the freeboard deck are to ensure watertightness.

4.3.2.2 Any opening in the collision bulkhead below the freeboard deck is not to be permitted.

4.3.2.3 Watertight doors situated below the freeboard deck may be accepted in watertight bulkhead except for collision bulkhead. The watertight doors on both sides of the bulkhead are to be provided with indicators or alarm devices to ensure that the doors are kept closed while the craft is at sea. Under the condition of complying with the requirements of craft's design and normal service, the number of openings on watertight bulkheads is to be as less as possible.

4.3.2.4 Openings on the collision bulkhead above the freeboard deck are to be provided with weathertight appliances.

4.3.3 Other requirements of external openings, including doors, windows and covers, etc.

4.3.3.1 The strength of all required weathertight external doors and watertight internal doors is to be the same as their adjacent structure. The external doors are to be open outwards to provide evacuation for passengers. The sill height and hatchway coaming height are to comply with the relevant requirements of the Administration.

4.3.3.2 Windows

(1) Structures and fastening types for all external windows of superstructure and deckhouse are to ensure weathertightness. The external windows are made of toughened safety glass, polycarbonate glass or laminated glass complying with the relevant standards accepted by CCS, and the mechanical properties of glass materials are to be submitted to CCS.

(2) The thickness t of external window glass is not to be less than:

$$t = \frac{b}{31.6}\sqrt{\frac{cp}{[\sigma_B]}} \quad \text{mm}$$

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

p – lateral pressure according to 4.4.4.6, in kN/m^2;

$[\sigma_B]$ – allowable bending stress of glass, in MPa,

$[\sigma_B]$ = 50 for toughened safety glass,

$[\sigma_B]$ = 26 for polycarbonate glass;

c – coefficient taken from Figure 4.3.3.2(2).

For laminated glass, each layer of glass is to be of toughened glass, the number of glass layers is not to be more than three, and the thickness difference for any two layers of them is not to be more than 2 mm, the thickness of plastic membrane between any two layers is not to be more than 0.76 mm. The thickness t of laminated glass is not to be less than:

$t = t_1+t_2 =1.2t_{eq}$, for two-layer laminated glass;

$t = t_1+t_2+t_3 =1.5t_{eq}$, for three-layer laminated glass

where: t_1 , t_2 , t_3 – thickness of glass layer, in mm;

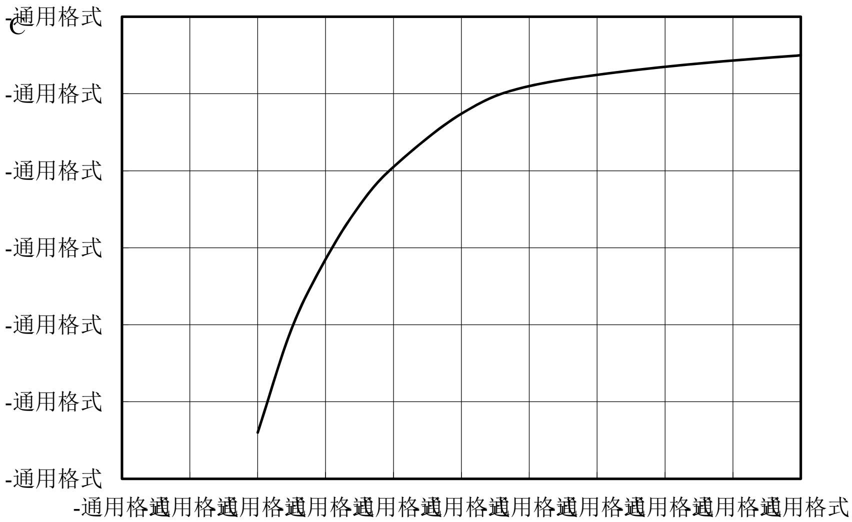
t_{eq} – equivalent thickness as calculated from single layer toughened safety glass, in mm.

In addition, the thickness t is not to be less than the following minimum value t_{min}:

t_{min} = 5.0 mm for toughened safety glass;

t_{min} = 6.0 mm for polycarbonate glass.

(3) The connections between external glass and window frame and between window frame and wall plating are to be fixed and reliable enough to subject to the possible wave impact during the normal navigation within the water services. Where the external window is made of polycarbonate glass, the depth of glass inserted in the frame of window is not to be less than 0.03b. b is the short side length of window opening.



window aspect ratio = long side length/short side length

Figure 4.3.3.2(2)

(4) The external window glass may be fastened directly to wall plating by glue joint. Where necessary, metal horizontal frames are to be provided at the lower edge of window glass to support the glass weight. The glue is to be capable of resisting ultraviolet light, low and high temperatures and cleaning chemicals. The properties of glue such as long-life joint strength and its working requirements and procedure documents are to be submitted to CCS for approval. The tensile strength of glue is not to be less than 2.5 MPa.

① The joint width d is not to be less than:

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

where: P_W= 0.0125(50+0.5V)^2 , in kN/m^2;

V – maximum speed in calm water, in kn, but not to be less than 30 kn;

b – short side length of window, in mm;

l – long side length of window, in mm;

σ_t – minimum tensile strength of glue, in MPa.

The minimum joint width d_{min} = 20b mm, and not to be less than 15 mm.

② The thickness t of glue is not to be less than:

t =5l mm, for toughened safety glass;

t =8l mm, for polycarbonate glass.

The minimum glue thickness t_{min}= 6 mm.

(5) Side scuttles to the spaces below the freeboard deck are to be fitted with efficient hinged inside deadlights so arranged that they can be effectively closed and secured watertight.

(6) Rectangle windows are permitted to be fitted in walls of the spaces above the freeboard deck except in front wall of first tier superstructure for craft navigating in greater coastal service restriction, but they are to be fitted with portable deadlights according to Table 4.3.3.2. The deadlights are to be made of metal or composite material, the strength of which is to be the same as their surrounding structure, and to be stowed in such a way as to provide quick mounting.

Table 4.3.3.2

Service restriction	Number of deadlights/Number of windows	
	Superstructure front 1st tier	Superstructure side 1st tier Superstructure front 2nd tier
GCSR	No permission	One for each type of windows
CSR	50%	
SWSR	25%	
CWSR	—	

4.3.3.3 Hatch covers

(1) The structural strength for all exposed hatch covers is to be equivalent to that for their adjacent structures.

(2) The closing appliances for hatch covers are to ensure weathertightness.

(3) Where the hatch cover on vehicle deck is subject to vehicle load, the design pressure on hatch cover is to be taken according to vehicle load for checking its strength.

4.3.4 Freeing ports

4.3.4.1 Where bulwarks on the weather portions of freeboard decks form wells, ample area of freeing ports at bulwarks are to be provided for rapidly freeing water.

Section 4 Design Loads

4.4.1 Vertical acceleration at center of gravity of a craft

4.4.1.1 External loads applied on the hull structure for a high speed craft are different from a conventional ship. When a craft navigates with high speed at wave which may be present in its service restriction, the more significant impact pressure of wave will act on the hull. The impact pressure is related to vertical acceleration at center of gravity of a craft.

4.4.1.2 The average 1/100 highest vertical acceleration at craft's gravity centre is to be taken as the design value to determine the design loads. The relation among the vertical acceleration a_{cg} and significant wave height $H_{1/3}$ and craft's speed V_H corresponding to the wave height is as follows.

(1) For various type craft other than ACV:

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

where: g – acceleration of gravity, g = 9.81 m/s^2

V_H – speed navigating at sea with significant wave height $H_{1/3}$, in kn;

$H_{1/3}$ – significant wave height, in m;

β – deadrise angle at LCG (°), β_{max} = 30°; β_{min} = 10°;

The value β refers to Figure 4.4.1.2 (1). In the figure, (a), (b) and (c) are to be sharp chine craft, (d) and (e) are to be rounded chine craft;

K_T – hull type factor, determined according to the hull type:

K_T = 1 for monohull, normal catamaran and wave piercer craft;

K_T = 0.8 for SES;

K_T = 0.7 for hydrofoil craft.

(2) For ACV (when wave impact on midcraft only or on bow and stern):

$$a_{cg} = \left(0.044\sqrt{H_{1/3}}+0.022\right)\frac{V_H}{\sqrt[3]{\Delta}}g \qquad \text{m/s}^2$$

where: g, V_H and $H_{1/3}$ are the same as those in (1) of this paragraph.

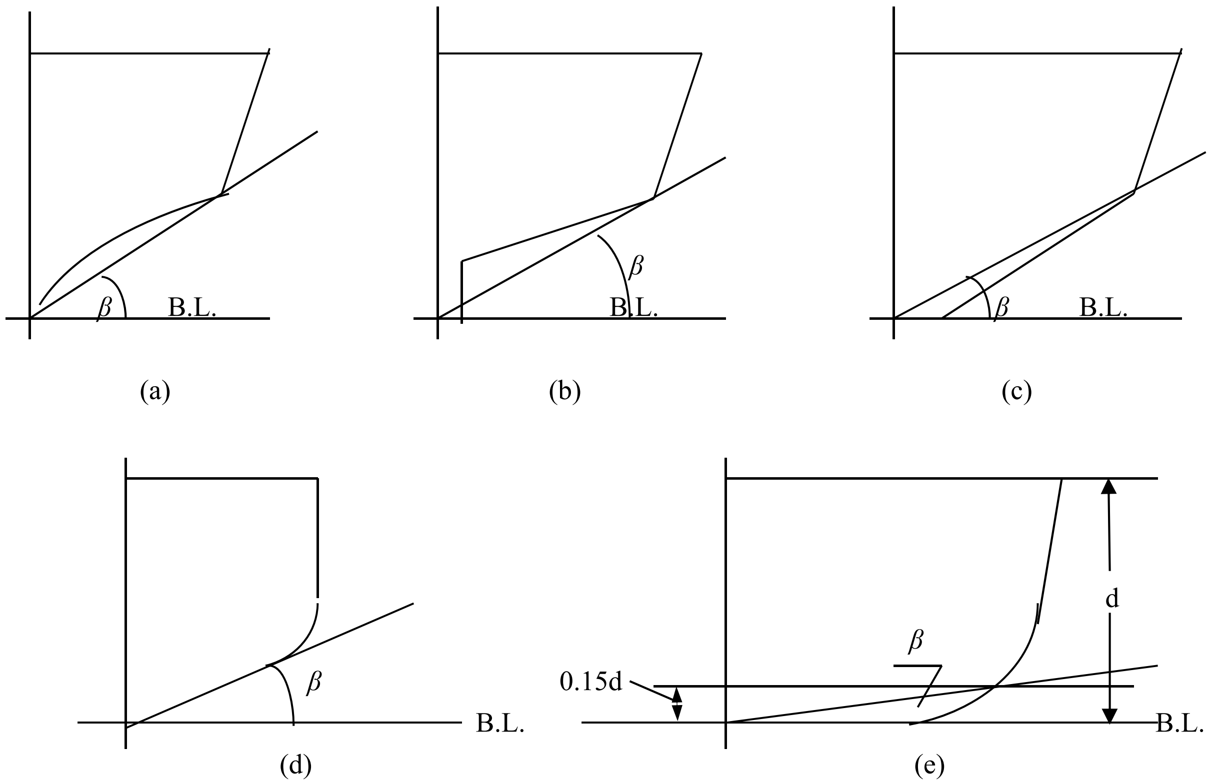


Figure 4.4.1.2(1)

4.4.1.3 A series of significant wave heights $(H_{1/3})_1 \sim (H_{1/3})_i$ which may be encountered by the craft is assumed by design unit according to the craft's service restriction. The maximum value $H_{1/3\ max}$ of the assumed wave heights is not to be more than the following values:

$H_{1/3\ max} = 6.0$ m for GCSR;

$H_{1/3\ max} = 4.0$ m for CSR;

$H_{1/3\ max} = 2.0$ m for SWSR;

$H_{1/3\ max} = 1.0$ m for CWSR.

4.4.1.4 A series of speed $(V_H)_1 \sim (V_H)_i$ corresponding to the series of assumed significant wave heights specified in 4.4.1.3 are to be established by design unit which may refer to model tests or full scale measurement of the sister's craft or other reasonable method with the consent of CCS.

4.4.1.5 According to a pair of $H_{1/3i}$, V_{Hi} specified in 4.4.1.3 and 4.4.1.4, the corresponding vertical acceleration α_{cgi} could be calculated according to the formula in 4.4.1.2. Where the calculated value α_{cgi} is more than 1.0 g, the design unit may take $\alpha_{cgi} \leq 1.0$ g (for passenger craft) and $\alpha_{cgi} \leq 1.2$ g (for cargo craft) as the design vertical acceleration. However the speed V_{Hi} is to be reduced until the acceleration α_{cgi} is not to be more than that obtained according to the formula in 4.4.1.2.

4.4.1.6 The maximum vertical acceleration of a series of α_{cgi} determined by 4.4.1.5 is to be taken as the design vertical acceleration at center of gravity.

4.4.1.7 The design value of vertical acceleration at gravity center of a craft is to be finally determined by the design unit or the owner. According to a series of $H_{1/3} \sim V_H$ corresponding to the design vertical acceleration calculated from the formula in 4.4.1.2, the "Speed Limit Curve during Navigating in Wave" is to be drawn and submitted to CCS for approval, and the signalboard is to be fixed in the navigation room. When the craft is navigating, its speed must be limited according to the significant wave height obtained by visual estimation at that time.

4.4.2 Slamming pressure on bottom

4.4.2.1 This provision applies to craft whose parts of hull immerse in seawater at high speed in fully laden condition, such as monohull craft, normal catamarans, wave piercer craft and SES. Their bottoms will withstand the slamming force. The bottom means the area extending from the keel line to chine, upper turn of bilge or pronounced spray rail.

4.4.2.2 The slamming pressure P_{sl1} on bottom is to be taken according to the data obtained from model test or full-scale test. If there is no test or measurement information, P_{sl1} is to be taken as:

$$P_{sl1} = 1.16 K_{l1} \left(\frac{\Delta}{nA} \right)^{0.3} \frac{50 - \beta_x}{50 - \beta} a_{cg} d_w \qquad \text{kN/m}^2$$

where: K_{l1} – longitudinal distribution factor,

$K_{l1} = 1$ for forward amidcraft;

$K_{l1} = 0.5$ for stern;

from stern to midcraft: K_{l1} is to be obtained by linear interpolation;

A –design load area for slamming pressure, in m^2;

for plate panels, A is usually not to be taken greater than $2.5S^2$;

for stiffeners and girders, A is to be taken as the product of spacing × span;

but for plate panels and frames, A is to be in no way less than $0.002\Delta/d$.

n – number of hull, n = 1 for monohull craft; n = 2 for various catamarans (including SES);

β – deadrise angle at LCG (°), see 4.4.1.2 (1);

β_x – deadrise angle at calculated transverse section (°), $\beta_{x\ max}$ = 30°; $\beta_{x\ min}$ = 10°;

d_w – slamming draught while a craft navigates in wave, $d_w = cd$, in m;

a_{cg}– vertical acceleration at center of gravity, in m/s^2, to be taken according to 4.4.1.2(1);

where: d is the draught of craft in fully loaded condition with no lift or propulsion machinery active.

c = 1.0 for monohull, normal catamaran and wave piercer craft,

c = 0.75 for SES.

4.4.2.3 The slamming pressure on bottom P_{sl1} is not to be less than the value obtained from 4.4.4.1 of this Section.

4.4.3 Slamming pressure on cross deck bottom

4.4.3.1 "Cross deck bottom" means the bottom surface of cross deck structure between two hulls of catamarans and the bottom of ACV or hydrofoil craft above water. This structure will withstand the slamming force when the craft sails at sea with high speed.

4.4.3.2 The slamming pressure P_{sl2} specified in 4.4.3.1 may be determined by the data obtained from model test or full scale test, and if no test data, it is to be taken as:

$$P_{sl2} = K_{l2}\left(\frac{\Delta}{A}\right)^{0.3} a_{cg}\left(1-\frac{H_{tx}}{CL}\right) \quad \text{kN/m}^2$$

P_{sl2} is to be taken not less than the side pressure obtained according to 4.4.4.1.

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

K_{l2} = 1.3 for aft of amidcraft;

within L/3 from F.P.:

K_{l2} = 2.6 for wave-piercing catamaran and normal catamaran;

K_{l2} = 2.1 for SES and ACV;

K_{l2} = 1.3 for hydrofoil craft;

within L/6 forward of amidcraft: K_{l2} is to be obtained by linear interpolation;

A – design load area for slamming pressure, in m^2, the same as 4.4.2.2;

C – coefficient, to be taken as:

$C = 0.066 - 0.000175L$.

H_{tx} –vertical distance from point for pressure calculation of cross deck bottom to design waterline, in m, $H_{tx\ max} = CL$;

a_{cg}– vertical acceleration at center of gravity, in m/s^2, see 4.4.1.2(1) and 4.4.1.2(2).

4.4.4 Pressure on craft's side, deck, superstructure and bulkhead

4.4.4.1 Pressure P_i acting on side is to be taken as:

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

where: h – vertical distance from the load point to upper deck, in m, which is not to be less than 0.8 m, but not more than 0.8 times the extent of side;

P_{sl}– slamming pressure on bottom in the same frame, in kN/m^2:

$P_{sl} = P_{sl2}$ for ACV and hydrofoil craft (see 4.4.3.2);

$P_{sl} = P_{sl1}$ for other craft (see 4.4.2.2).

4.4.4.2 Pressure P_{d1} acting on exposed deck is to be taken as:

$$P_{d1} = K_{l3}(0.2L + C) \quad \text{kN/m}^2$$

where: K_{l3} – longitudinal pressure distribution factor:

K_{l3} = 1.0 for forward of amidcraft,

K_{l3} = 0.75 for stern,

factors between midcraft and stern is to be obtained by linear interpolation;

C – service restriction coefficient:

C = 7.6 for GCSR and CSR,

C = 4.6 for SWSR and CWSR.

4.4.4.3 Pressure P_{d2} acting on unexposed deck (including superstructure and deckhouse decks) is to be taken as:

$$P_{d2} = 0.1L + 4.6 \quad \text{kN/m}^2$$

4.4.4.4 Pressure P_d acting on accommodation deck is to be taken as:

$$P_d = 4.5 \quad \text{kN/m}^2$$

4.4.4.5 Where the deck is designed to carry heavy unit, the influence of the vertical acceleration a_v of craft is to be considered as well as the weight of the unit. The vertical acceleration of the heavy unit may be taken as 0.5 a_v. The vertical acceleration a_v of the craft is to be taken as:

$$\alpha_v = K_\alpha \alpha_{cg} \quad \text{m/s}^2$$

where: K_α – vertical acceleration distribution factor,

K_α = 1.0 for aft amidcraft,

K_α = 2.0 for F.P.,

From F.P. to midcraft: K_α is to be obtained by linear interpolation;

α_{cg} – design vertical acceleration at L.C.G, specified in 4.4.1, in m/s^2.

4.4.4.6 Pressure P_{sd} acting on superstructures and deckhouses

(1) Pressure acting on end and side walls of superstructure and deckhouse is to be taken as:

$$P_{sd} = 15.6K_1K_2(CL + 0.8 - 0.3h) \quad \text{kN/m}^2$$

where: K_1 – location factor, to be taken as follows:

K_1 = 1.0 for fore end wall of first tier superstructure;

K_1 = 0.75 for fore end wall of second tier superstructure;

K_1 = 0.5 for side and aft end walls of superstructure and deckhouse.

K_2 – location factor, obtained according to the location of superstructure and deckhouse:

$K_2 = 1.0$ for area of forward amidcraft;

$K_2 = 0.75$ for area of aft amidcraft.

C – service restriction coefficient:

$C = 0.047$ for GCSR and CSR;

$C = 0.035$ for SWSR;

$C = 0.024$ for CWSR.

h – vertical distance from load point to full load water line, in m. For ACV, h is to be vertical distance from load point to skirt base line.

(2) Pressure P_{sd} acting on open top of superstructure and deckhouse is not to be less than 4 kN/m^2, but the pressure P_{sd} acting on top of first tier superstructure or deckhouse forward of amidcraft is not to be less than 6.6 kN/m^2.

(3) Minimum pressure of fore end wall of the first tier superstructure is not to be less than the pressure of exposed deck forward amidcraft in the formula of 4.4.4.2. Minimum pressure of other end and side walls of superstructure and deckhouse is not to be less than 4 kN/m^2.

4.4.4.7 Pressure of bulkheads P is to be taken as:

(1) Watertight bulkhead:

$$P = 10h \quad \text{kN/m}^2$$

where: h – vertical distance from load point to the highest point of the bulkhead deck, in m.

(2) Bulkhead of liquid tank, the greatest of the following to be taken:

$$P = (9.81 + 0.5a_v)h \quad \text{kN/m}^2$$

$$P = 10(h + \frac{2}{3}h_p) \quad \text{kN/m}^2$$

$$P = 10(h + 1.0) \quad \text{kN/m}^2$$

where: a_v – vertical acceleration of craft at the position of the bulkhead, in m/s^2, obtained from 4.4.4.5;

h – vertical distance from load point to top of the liquid tank, in m;

h_p – vertical distance from top of the liquid tank to top of the air pipe, in m.

(3) Collision bulkhead:

$$P = 12.5h \quad \text{kN/m}^2$$

where: h – vertical distance from load point to the highest point of bulkhead deck, in m.

Section 5 Scantlings of Hull Structure Made of Aluminum or Steel

4.5.1 General requirements

4.5.1.1 For the hull structure made of aluminum alloy and steel, in addition to the requirements of this Section, the scantlings of structural members are to comply with the related requirements of Hull girder strength in Section 8, Stability of Structural Members in Section 9 and Hull Vibration in Section 11 of this Chapter.

4.5.1.2 For plates with thickness equal to or greater than 4 mm, 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. For plates with thickness less than 4 mm, where the decimal part is 0.15 mm or less, it may be neglected; where it is greater than 0.15 mm but less than 0.65 mm, it is to be taken as 0.5 mm; where it is 0.65 mm or more, a round number of 1.0 mm is to be taken.

4.5.1.3 Symbols

t – Rule thickness of plating, in mm;

W— Rule section modulus (including effective plate flange), in cm^3. The effective breadth b_e of the attached plate is to be taken as:

For secondary member, $b_e = s$;

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

When the member web is not vertical to attached plate and angle α between web and attached plate is less than 75°, the actual section modulus may be 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;

σ_s – yield stress of material, in N/mm^2:

$\sigma_s = \sigma_{p0.2}$ for aluminum alloy, see the relevant requirements of CCS Rules for Materials and Welding;

for steel, see the relevant requirements of CCS Rules for Materials and Welding;

σ_{sw} – yield stress of material in welded condition, in N/mm^2:

$\sigma_{p0.2}$ is to be taken as the yield stress of the material in annealed condition for aluminum, see the relevant requirements of CCS Rules for Materials and Welding;

$\sigma_{sw} = \sigma_s$ for steel.

4.5.2 Minimum scantlings

4.5.2.1 Minimum thickness t_{min} of plating is to be taken as follows:

$t_{min} = K_0\sqrt[3]{L}$ mm for monohull craft and catamaran (excluding SES)

$t_{min} = 0.85K_0\sqrt[3]{L}$ mm for SES and hydrofoil craft

$t_{min} = 0.8K_0\sqrt[3]{L}$ mm for ACV

where: K_0 — coefficient, obtained from Table 4.5.2.1.

The minimum thickness of plate keel for monohull and catamarans is to be increased by 2 mm over the above value. The width of plate keel is not to be less than 0.1B (for catamarans, B is the maximum molded width of one hull), and is to be maintained over the whole length of the ship as far as practicable.

Coefficient K_0 **Table 4.5.2.1**

Item	K_0	
	Steel	Aluminum
Bottom	1.40	1.55
Cross deck bottom*	1.30	1.40
Side**	1.30	1.40
Main deck	1.10 (not less than 3 mm) 1.30 (transverse framing)	1.40 1.50 (transverse framing)
Unexposed deck	0.90	1.16

Bulkhead		1.00	1.16
Superstructure and deckhouse	Front	1.20	1.30
	Side, behind	0.86	0.92
	Top	0.65 (not less than 2 mm)	0.80
Main engine foundation***		1.90	1.90

* K_0 for cross deck bottom of wave piercer craft is to be taken as 0.80 within the region where the height H_{tx} of load point is greater than 0.85*CL*. For coefficient *C*, see 4.4.3.2.

** The minimum plate thickness coefficient of side plating up to 0.15 m above design waterline is to be taken according to the minimum plate thickness coefficient of bottom plating.

*** The minimum plate thickness of main engine foundation of any type of high speed craft is to be calculated by

$t_{\min} = K_0 \sqrt[3]{L}$.

For craft with round chine, the bilge plating is divided by the point of intersection of the deadrise line β and round chine line (see Fig 4.4.1.2 (1)), the portion above the point is considered as the side plating, and the portion below the point is considered as the bottom plating.

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

(1) The minimum thickness $t_{\min}$ of the face plate is to be taken as:

$$t_{\min} = \frac{b}{12} \quad \text{mm} \quad \text{for aluminum alloy}$$

$$t_{\min} = \frac{b}{15} \quad \text{mm} \quad \text{for steel}$$

where: b – face plate width, in mm.

(2) The minimum thickness $t_{\min}$ of the web is to be taken as:

$$t_{\min} = \frac{h}{50} \quad \text{mm} \quad \text{for aluminum alloy}$$

$$t_{\min} = \frac{h}{70} \quad \text{mm} \quad \text{for steel}$$

where: h – web depth, in mm.

4.5.2.3 Deck pillar

The minimum wall thickness for tubular pillar or built-up pillar is not to be less than 4 mm.

The allowable load P of aluminum deck pillar is to be calculated according to the following formula:

$$P = A(6 - 0.0349\frac{l}{r})\sigma_s 10^{-2} \quad \text{kN}$$

where: A – cross-section area of pillar, in cm^2;

l – length of pillar, in cm;

r – minimum radius of inertia of the cross-section of pillar, in cm.

The steel pillars are to comply with the appropriate requirements of CCS Rules for Classification of Sea-going Steel Ships.

4.5.3 Bending strength for aluminum alloy structure

4.5.3.1 Plating

The thickness of plating is not to be less than:

$$t = KC_1C_2s\sqrt{\frac{P}{\sigma_{sw}}} \quad \text{mm}$$

where: K - coefficient, obtained from Table 4.5.3.1;

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

C_2 –correction factor for ratio of the longer side l of panel to its shorter side s, taken as follows:

$C_2 = \frac{l}{s}(1-0.25\frac{l}{s})$ for $l/s < 2$;

$C_2 = 1.0$ for $l/s \geq 2$.

The intermediate value may be obtained by interpolation.

Where the stiffened plates formed by extruding are used and the welded joint of the plates are far away from the edge of the plates, σ_{sw} in the formula may be taken as σ_s, see 4.5.1.3. Where riveting structure is used, σ_{sw} is to be taken as $0.9\sigma_s$.

4.5.3.2 Stiffeners and frames

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

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

(1) K is to be obtained from Table 4.5.3.1.

(2) The yield stress σ_{sw} in welded condition is to be taken for all longitudinals except bulkhead stiffeners.

(3) The yield stress σ_s of the material may be taken as in the above formula for all girders, web frames and web beams, except for hull bottom and cross deck bottom.

(4) $\sigma_{sw} = 0.9\,\sigma_s$ for riveting structure.

Coefficient *K* **Table 4.5.3.1**

Item / Location	Plating	Secondary members			Primary members
		Longitudinal	Transverse, frame, floor	Vertical stiffener	Girder, web frame, plate floor, web beam
Bottom, cross deck 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	25.8			170	150
Superstructure & deckhouse side, behind	25.8			150	150
Collision & liquid tank bulkheads	25.8			130	150
Watertight bulkhead	23.4			120	150

4.5.4 Bending strength for steel structure

4.5.4.1 Plating

The thickness t of plating is not to be less than:

$$t = K_1C_1C_2s\sqrt{\frac{P}{\sigma_s}} \quad \text{mm}$$

where: K_1 – coefficient, obtained from Table 4.5.4.1;

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

C_2 –correction factor for ratio of the longer side l of panel to its shorter side s, taken as follows:

$C_2=\frac{l}{s}(1-0.25\frac{l}{s})$ for $l/s < 2$;

$C_2=1.0$ for $l/s \geq 2$.

Coefficient K_1 **Table 4.5.4.1**

Location		Within 0.1 L from F. P. & A.P.	Within 0.4 L at amidcraft
Bottom, cross deck bottom		21.8	25.0
side	near bottom	21.8	25.0
	near neutral axis	20.5	Longitudinal framing: 20.5 Transverse framing: 21.8
	near deck	20.5	25.0
Deck (including Superstructure / deckhouse top)		Longitudinal framing: 20.5 Transverse framing: 21.8	25.0
Superstructure/deckhouse Bulkhead of side and ends		21.8	
Collision and liquid tank bulkheads		21.8	
Watertight bulkhead		19.0	

4.5.4.2 Stiffeners and frames:

The section modulus W 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, obtained from Table 4.5.4.2.

Coefficient K_2 **Table 4.5.4.2**

Location	Secondary members			Primary members
	longitudinal	transverse, frame, floor	vertical stiffener	girder, web frame, plate floor, web beam
Bottom, cross deck bottom	136	150		135
Side	128	150		150
Deck (incl. superstructure/ deckhouse top)	Deck*: 212/128 Superstructure/deckhouse top: 150	150		150
Superstructure/deckhouse front, side			150	150
Superstructure/deckhouse behind			150	150
Collision & liquid tank bulkheads			150	150
Watertight bulkhead			109	109

* Where the actual midsection modulus in way of the deck is equal to rules midsection modulus, K_2 is to be taken as 212; where the midsection modulus in way is equal to or greater than 2 times rules value, K_2 is to be taken as 128; intermediate values are to be obtained by linear interpolation.

4.5.5 Shearing strength for longitudinals and girders

4.5.5.1 The effective shear area A_e at end of longitudinals is not to be less than A_{emin} obtained from the following formula:

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

The shear area A_e is calculated as follows:

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

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

t – web thickness of longitudinals, in mm.

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

$$A_{e\min} = 13.5\frac{slP}{\sigma_{sw}} \qquad \text{cm}^2$$

The shear area A_e is to be calculated as follows:

$A_e = 0.01h_w t_w$, in cm^2, for no bracket at end of girder

$A_e = 0.01h_w t_w + \Delta A_e$, in cm^2, for bracket at end of girder

where: h_w – net girder height after deduction of cutouts in the cross section considered;

t_w – web thickness;

ΔA_e – additional shear area at end of girder with bracket, in cm^2, obtained according to the horizontal angle of the bracket's face plate, see Figure 4.5.5.2.

$\Delta A_e = 0.9 f_1$ where $\theta = 45°$; $\Delta A_e = 0$, where $\theta = 0°$; ΔA_e; f_1 may be obtained by interpolation where $\theta = 0° \sim 45°$; f_1 is the area of the bracket's face plate in the cross section considered, in cm^2.

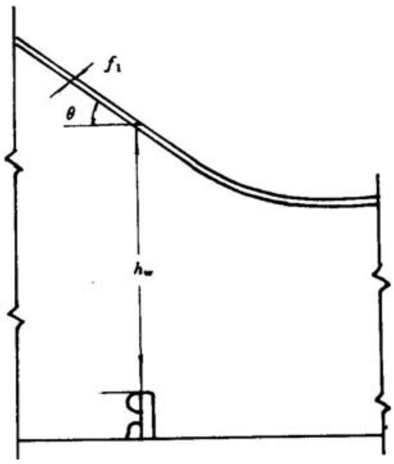


Figure 4.5.5.2

Section 6 Scantlings of Hull Structure Made of FRP

4.6.1 General requirements

4.6.1.1 For the hull structure made of fabric reinforced plastics (FRP), in addition to the requirements of this Section, the scantlings of structural members are to comply with the related requirements of Hull girder strength in Section 8, Stability of Structural Members in Section 9 and Hull Vibration in Section 11 of this Chapter.

4.6.1.2 The difference in elastic modulus in the two principal directions is not to be more than 20%, which is the basic condition to determine the members' scantlings specified in this Section.

4.6.1.3 The mechanical properties of test specimen of FRP for a craft's hull are not to be less than that as required in Chapter 2, PART TWO of CCS Rules for Materials and Welding.

4.6.1.4 This laminated plate moulded by lay-out with chopped strand mat (CSM) and biaxial woven rovings (BIAXIAL) alternately is recommended.

4.6.1.5 Symbols

t – rule thickness of plating, in mm;

W – Rule section modulus (including effective plate flange), in cm^3. The effective breadth b_e of the attached plate is to be taken according to 4.6.5.2 of this Section:

When the member web is not vertical to attached plate and angle α between web and attached plate is less than 75°, the actual section modulus may be 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;

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

τ_u – ultimate shear stress of member web, in N/mm^2;

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

4.6.2 Minimum scantlings

4.6.2.1 The minimum requirements for amount of reinforcement of glass fibre single skin laminates are to be given by:

$$W = a + kL$$

where: W – mass of reinforcement per unit area, in g/m^2;

a, k – coefficient, obtained from Table 4.6.2.1;

L – length of craft, in m.

Coefficient *a*, *k* **Table 4.6.2.1**

Structural member	*a*	*k*
Hull bottom, side and transom	2100	105.0
Stem and keel (width to be defined)	3750	187.5
Chine and transom corners	2900	145.0
Bottom aft in way of rudder, shaft braces, and shaft penetrations	3300	165.0
Weather deck (not intended for cargo)	4200	0.0
Cargo deck	3996	70.2
Accommodation deck	2900	0.0
Tank bulkheads and double bottom	4200	0.0
Tank bulkheads	4500	0.0
Other bulkheads	2500	0.0
Superstructure and deckhouse	3108	54.6

The minimum requirements for single skin laminates fabricated from other types of reinforcements are subject to special consideration.

4.6.2.2 The minimum requirements for sandwich panels

(1) The minimum requirements for amount of reinforcement of single skin laminates are to be given by:

$$W = a + kL$$

where: W – mass of reinforcement per unit area, in g/m^2

a, k – coefficient, obtained from Table 4.6.2.2 (for mixed material reinforcements may be found by linear interpolation);

L – length of craft, in m.

Coefficient *a, k* **Table 4.6.2.2(1)**

Structural member	*a*		*k*	
	Glass fibre	Carbon fibre/ Aramid	Glass fibre	Carbon fibre/ Aramid
Hull bottom, side and transom below deepest WL	1200	800	60.0	40.0
Hull side, and transom above deepest WL	800	550	40.0	27.5
Hull bottom and side, inside of hull	1184	814	20.8	14.3
Stem and keel	3000	2000	150.0	100.0
Weather deck (not for cargo), wet deck, other accommodation deck, tank bulkheads and double bottom, watertight bulkheads	1600	1100	0.0	0.0
Cargo deck	2220	1480	39.0	26.0
Accommodation deck, if adequately protected	1200	800	0.0	0.0
Decks, underside skin	750	500	0.0	0.0
Structural bulkheads	1200	800	0.0	0.0
Superstructure and deckhouse, outside	888	592	15.6	10.4
Inside void spaces without normal access	750	500	0.0	0.0

(2) The minimum requirements for sandwich core material

The shear strength of sandwich core material of hull bottom, side, transom, structural members of cargo deck is not to be less than 0.8 N/mm^2, and not to be less than 0.9 N/mm^2 for compressive strength; the shear strength of other structural members is not to be less than 0.5 N/mm^2, and not to be less than 0.6 N/mm^2 for compressive strength.

4.6.3 Thickness of single skin laminate

4.6.3.1 The thickness t of single skin laminate is not to be less than:

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

where: C — correction factor for ratio of the longer side l of panel to its shorter side s, taken as follows:

$$C = \frac{l}{s}(1 - 0.25\frac{l}{s}) \quad \text{for } l/s < 2;$$

$$C = 1.0 \quad \text{for } l/s \geq 2;$$

σ_{fnu} — ultimate bending stress of laminate, in N/mm^2.

4.6.3.2 The width of plate keel is not to be less than 0.1B (B is breadth of craft; for catamaran, B is breadth of each hull). The thickness of plate keel is not to be less than 1.5 times the thickness of bottom plate and is to keep constant within the whole length as practicable as possible.

4.6.4 Thickness of sandwich panels

4.6.4.1 The total thickness t of a structural sandwich panel is not to be less than:

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

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

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

K – coefficient:

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

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

$K = 1.0$ for core of plywood;

K is to be specially considered for core of other material.

4.6.5 Bending strength for stiffeners and frames

4.6.5.1 The section modulus W of stiffeners and frames is not to be less than:

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

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

K – coefficient, obtained from Table 4.6.5.1.

Coefficient *K* **Table 4.6.5.1**

	K	
	Girder, web frame, plate floor, web beam	Longitudinals, floor, frame, beam, stiffener
Bottom	480	400
Cross deck bottom	480	400
Side	480	400
Deck	480	400
Superstructure	480	400
Watertight bulkhead	480	400
Liquid tank & collision bulkheads	480	480

4.6.5.2 The rule section modulus of stiffeners and frames are the minimum section modulus of them with their effective flange. The width of effective attached plating of members is to be taken as follows.

(1) Where the attached plating is a single skin panel, the narrower of following is to be taken:

$$b_e = s \quad \text{mm}$$

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

(2) Where the attached plating is a structure sandwich panel:

① For ineffective core such as cellular plastic or balsa wood, etc., the narrower of following is to be taken:

$$b_e = s \quad \text{mm}$$

$$b_e = 11d \quad \text{mm}$$

② For effective core such as plywood, etc., the narrower of following is to be taken:

$$b_e = s \quad \text{mm}$$

$$b_e = 35d \quad \text{mm}$$

where: t – total thickness of the attached plating, in mm;

d – distance between centrelines of opposite skin laminates of a sandwich panel, in mm;

b_s – net width of stiffener, in mm.

4.6.5.3 Where the effective material such as pine or plywood is employed as core of the member, the core affection is to be taken into account in calculating the section modulus. The section area of the core is to be reduced by the ratio of its bending modulus of elasticity to the bending modulus of elasticity of the member's laminate.

4.6.5.4 The main engine seating is to be of ample strength and rigidity. The longitudinal girders of the seating are to be strengthened according to the main engine horse power. The longitudinal girders are to be fitted with transverse bracket plates and tripping brackets in line with every floor, to ensure the effective support.

4.6.6 Shearing strength for girders

4.6.6.1 The effective web plate area of girders A_e is to be calculated as follows:

$$A_e = 0.01 h_w t_w \quad \text{cm}^2 \qquad \text{for no bracket at end of girder}$$

$$A_e = 0.01 h_w t_w + \Delta A_e \quad \text{cm}^2 \qquad \text{for bracket at end of girder}$$

where: t_w – total thickness of FRP web plate, in mm;

h_w, ΔA_e – are the same as in 4.5.5.2 of this Chapter.

4.6.6.2 The effective web plate area A_e calculated in accordance with the requirements of 4.6.6.1 above is not to be less than $A_{e\,min}$ as follows:

$$A_{e\min} = \frac{25.5 slP}{\tau_u} \quad \text{cm}^2$$

where: τ_u – ultimate shear stress of member web, in N/mm^2.

4.6.7 Pillar

4.6.7.1 Aluminum alloy or steel is permitted to be used for deck pillars, see 4.5.2.3 of this Chapter. Other materials may be used subject to agreement of CCS.

Section 7 Vehicle Deck, Ramp and Propeller Shaft Brackets

4.7.1 Vehicle deck

4.7.1.1 Symbols

t – Rule thickness of plating, in mm;

W – Rule section modulus, including effective plate flange, in cm^3, the same as 4.5.1.3;

σ_s – yield stress of material, in N/mm^2,

$\sigma_s = \sigma_{p0.2}$ for aluminum alloy, see the relevant requirements of CCS Rules for Materials and Welding; for steel, see the relevant requirements of CCS Rules for Materials and Welding;

σ_{sw} – yield stress of material in welded condition, in N/mm^2, $\sigma_{sw} = \sigma_s$ for steel;

$\sigma_{P0.2}$ is to be taken as the yield stress of the material in annealed condition for aluminum, see the relevant requirements of CCS Rules for Materials and Welding;

s – calculated spacing of beams or longitudinals, in m;

l – calculated span of beams or longitudinals, in m.

4.7.1.2 Thickness of vehicle deck plating

(1) The thickness t of steel vehicle deck plating is not to be less than that obtained from the following formula:

$$t = 59\sqrt{\frac{P}{\sigma_s}(1+0.5n_v)} \quad \text{mm}$$

where: P – load on one axle, in t, i.e. total weight of the vehicle divided by the number of axles of the vehicle. Where the loads on axles are not uniform, P is to be taken as the maximum axle load;

n_v – vertical overload coefficient at the calculated deck plating, to be calculated as follows:

$$n_v = a_v / g$$

α_v – vertical acceleration at the calculated deck plating, in m/s^2, to be obtained from the formula of 4.4.4.5.

(2) The thickness t of aluminum alloy vehicle deck plating is not to be less than that obtained from the following formula:

$$t = 54\sqrt{\frac{P}{\sigma_{sw}}(1+0.5n_v)} \quad \text{mm}$$

where: P, n_v – the same as 4.7.1.2(1).

4.7.1.3 Longitudinals or beams

(1) The section modulus W of longitudinals or beams for steel vehicle deck is not to be less than that obtained from the following formula:

$$W = 0.536K_1P(1+0.5n_v)lf + 0.638P_d sl^2 f \quad \text{mm}$$

where: P, n_v – the same as 4.7.1.2(1);

P_d – calculated pressure for deck, in kN/m^2, see 4.4.4;

K_1 – coefficient, to be taken in Table 4.7.1.3;

f – material factor, to be calculated as follows:

$$f = \frac{235}{\sigma_s}$$

Coefficient K_1 **Table 4.7.1.3**

K	0.1	0.2	0.3	0.4	0.5 or more
K_1	15.4	14.6	13.35	11.8	10.1

Note: Where in the Table, K = (wheel spacing)/(span of framing). Wheel spacing is to be taken as the spacing between the two outermost wheels on the same axle.

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

$$W = \frac{205}{\sigma_{sw}} W_s \qquad \text{cm}^3$$

where: W_s – section modulus calculated according to the formula of 4.7.1.3(1) and where f in this formula is assumed to be taken as 1, in cm^3.

4.7.1.4 Deck transverses or girders

The scantlings of vehicle deck transverses or girders are to be determined according to direct calculation in Section 10 of this Chapter.

4.7.2 Stern doors serving as vehicle ramps

4.7.2.1 For ro-ro passenger craft, stern doors are normally used for access to vehicle decks. And they also serve as vehicle ramps.

4.7.2.2 The structural strength of vehicle ramps is to comply with the relevant provisions in 4.7.1 of this Chapter and those of CCS Rules for Classification of Sea-going Steel Ships. The vertical inertial force of vehicle may not be taken into account in the vehicle load acting on ramps.

4.7.2.3 For connecting hinges of vehicle ramps reference may be made to the relevant provisions of CCS Rules for Classification of Sea-going Steel Ships.

4.7.2.4 Where stern doors also serving as vehicle ramps give access to spaces below the ro-ro space deck, they are to be weathertight, and fitted with the adequate means of securing and supporting so as to be commensurate with the strength and stiffness of the surrounding structure. Where the hull of craft is made of aluminum alloy, the insulation from steel stern door is to be taken care of, so as to protect against electrochemical corrosion at joints of two kinds of metal.

4.7.3 Shaft brackets

4.7.3.1 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 4.7.3.2 to 4.7.3.6. Special consideration is to be given to arms with an abnormal section.

4.7.3.2 For single arm shaft brackets, a section modulus Z_{xx} at root to its longer axis x-x is to be not less than that determined from the following formula:

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

where: K — material factor of shaft bracket, $K = 400/\sigma_t$, where σ_t 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 4.7.3.4.

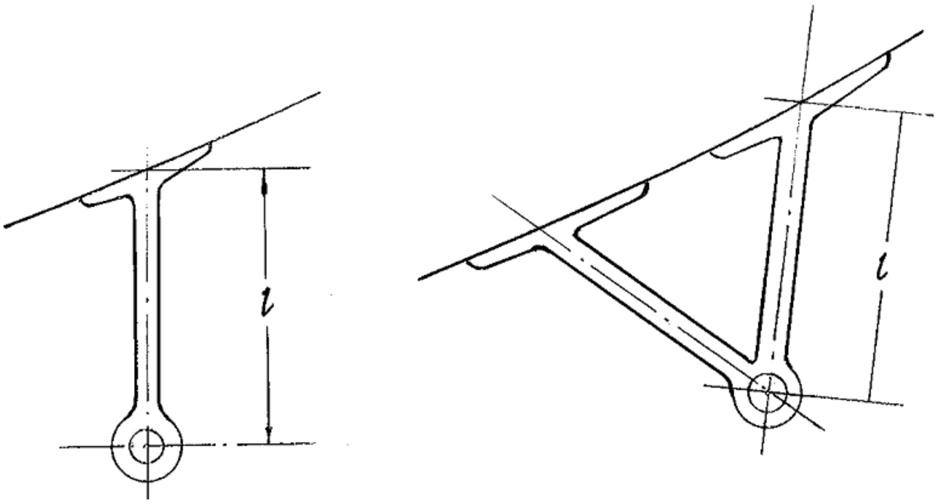
4.7.3.3 The area of any cross section along the arm length of single arm shaft brackets is to be not less than 60% of the area of the bracket at root.

4.7.3.4 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:

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

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 4.7.3.4.

K and d_s are the same as those in 4.7.3.2.



Single arm shaft bracket Double arm shaft bracket

Figure 4.7.3.4

4.7.3.5 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:

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

where: t — thickness of sectional area, in cm, obtained by the formula in 4.7.3.4.

4.7.3.6 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.

4.7.3.7 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.

4.7.3.8 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.

Section 8 Hull Girder Strength

4.8.1 General requirements

4.8.1.1 Monohull craft, catamarans and ACVs with the length L not more than 50 m may be exempted from check of longitudinal strength of hull, provided that there is no large openings on strength deck within $0.5L$ amidships, the ratio of L/D of the craft is less than 12 and local strength requirements for hull are complied with.

4.8.1.2 For all high speed craft other than those mentioned in 4.8.1.1, the longitudinal strength of the hull in displacing condition and in high speed navigating condition with wave slamming are to be checked respectively.

4.8.1.3 For various catamarans, the transverse strength and the torsional strength when navigating in wave at high speed are to be checked.

4.8.1.4 For hydrofoil craft, the longitudinal strength in take-off mode, hull-borne mode and in foil-borne mode are to be calculated respectively.

4.8.1.5 For air-cushion vehicle, the longitudinal strength in landing condition, in addition, is to be checked. In this case, the overload acceleration at craft's center of gravity is to be taken as 1.25 g.

4.8.1.6 For all craft, the full load departure condition is to be taken for hull girder strength.

4.8.1.7 When the superstructure and deckhouse of a craft with notation GCSR comply with the requirements specified in 4.8.7.1(2), it is considered that they make no contribution to the longitudinal strength of hull girder and their section modulus is not to be taken into account of the midcraft section modulus. And the measures to reduce the extent of contributing to the hull girder bending are to be adopted for the superstructure and deckhouse as practical as possible.

4.8.2 Longitudinal midcraft bending moment resulting from slamming force when a craft is sailing at high speed

4.8.2.1 For craft other than ACVs, the longitudinal bending moment M_B resulting from wave slamming may be calculated as follows:

$$M_B = C_1 C_2 C_3 (1+n)(l_x - 0.175\frac{\Delta}{B_s d}(1+0.2n))\Delta g \quad \text{kN} \cdot \text{m}$$

where: C_1 — coefficient,

C_1=1.0 for hogging

C_1= -1.0 for sagging

C_2 — coefficient, C_2 = 0.5;

C_3 — ship form coefficient,

C_3= 0.80 for wave piercer craft

C_3= 1.00 for other craft

n — overload coefficient, to be calculated as follows:

$n = a_{cg}/g$

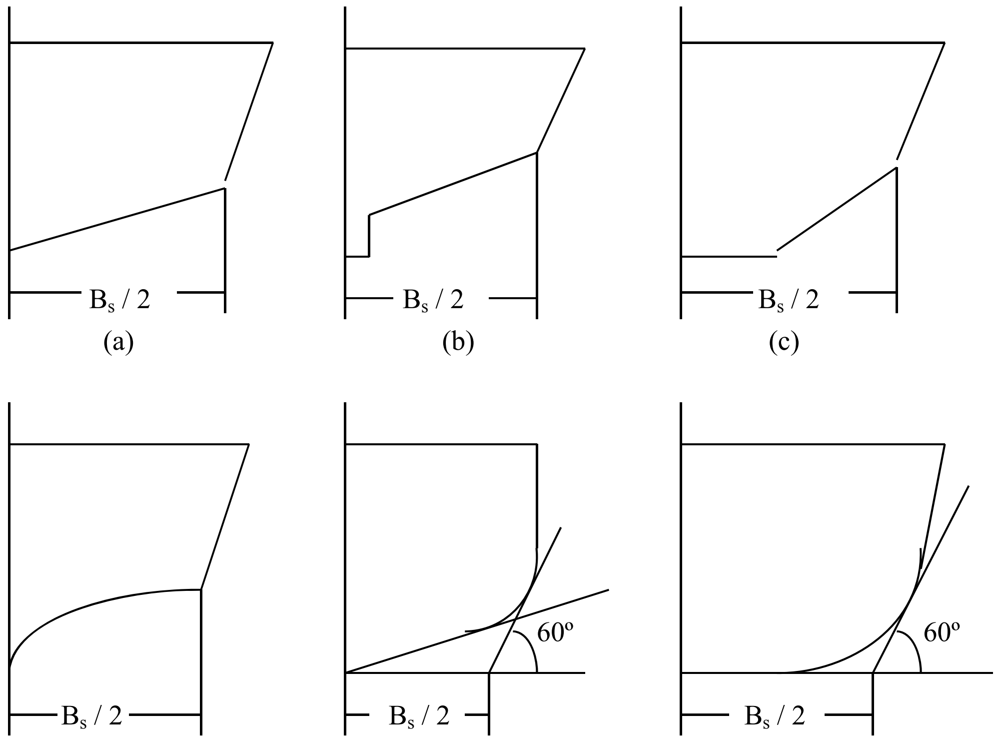
a_{cg} — vertical acceleration at center of gravity, in m/s^2, see 4.4.1.2 (1);

l_x — half of the longitudinal distance from the center of gravity of the fore half body to the center of gravity of the aft half body of the craft, in m, and if l_x is unknown, 0.25L may be taken as its approximate value;

B_s — breadth of impact area resulting from wave crest slamming force acting on the bottom amidships when both ends of craft are out of water, in m;

B_s may be taken according to Figure 4.8.2.1 for sharp-bilge craft and rounded-bilge craft;

B_s is to be the sum of breadths of impact areas on two hulls for various catamarans.



(d) (e) (f)

Figure 4.8.2.1

4.8.2.2 For ACVs, the hogging bending moment resulting from slamming force acting on the bottom amidcraft (impact on midcraft) is normally to be less than the sagging bending moment resulting from slamming force acting on bow and stern of the craft (impact on bow/stern). In general, only sagging bending moment is required to be checked, and this bending moment M_B may be calculated as follows:

$$M_B = 0.075\,(1+n)(1-0.2n)L\Delta g \qquad \text{kN·m}$$

where: n – overload coefficient, to be calculated as follows:

$$n = a_{cg} / g$$

α_{cg} – vertical acceleration at center of gravity, in m/s^2, to be calculated according to the formula of 4.4.1.2(2).

For ACVs of 25 m or greater in length, the sagging bending moment resulting from slamming force acting on the bottom at bow (impact on bow) is also to be taken into account, and the Method in Appendix 1 or other method approved by CCS may be used in calculation.

4.8.3 The longitudinal bending moment in displacing navigating condition

4.8.3.1 The hogging bending moment and sagging bending moment are to be determined respectively by the sum of still water bending moment and wave bending moment.

4.8.3.2 When calculating the wave bending moment, it is assumed that the length of wave equals the craft length and the maximum (significant value) wave height of the service restriction of the craft is to be taken.

4.8.3.3 For high speed monohull craft with Froude number ($Fn = V / \sqrt{gL}$)less than 0.80, the check of longitudinal midcraft bending moment in displacing navigating condition may be exempted.

4.8.4 Longitudinal bending moment for hydrofoil craft

4.8.4.1 For a fully submerged autocontrol hydrofoil craft and a piercing hydrofoil craft, the longitudinal bending moment M, while it takes off in the wave with the design maximum wave height, may be calculated as follows:

$$M = 0.654[\frac{C(3.175 - \lg\Delta)}{tg^{2/3}\beta} + 1.25]\Delta L \qquad \text{kN·m}$$

where: C – coefficient, obtained from following formula:

$$C = 0.28H_w(F_{r\nabla} - 1)(1 - 0.016H_W - 0.086F_{r\nabla}) - 0.0434 \quad \text{for sagging condition}$$

$$C = 0.22H_w(F_{r\nabla} - 1.51)(1 - 0.026H_W - 0.03F_{r\nabla}) - 0.1026 \quad \text{for hogging condition}$$

H_w – maximum design wave height, in m,

$F_{r\nabla}$ – volume Froude number, $F_{r\nabla} = V_f / \sqrt{g\nabla^{1/3}}$, V_f is take-off speed, in m/s, g is standard gravity acceleration, in m/s^2, ∇ is the volume of displacement of craft in full load condition, in m^3;

β – deadrise angle (°), measured at 0.8L section from A.P. for sagging condition and measured at midsection for hogging condition, see Fig 4.4.1.2(1).

4.8.4.2 The longitudinal bending moment in displacing condition may be calculated according to the formula specified in 4.8.4.1. The maximum design wave height H_w is to be taken, and the speed navigating in the wave with the maximum design wave height in displacing condition is to be taken in calculation.

4.8.4.3 For foil-borne mode, the longitudinal bending moment only in sagging condition is to be taken into account. The bending moment M_{ww} in sagging condition may be calculated as follows:

$$M_{ww} = M_{ws}\frac{4.135}{l_K}H_{1/3}(1+\frac{0.415V}{l_K})[1-\frac{\pi(d_f+d_A)}{l_K}] \quad \text{kN·m}$$

where: M_{ws} – still water moment in foil-borne mode, in kN·m, to be determined by the normal method according to balance between the whole weight of the craft and its foils' hydrodynamic lifting force;

V – speed of the craft in foil-borne mode in still water, in knot;

$H_{1/3}$ – maximum wave height (significant value) while the craft is in foil-borne mode, in m, the same as defined in 4.4.1.2(1);

l_k – spacing between fore foil and after foil, in m;

d_f – submerging depth of fore foil, in m;

d_A – submerging depth of after foil, in m.

4.8.5 Shear forces of hull girder

4.8.5.1 A maximum vertical hull girder force Q at L/4 section or 3L/4 section from F.P. for a craft specified in 4.8.1.2 and hydrofoil craft specified in 4.8.1.4 may be calculated as follows:

$$Q = \frac{4M_B}{L} \quad \text{kN}$$

where: M_B – the greater of longitudinal midcraft bending moment, obtained from 4.8.2, 4.8.3 and 4.8.4, in kN·m.

4.8.5.2 Where the shearing stress on the side panel and the longitudinal panel made of sandwich construction with cellular plastics core for hull structure made of F.R.P is calculated, the section area of these panel is to be taken into account the sum of thickness of its both skin laminates without thickness of the core.

4.8.6 Transverse bending moment, vertical shear force and torsional moment for normal catamaran, wave piercer craft and SES

4.8.6.1 Transverse bending moment M_{BX} for normal catamarans, wave piercer craft and SES with length L less than or equal to 50 m may be calculated as follows::

$$M_{BX} = C_1\Delta a_{cg}b \quad \text{kN·m}$$

where: C_1 – coefficient, obtained from Table 4.8.6;

a_{cg} –vertical acceleration at center of gravity, in m/s^2 , see 4.4.1.2(1), but not to be less than 1.0g;

b – transverse distance between the centerline of the two hulls, in m.

4.8.6.2 The greater of transverse bending moment M_{BX} for the above-mentioned catamarans with length L greater than 50 m may be obtained from following two formulae:

$$M_{BX} = M_{BX0}(1+\frac{a_{cg}}{g}) \qquad \text{kN·m}$$

$$M_{BX} = M_{BX0} + 3.09L^{1.05}B_{WL}^{0.146}d^{1.30}H_w(Z-\frac{d}{2}) \qquad \text{kN·m}$$

where: a_{cg} –vertical acceleration at center of gravity, in m/s^2, see 4.4.1.2(1), but not to be less than 1.0g;

H_w – the lesser of maximum wave height (significant value) of the service restriction of the craft and 0.14B;

Z – vertical distance from the neutral axis of the midcraft section of cross deck structure subjected to transverse bending moment to the base line of the craft, in m;

M_{BX0} – still water transverse bending moment, in kN·m, may be calculated as follows:

$$M_{BX0} = 2.45\Delta(b-0.8B^{0.88}) \qquad \text{kN·m}$$

where: b – the same as defined in 4.8.6.1.

4.8.6.3 Vertical shear force Q_t in the centerline of cross deck structure for various catamarans may be calculated as follows:

$$Q_t = C_2\Delta a_{cg} \qquad \text{kN}$$

where: C_2 – coefficient, obtained from Table 4.8.6;

a_{cg} –vertical acceleration at center of gravity, in m/s^2, see 4.4.1.2(1), but not to be less than 1.0g.

Coefficient C_1, C_2 and C_3 **Table 4.8.6**

Service Restriction	C_1	C_2	C_3
Greater Coastal Service Restriction	0.155	0.200	0.100
Coastal Service Restriction	0.135	0.182	0.075
Sheltered Water Service Restriction	0.125	0.167	0.063
Calm Water Service Restriction	0.115	0.154	0.063

4.8.6.4 Torsional moment M_{ty} to the transverse axis Y (in craft breadth direction) resulting from unsynchro-pitching of twin hulls for various catamarans may be calculated as follows:

$$M_{ty} = C_3\Delta a_{cg}L \quad \text{kN · m}$$

where: C_3 — coefficient, see Table 4.8.6;

a_{cg} —vertical acceleration at center of gravity, in m/s^2, see 4.4.1.2 (1), but not to be less than 1.0g.

4.8.6.5 Torsional moment M_{tx} to the longitudinal axis X (in craft length direction) resulting from the navigation in oblique waves for various catamarans may be calculated as follows:

$$M_{tx} = 2C_3 \Delta a_{cg} b \quad \text{kN} \cdot \text{m}$$

where: C_3 — coefficient, see Table 4.8.6;

a_{cg} — vertical acceleration at center of gravity, in m/s^2, see 4.4.1.2 (1), but not to be less than 1.0g;

b — transverse distance between the centerline of the two hulls, in m.

4.8.7 Section modulus of hull girder

4.8.7.1 The midsection at the weakest part of the structure within ±0.5*L* amidcraft is generally to be taken as the checked section in the calculation of hull girder strength.

(1) All continuous longitudinal members within 0.4*L* amidcraft may be taken into account in the calculation of midsection modulus. However where openings having a depth greater than 25% of that of the web plate are cut in them, the sectional areas of these openings are to be deducted from the midsection area.

(2) A superstructure or deckhouse having a length greater than 0.2*L*, but within 0.4*L* amidcraft may be in general taken into account in the hull girder strength. Where there are a large amount of openings on the side walls of above mentioned long superstructure or deckhouse and the sum of length of all openings on each side wall exceeds half of the structure length or the flexible connection between the superstructure or deckhouse and the main hull is adopted, the structure is not to be considered to make contribution to the hull girder strength.

(3) The longitudinal members, which meet the requirements of structure stability specified in Section 9 of this Chapter, can be taken into account in the midcraft section modulus.

4.8.7.2 The weakest longitudinal section within the breadth of cross deck is to be taken for checking hull transverse strength of various catamarans (including wave piercer craft). All continuous transverse members within the internal sides of the two hulls can be taken into account in the calculation of longitudinal midsection modulus. However where openings having a depth greater than 25% of that of the web plate are cut in them, the sectional areas of these openings are to be deducted from the midsection area.

4.8.7.3 Where a high speed craft adopted F.R.P sandwich construction as parts of hull's members, the concept of Equivalent Section Modulus (W_e) is to be introduced.

(1) 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:

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

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 middle section, in cm;

E_i – modulus of elasticity for each member's material composing of the middle section, in N/mm^2;

I_i – moment of inertia to the neutral axis of the middle section for each member, in cm^4.

(2) For checking hull transverse strength of various catamarans (including wave piercer craft), the equivalent section modulus of the section taken for check according to 4.8.7.2 may be referred to the above formula.

4.8.8 Check of overall strength

4.8.8.1 The longitudinal bending strength of hull girder is to be checked according to 4.8.1.2. The longitudinal bending stress σ of hull girder cross section may be calculated as follows:

$$\sigma = \frac{M}{W} \times 10^3 \quad \text{N/mm}^2$$

where M is longitudinal bending moment calculated according to the provisions of 4.8.2, 4.8.3 or 4.8.4, and W is section modulus calculated respectively for deck and bottom according to the section specified in 4.8.7.1, in cm^3.

4.8.8.2 In addition, the shearing strength of hull girder is to be checked. The two cross sections with maximum shearing force, i.e. hull cross sections at $L/4$ and $3L/4$ from the fore perpendicular, may be taken for check. If there is no longitudinal bulkhead at such sections, the maximum shearing force τ of side plating may be calculated by the following formula, and otherwise the shearing force is to be calculated according to thin wall shear flow theory:

$$\tau = 100 \frac{QS}{I_y t} \quad \text{N/mm}^2$$

where: Q — gross shearing force of the section under check, calculated according to 4.8.5.1, in kN;

S — static moment of the portion of the section above neutral axis, in cm^3;

I_y — moment of inertia of transverse section to its horizontal neutral axis, in cm^4;

t — total thickness of shell plating at horizontal neutral axis, in mm.

4.8.8.3 Check of general transverse strength of catamarans

(1) For normal catamarans, wave piercer craft and SESs, the gross transverse bending stress of upper and lower edge elements of the longitudinal section under check for cross deck structure bearing transverse bending moment is to be calculated using the transverse bending moment specified in 4.8.6.1 and 4.8.6.2 as well as the section modulus calculated according to 4.8.7.2.

(2) In addition, the shearing stress of elements of the longitudinal section under check for cross deck structure bearing shearing force is to be calculated according to the shearing force Q_t specified in 4.8.6.3.

4.8.8.4 Check of torsional strength of catamarans

For normal catamarans, wave piercer craft and SESs, the pure torsional shearing stress at the longitudinal centre section of cross deck structure is to be checked according to the calculation of M_{ty} in 4.8.6.4, and the pure torsional stress of transverse midcraft section of cross deck is to be checked according to the calculation of M_{tx} in 4.8.6.5.

4.8.8.5 If direct calculation of hull overall strength is carried out according to Appendix 2 or

Appendix 3, the checks specified in 4.8.8.2 and 4.8.8.3(2) above are also to be performed.

4.8.9 Allowable stress for calculation of general strength

4.8.9.1 Allowable stress of aluminum or steel hull is to be taken as follows:

(1) allowable tensile stress for members $[\sigma] = 0.67\sigma_{sw}$, for steel hull $\sigma_{sw} = \sigma_s$;

(2) allowable compressing stress for members is referred to in Section 9 of this Chapter;

(3) allowable shearing stress $[\tau] = 0.38\ \sigma_{sw}$, for steel hull $\sigma_{sw} = \sigma_s$;

where: σ_s – yield stress of member's material, in N/mm^2, the same as defined in 4.5.1.3;

σ_{sw} – yield stress of member's material in welded condition, in N/mm^2, the same as defined in 4.5.1.3.

4.8.9.2 Allowable stress for F.R.P. hull is as follows:

(1) Allowable tensile stress of members for a normal craft $[\sigma_b] = 0.3\sigma_{nu}$; allowable tensile stress of members for a planing craft $[\sigma_b] = 0.24\ \sigma_{nu}$, σ_{nu} is the ultimate tensile stress of G.R.P laminate, in N/mm^2.

(2) Allowable compressing stress of members for a normal craft $[\sigma_b] = 0.3\sigma_{pnu}$; allowable compressing stress of members for a planing craft $[\sigma_b] = 0.24\ \sigma_{pnu}$, σ_{pnu} is the ultimate compressing stress of G.R.P laminate, in N/mm^2.

(3) For single skin panel, allowable shearing stress $[\tau] = 0.25\ \tau_u$, τ_u is critical shearing stress of the skin laminate of the sandwich panel, in N/mm^2; for sandwich panel, allowable shearing stress $[\tau] = 0.5\ \tau_{cr}$, τ_{cr} is critical shearing stress of the skin laminate of the sandwich panel, in N/mm^2 , the smaller of both following is to be taken as:

$$\tau_{cr} = 0.3(E_f^{45^0} E_c G_c)^{1/3} \quad \text{N/mm}^2$$
$$\tau_{cr} = 0.4\gamma G_c \quad \text{N/mm}^2$$

where: $E_f^{45^0}$ – compressing modulus of elasticity for the skin laminate of sandwich panel in 45° direction, in N/mm^2;

E_c – compressing modulus of elasticity of core material, in N/mm^2;

G_c – shearing modulus of elasticity of core material, in N/mm^2;

γ – same as 4.6.4.1.

4.8.10 Hull rigidity

4.8.10.1 For a hydrofoil craft, the moment of inertia I of midcraft section is to meet the requirements of the following formula:

$$I > 10.88 \frac{\Delta l_K{}^2}{E} \times 10^6 \quad \text{cm}^4$$

where: l_k – longitudinal distance between fore and after foils, in m;

E – modulus of elasticity of hull's material, in N/mm^2 .

4.8.10.2 For a F.R.P craft, the moment of inertia I of midcraft section is to meet the requirements of the following formula:

$$I > 4.0 W_0 L \quad \text{cm}^4$$

where: $W_0 = \frac{M}{[\sigma]}$, cm^3;

M – maximum longitudinal bending moment according to 4.8.2, 4.8.3 and 4.8.4, in kN·m;

$[\sigma]$ – the smaller of $[\sigma_p]$ and $[\sigma_b]$ specified in 4.8.9.2, in N/mm^2.

Section 9 Stability of Structural Members

4.9.1 General requirements

4.9.1.1 The stability in the general longitudinal bending condition for bottom, deck, side shell plating and the longitudinals of aluminum hull and steel hull is to be checked. However the longitudinal stability of the structural members for these craft whose girder strength may be exempted according to the requirements in 4.8.1.1 may not be checked.

4.9.1.2 For these craft whose girder strength may be exempted according to the requirements in 4.8.1.1, where higher strength steel is adopted as hull's material, the longitudinal stability of the structural members is still to be checked.

4.9.1.3 The stability in the general transverse bending condition for transverses of cross deck structure for catamarans with aluminum or steel hull structure is to be checked.

4.9.1.4 The stability of a sandwich panel exposed to compress for a F.R.P craft is to be checked.

4.9.2 Rectangular metal plating

4.9.2.1 The ideal elastic buckling stress σ_E for bottom or deck panels may be taken as:

$$\sigma_E = 0.9 K_c E (\frac{t}{s})^2 \quad \text{N/mm}^2$$

where: E — modulus of elasticity of material:

$E = 0.69 \times 10^5$ in N/mm^2 for aluminum plate

$E = 2.06 \times 10^5$ in N/mm^2 for steel plate

t — plate thickness, in mm;

s — length of shorter side of panel, in mm;

K_c — coefficient, to be taken according to the direction of panel compression:

$K_c = 4.0$ if the panel is compressed along its longer side;

$K_c = C\left[1+\left(\frac{s}{l}\right)^2\right]^2$ if the panel is compressed vertical to its longer side

where: l — length of longer side of the panel, in mm;

C = 1.21 if secondary member at longer side of the panel is of angle/aluminum or T-section;

C = 1.10 if secondary member at longer side of the panel is of bulb flat/aluminum;

C = 1.05 if secondary member at longer side of the panel is of flat bar/aluminum..

4.9.2.2 The ideal elastic buckling stress σ_E for a rectangular plate of the side shell may be taken as:

$$\sigma_E = \frac{7.56}{j+1.1} E\left(\frac{t}{s}\right)^2 \qquad \text{N/mm}^2$$

where: E, t and s – refer to 4.9.2.1;

φ – coefficient of stress distribution (σ for the stress on upper edge of the plate, $\varphi\sigma$ for one on the lower edge), $0 \leq \varphi \leq 1$.

4.9.2.3 The critical buckling stress σ_{cr} of plate may be taken as:

$$\sigma_{cr} = \sigma_E \qquad \sigma_E \leq \frac{\sigma_s}{2}$$

$$\sigma_{cr} = \sigma_s\left(1 - \frac{\sigma_s}{4\sigma_E}\right) \qquad \sigma_E > \frac{\sigma_s}{2}$$

where: σ_E – ideal elastic buckling stress , in N/mm^2, see 4.9.2.1;

σ_s – yield strength of material, in N/mm^2 , the value corresponding to elongation 0.2% is to be taken and not to exceed 70% of tensile strength.

4.9.2.4 The calculated compressive stress σ_d of a plate is not to be greater than the allowable critical buckling stress $[\sigma_{cr}]$ obtained from the following formula:

$$[\sigma_{cr}] = \eta\sigma_{cr} \qquad \text{N/mm}^2$$

where: η – safety factor on stability,

$\eta = 0.8$ when $S/t \leq 60$;

$\eta = 0.9$ when $60 < S/t \leq 120$;

the intermediate value may be obtained by interpolation;

s – length of short side of panel, in mm;

t – plate thickness, in mm.

4.9.2.5 For panels with the ideal elastic buckling stress $\sigma_E < \sigma_s/2$, the calculated compressive stress σ_d is permitted to exceed the critical buckling stress σ_{cr}, but not to be greater than 80% of the mean ultimate compressive stress σ_u obtained from the following formula:

$$\sigma_u = (1-2C)\sigma_E + C\sigma_s$$

where: σ_E, σ_s —refer to 4.9.2.3;

C — coefficient,

C = 0.375 if the panel is compressed along its longer side, $C = 0.75/(l/s+1)$ if the panel is compressed vertical to its longer side, where:

l –length of long side of panel;

s –length of short side of panel.

4.9.3 Metal longitudinal and girder

4.9.3.1 The ideal elastic buckling stress σ_E for longitudinal or girder with attached plating is to be taken as:

$$\sigma_E = C\frac{\pi^2 E}{l^2}\frac{I}{A} \qquad \text{N/mm}^2$$

where: I – moment of inertia of section for longitudinal or girder with attached plating, in cm^4;

A – area of section for longitudinal or girder with attached plating, in cm^2;

l – span of longitudinals or girders when exposed to longitudinal compress, or span of beams or web frames when exposed to transverse compress, in cm;

E – modulus of elasticity of material, as referred to 4.9.2.1;

C – constraining coefficient for ends of longitudinal or girder. The end will be considered fixing if there is a bracket provided with sufficient size, while the end will be considered simple supporting if there is no bracket provided.

$C = 1$ for two ends of simple supporting;

$C = 2$ for one end with simple supporting and the other one fixed supporting;

$C = 4$ for two ends of fixing.

50% of sectional area of longitudinals on effective breadth of attached plating of girder and 50% of sectional area of beam on effective breadth of attached plating of web beam are to be taken into account in the calculation of the moment of inertia of section I and the area of section A of primary members.

4.9.3.2 In the calculation of the moment of inertia of section I and the area of section A as specified in 4.9.3.1, the reduced effective breadth b_e of attached plating for the longitudinal/beam and the girder/web beam is to be calculated respectively by the following formulae:

(1) For attached plating of longitudinal/beam:

$$b_e = (0.44 + 0.56\frac{[\sigma_{cr}]}{\sigma_s})s \qquad \text{mm}$$

but b_e is not to be greater than $0.8s$.

where: s – refer to 4.9.2.1;

σ_s – refer to 4.9.2.2;

$[\sigma_{cr}]$ – to be obtained from σ_{cr} in 4.9.2.3 by 0.8, σ_E in the formula to be taken as:

$$\sigma_E = 11.5E(\frac{t}{s})^2 \qquad \text{N/mm}^2$$

(2) For attached plating of girder/web beam:

$$b_e = Cb \qquad \text{mm}$$

where: b – mean breadth of load area for girder/web beam, in mm;

C – coefficient as given in Table 4.9.3.2(2).

Coefficient *C* **Table 4.9.3.2(2)**

r \ α/b	0	1	2	3	4	5	6	> 7
≥ 6	0.00	0.38	0.67	0.84	0.93	0.97	0.99	1.00
5	0.00	0.33	0.58	0.73	0.84	0.89	0.92	0.93
4	0.00	0.27	0.49	0.63	0.74	0.81	0.85	0.87
≤ 3	0.00	0.22	0.40	0.52	0.65	0.73	0.78	0.80

Notes: r – numbers of evenly spaced point loads on the span of the girder;

α – calculated span of the girder, in mm;

α =1-h, for simple supported ends;

α =0.6(l-h), for fixed ends;

where: h – web height, in mm;

l – span of the girder, in mm.

The boundary of above end may be determined as specified in 4.9.3.1.

4.9.3.3 The ideal elastic buckling stress σ_E for the face plate and the web plate of girder/web beam is to be calculated respectively by the following formula:

(1) For face plate:

$$\sigma_E = 0.38E\left(\frac{t_f}{b_f}\right)^2 \quad \text{N/mm}^2$$

where: t_f – thickness of face plate, in mm;

b_f – breadth of face plate, in mm;

for T type of girder, half of the breadth is to be taken.

Where the face plate of girder/web beam is too long, the tripping bracket is to be provided within the span and the ideal elastic buckling stress σ_E is to be calculated by the following formula:

$$\sigma_E = 0.38E\left(\frac{t_f}{b_f}\right)^2 + 0.9E\left(\frac{t_f}{l_f}\right)^2 \quad \text{N/mm}^2$$

where: l_f– face plate span between brackets, in mm.

(2) For web plate:

$$\sigma_E = 3.8E\left(\frac{t}{h}\right)^2 \quad \text{N/mm}^2$$

where: t – thickness of web plate, in mm;

h – height of web plate, in mm.

4.9.3.4 The critical buckling stress for the longitudinal/beam, girder/web frame and the face plate and web plate of girder/web frame is to be determined by the same method in 4.9.2.3.

4.9.3.5 The allowable critical buckling stress of the longitudinal/beam and the face plate and web plate of girder/web beam is to be calculated by the same method in 4.9.2.4.

4.9.3.6 The allowable critical buckling stress $[\sigma_{cr}]$ for girder/web frame is to be calculated by the following formula:

$$[\sigma_{cr}] = \eta\sigma_{cr} \quad \text{N/mm}^2$$

where: σ_{cr} – critical buckling stress, see 4.9.3.4;

η – safety factor of stability, to be calculated as follows:

$$\eta = \frac{K}{1+\frac{l}{r}}$$

but η is not to be less than 0.3.

where: K – coefficient,

= 0.7, in general;

= 0.6, when design loads are primarily dynamic;

r – radius of inertia of section of girder/web frame, in cm;

l – span of girder/web frame, in m.

4.9.3.7 The calculated stress σ_d of compressing member is not to be greater that the allowable critical buckling stress as defined in 4.9.3.5 and 4.9.3.6. σ_d is to be calculated by the following formula:

$$\sigma_d = 10\frac{P}{A} \quad \text{N/mm}^2$$

where: P – compressing force withstood by the member, in kN;

A – sectional area of the member with attached plating, cm^2.

4.9.4 Sandwich panels of F.R.P

4.9.4.1 For a sandwich panel with PU cellular plastics core, the critical local buckling stress σ_{cr} of its skin laminate is to be taken as the smaller according to the following formulae:

$$\sigma_{cr} = 0.5(E_f E_c G_c)^{1/3} \quad \text{N/mm}^2$$

$$\sigma_{cr} = 1.39\gamma^{0.639} G_c \quad \text{N/mm}^2$$

where: E_f – compressing modulus of elasticity of skin laminate, in N/mm^2;

E_c – compressing modulus of elasticity of core material, in N/mm^2;

G_c – shearing modulus of elasticity of core material, in N/mm^2;

γ – same as 4.6.4.1.

4.9.4.2 For a sandwich panel with PVC cellular plastics core, the critical local buckling stress σ_{cr} of its skin laminate is to be taken as the smaller according to the following formulae:

$$\sigma_{cr} = 0.5(E_f E_c G_c)^{1/3} \quad \text{N/mm}^2$$

$$\sigma_{cr} = 1.52\gamma^{0.585} G_c \quad \text{N/mm}^2$$

where: E_f, E_c, G_c, γ the same as 4.9.4.1.

4.9.4.3 The calculated compressive stress of above-mentioned both panels is not to be greater than 0.3 σ_{cr} calculated according to 4.9.4.1 and 4.9.4.2, and 0.3 σ_{pnu}, σ_{pnu} is the ultimate compressive stress of its skin laminate.

4.9.4.4 For a sandwich panel with plywood core, the ultimate compressing stress σ_{pnu} is to be calculated as follows:

$$\sigma_{pnu} = 0.15(E_f E_c G_c)^{1/3} \quad \text{N/mm}^2$$

where: E_f, E_c, G_c the same as 4.9.4.1.

4.9.4.5 The calculated compressing stress of a sandwich panel with plywood core is not to be more than 0.6 σ_{pnu} .

Section 10 Direct Calculation

4.10.1 General requirements

4.10.1.1 In addition to complying with the Rule minimum plate thickness, hull structures of the following high speed craft made of steel or aluminum are to be subject to global structural strength verification by direct calculation in accordance with Appendix 2 of the Rules:
(1) Monohull craft and normal catamarans of more than 50 m in length;
(2) Wave piercer craft;
(3) High speed craft of novel design or unusual form.

In addition to complying with the Rule minimum plate thickness, hull structures of the following high speed craft made of composite material are to be subject to global structural strength verification by direct calculation in accordance with Appendix 3 of the Rules:
(1) Monohull craft more than 30 m in length;
(2) Wave piercer craft;
(3) catamarans;
(4) High speed craft of novel design or unusual form.

4.10.1.2 Structures subjected to large local load, such as vehicle deck, helicopter platform, etc., are to be subject to direct calculation and analysis of local strength.

4.10.1.3 For craft with length and form complying with the requirements in 4.10.1.1 but operating in sheltered water service restriction or calm water service restriction, the need for using direct calculation in the global structural strength evaluation may be determined according to the sea state and subject to agreement of CCS.

4.10.1.4 The direct calculation is to be based on loads, combination conditions and allowable stresses as defined in Appendix 2 or Appendix 3.

4.10.1.5 Recognized structural finite element calculation software is to be used in the structural analysis.

4.10.1.6 If the hull structural scantlings are determined by direct calculation, a detailed direct calculation description is to be submitted, including loads, calculation models and boundary conditions.

4.10.2 Documents submitted for approval

4.10.2.1 The direct calculation documents submitted for approval are to be prepared according to the following requirements.
(1) Drawings and Drawings list used in calculation are to be submitted.
(2) At least the following are to be included in the direct calculation report:

① Description of objectives and conditions of calculation;
② Software used in calculation;
③ Detailed description of calculation model, including simplification, structural model extent and modeling method, thickness of structural members, boundary conditions and model diagrams;
④ Description of basis, main data, distribution and condition combinations of load

calculation;

⑤ For the applied loads obtained from the model test, the complete and detailed model test information and load calculation method are to be submitted and agreed by CCS;

⑥ Calculation results for each condition, including deflection plots and data of structural model, stress contour plots of each area and stress values of primary members, summary stress report for maximum yielding and buckling, unity ratio working stresses to allowable stresses and conclusions.

Section 11 Hull Vibration

4.11.1 General requirements

4.11.1.1 It is to be ensured that the severe global vibration and the local vibration of hull (including shell, deck, etc.) is not to happen when a craft is running in a fully loaded condition, and special attention is to be paid to the vibrations of the structural members of the bottom area nearby the propeller and of the area nearby the main engine and the hover fan, so as to avoid such vibrations causing damage to structures, affecting normal functioning of machinery and equipment, jeopardizing safety for the crew and passengers.

4.11.1.2 The calculation of hull vibration may be referred to CCS Guidelines for Vibration Control Onboard or other equivalent methods. Hull vibration may also be surveyed by full-scale test.

4.11.1.3 The requirements of this Section are not considered as conditions of classification.

Section 12 Weld Design for Metal Hull Structures

4.12.1 General requirements

4.12.1.1 This Section applies to the weld design for normal hull structures and structural members of high speed craft made of metal materials, special structures will be subject to individual consideration.

4.12.1.2 The weld design for hull structures of steel high speed craft is to comply with the relevant provisions in Section 4, Chapter 1, PART TWO of CCS Rules for Classification of Sea-going Steel Ships.

4.12.1.3 The weld design for normal hull structures of aluminum high speed craft is to comply with the following provisions in this Section, special structures will be subject to individual consideration. The welding procedures for hull structures are to comply with the relevant requirements of CCS Rules for Materials and Welding.

4.12.1.4 For high speed craft with mixed hull structures, of which the main hull is of steel and superstructures/deckhouses are of aluminum alloy, the bulkheads of aluminum superstructures/deckhouses and the upper deck of steel hull are to be connected by aluminum-steel transition joints approved by CCS.

4.12.2 General design principle of welded aluminum alloy structure

4.12.2.1 The arrangement of the weld seams is to take into account the structural continuity, and the restraint of the whole structure is to be minimized. Also, the weld seams are to be so arranged as to be convenient for the operation and inspection of welding.

4.12.2.2 The weld seams of hull structures are not to be arranged in the areas of maximum stress or areas liable to stress concentration. Sufficient transitional areas are to be arranged at positions where the section changes suddenly, and excessive concentration of weld seams are to be avoided.

4.12.2.3 Generally, double side continuous weld is to be used in the following structures:
(1) joint seams of keel girder and flat keel;
(2) joint seams of machinery sub-structure and supporting structure;
(3) joint seams of the boundaries of oiltight and watertight structures;
(4) joint seams of all structures of the steering gear;
(5) bottom and bow structural seams within areas subject to impact;
(6) joint seams of supporting and ends of stiffeners, pillars, cross ties and girders;
(7) joint seams of all structures within the area above the propeller with a radius at least 1.5 times the diameter of the propeller;
(8) joint seams of bracket plates and adjacent girders or other structural members;
(9) joint seams of ends of girder webs subject to greater shearing stress;
(10) joint seams of bracket plates and bulkhead plates.

4.12.2.4 Where steel-aluminum transition joints are used, the load capacity of the joints is to be considered so as to reduce the normal stress level of the joints as far as practicable.

4.12.2.5 The strength, plasticity and corrosion resistance of filler material used in aluminum alloy welding are to be compatible with the parent material.

4.12.3 Design of butt welds

4.12.3.1 Butt welds are generally to be full penetration welds. For structures subject to low stress level and double side welding is impracticable, single side welding with backing may be used provided that the quality is guaranteed and prior agreement of CCS is obtained.

4.12.3.2 Where full penetration welds are arc welded, plates with thickness under 5 mm may be welded ungrooved; plates with thickness over 8 mm are to be groove welded with a groove angle of generally 60° to 90°, the root face to be 1.5 to 3 mm and the gap to be 0 to 4 mm.

4.12.4 Design of lap welds and tack welds

4.12.4.1 In general, lap welds are not to be used as the structural joints that transmit tensile or compression loads. Where the lap welds in such structures are unavoidable, there is to be sufficient lap width.

4.12.4.2 The spacing of tack welds is generally not to be greater than 20 times the plate thickness, and the length of the weld is to be at least 4 times the plate thickness. Tack welds are to be avoided at positions such as corners, ends, or positions subject to high load or stress concentration.

4.12.5 Design of fillet welds

4.12.5.1 Fillet welds may be of T shape or cross shape joints, and are generally to be the double side welds (as shown in Figure 4.12.5.1(a)). These two joint types may be sub-divided into double side continuous welding, double side intermittent welding and staggered intermittent welding (as shown in Figure 4.12.5.1(b)).

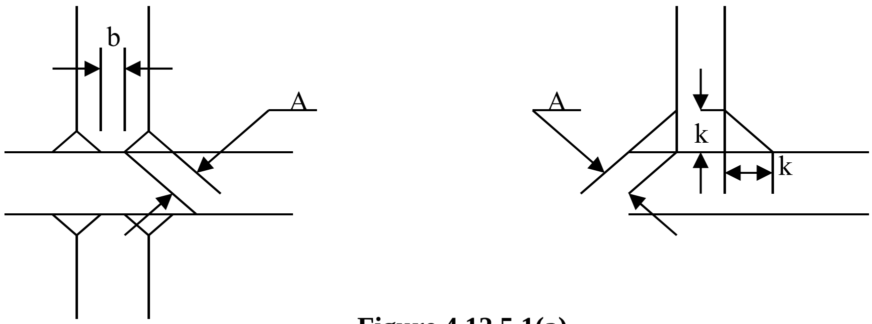


Figure 4.12.5.1(a)

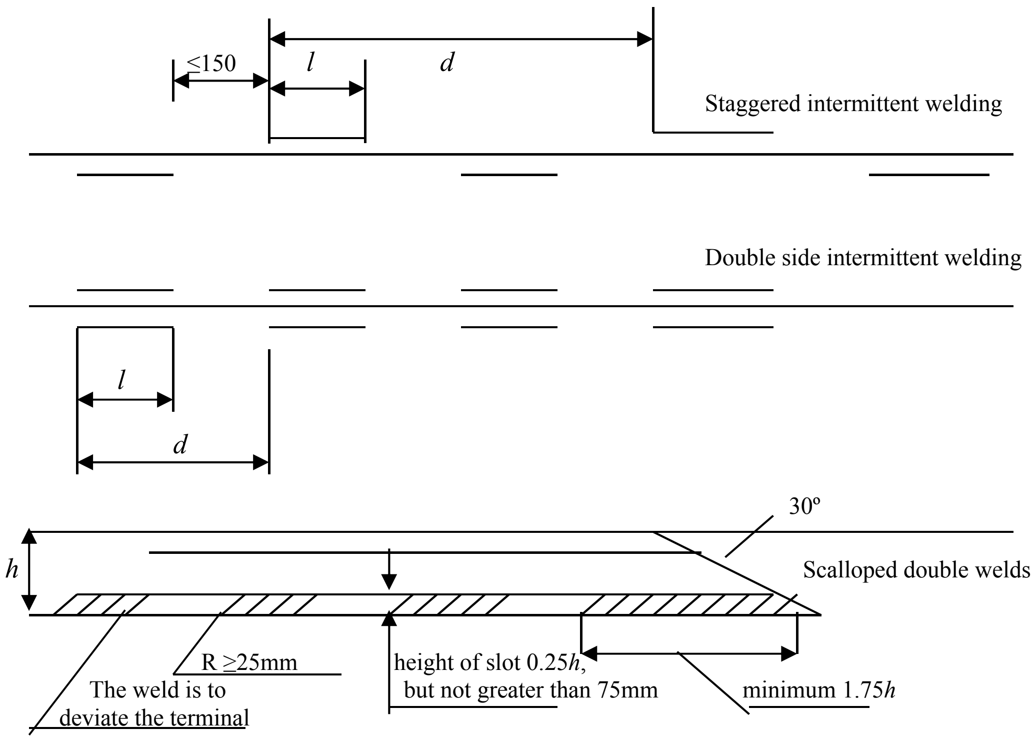


Figure 4.12.5.1(b)

4.12.5.2 For fillet welds subject to high stress level, deep penetration welding with vertical beveled plate may be used, or even the full penetration double side welding is to be used. For fillet welds subject to medium stress level, chain intermittent welding or staggered intermittent welding may be allowed. The application of single side fillet welding is to be subject to agreement of CCS.

4.12.5.3 For fillet welds where double side continuous welding is required, the throat depth h is not to be less than the value given by the following formula:

$$h = Wt \quad \text{mm}$$

where: W– welding parameter. Welding parameters for hull structures are given in Table 4.12.5.3;

t – minimum thickness of structure, in mm. It denotes the thickness of the thinner plate of the components of the fillet weld joints.

Where deep penetration welding is used, the throat depth may be 10% less, but the depth reduced is not to be greater than 1.5 mm.

Table 4.12.5.3

Item	Welding parameter	Note
(1) General structures		
Watertight or oiltight boundaries	0.34	
Non-sealing plate boundaries	0.13	Intermittent welding is permitted.
General lap joint welds	0.27	
Welds of stringers, frames, and other stiffeners with shell plates, decks and bulkhead plates	0.10	
	0.13	In liquid tank
	0.21	At terminals
(2) Bottom structures		
Non-sealing centre girders with decks	0.27	
with bed plates	0.21	No slot
Boundaries of non-sealing floor plates, side girders and bracket plates	0.21	
Inner-bottom longitudinal or main engine foundation girder		
with face plate	0.44	Continuous welding
with hull structure	0.44	Continuous welding
Propeller boss	0.27	
(3) Hull frame		
webs and girders of web frame		
with shell plates	0.13	
with face plates	0.13	
(4) Deck and supporting structure		
Weather deck with shell plate	0.44	Continuous welding
Other decks with shell or bulkhead plates (except boundaries of liquid tank)	0.21	Continuous welding
Girder webs with decks and terminal brackets with decks	0.10	
Girder webs with decks at terminal brackets	0.21	Continuous welding
Girder face plates with webs	0.10	
(5) Superstructure, deckhouse and enclosures		
Outer casing walls with decks	0.34	
Inner casing walls	0.13	

4.12.5.4 Where intermittent welding is used, the throat depth h_1 is to be calculated by the following formula:

$$h_1 = hd / l \quad \text{mm}$$

where: d – pitch of welds, in mm, denotes the length from the beginning of a weld to the beginning of the next weld;

l – length of weld, denotes the continuous length of weld, however, it is not to be less than 15 times the plate thickness or 75 mm, whichever is less.

4.12.5.5 The height of leg of fillet weld k is not to be less than the value calculated by the following formula:

$$k = \sqrt{2}h \quad \text{mm}$$

No matter which weld type and welding method are used, k is not to be less than 3 mm, however, it is also not necessary to be greater than 1.5 times the thickness of the thinner plate. The height of the leg of the intermittent weld is not necessary to be greater than 7 mm.

4.12.5.6 Where intermittent welding is used, the corner flange welds within the specified length of the following positions are to be double side continuous fillet welds:

(1) the length of corner flange weld at bracket toe is not to be less than the height of connecting frame, and is neither to be less than 75 mm;

(2) section terminals, especially when short sections are end sloped, the length of corner flange

weld is to be the height of sections or not to be less than the length of the sloped part, whichever is greater;
(3) various kinds of holes, cut ends and cross parts of all joint structures that are vertical to each other are to have a length not less than 75 mm.

4.12.5.7 Where structural components pass through liquid tank bulkheads, there is to be a double side full penetration fillet weld of not shorter than 75mm on both sides of the bulkhead.

Section 13 Corrosion Prevention for Hull Structures

4.13.1 Application

4.13.1.1 Requirements in this Section apply to corrosion prevention of materials used for steel and aluminum alloy high speed craft and for hull structure made of FRP.

4.13.1.2 For hull structure of aluminum alloy high speed craft, coatings, tapes, sacrificial anodes, impressed-current systems or other corrosion preventive measures are to be used.

4.13.1.3 The corrosion prevention of hull structure of steel high speed craft is to comply with the requirements of this Section and relevant provisions in Section 6, Chapter 1, PART TWO of CCS Rules for Classification of Sea-going Steel Ships.

4.13.2 Corrosion preventive coatings for aluminum alloy hull

4.13.2.1 Coatings used for corrosion prevention of aluminum alloy craft are to be approved by CCS.

4.13.2.2 The chemical composition of coatings is to be compatible with aluminum alloy, and is not to contain elements such as copper, lead, mercury or other metals which can induce galvanic or other forms of corrosions. Insulating coatings intended to prevent galvanic corrosion are not to contain graphite or other conducting materials.

4.13.2.3 Coatings are to be applied in accordance with the manufacturer's instructions, and are to be preceded by appropriate cleaning and chemical conversion in the surface, including welds and corners. While coating, the temperature of the metal surface is to be at least 3℃ above the dew point. Coatings are to be free from voids, scratches or other imperfections which are potential sites for localized corrosion. Besides, the manufacturer is to submit to CCS with composition of coating layers, coating thickness, drying time, coating intervals and wetness of the surface while coating, etc., for approval.

4.13.3 Corrosion prevention for faying surface between aluminum alloy and other metals

4.13.3.1 For aluminum alloy hull, suitable means, such as rubber or non-wicking and non-water absorbing insulating tapes and galvanized sheets, are to be taken to avoid direct contact of faying surfaces of aluminum alloy to other metals when such faying surfaces occur in hull structure. The use of other types of insulating tapes is to be approved by CCS.

4.13.3.2 When steel and aluminum materials are connected, the same aluminum-based paint is to be used and red lead paint is prohibited.

4.13.3.3 When steel and aluminum materials are connected by means of riveting, downstream riveting (i.e. aluminum is outside) is to be used with aluminum rivets.

4.13.3.4 Suitable means, such as special pipe hangers, are to be taken to avoid conductive connections between aluminum alloy hull and non-aluminum piping systems. When piping passes through structures where watertightness is required, such as bulkheads, deck, tanktops and shell, etc., special fittings are to be used to maintain isolation between non-aluminum piping and aluminum alloy.

4.13.3.5 Appendages of metals other than aluminum alloy, such as engine beds, pump foundations, propeller shafts and rudders, etc., are to be suitably isolated from aluminum alloy hull by such means as non-metallic bearing castings, non-conductive packing and suitable non-wicking and non-water absorbing tapes and coatings.

4.13.4 Corrosion prevention for faying surfaces between aluminum alloy and non-metals

4.13.4.1 Aluminum alloy in direct contact with wood or insulating materials is to be protected from the corrosive effects of the impurities in these materials by a suitable coating or covering.

4.13.4.2 Any adhesives which may be used to connect insulation material and aluminum alloy are to be free of agents which would be corrosive to aluminum alloy. Foaming agents harmful to aluminum alloy, such as freon, are not to be contained in insulating foams.

4.13.4.3 Areas where dirt or soot are likely to collect and remain for prolonged periods are to be protected from pitting corrosion by the use of coatings or other suitable means.

4.13.5 Corrosion prevention under wet condition

4.13.5.1 Suitable means are to be used to avoid such arrangements that would induce crevice corrosion in wet spaces. In bilge spaces, chain lockers and similar locations where exfoliation corrosion may be of concern, materials used are to be suitably heat-treated to resist this form of corrosion.

4.13.6 Corrosion prevention under elevated temperature

4.13.6.1 For service temperature of 60℃ or higher, only aluminum alloy and filler metals specially designated for service at these temperatures are to be used.

4.13.7 Stray current protection

4.13.7.1 Precautions are to be taken when in dock to prevent stray currents from welding power or other sources from adversely affecting the aluminum alloy hull. AC power sources are to be insulated from the hull. For DC power sources, grounding is to be avoided if possible. Where grounding to the hull is required for the purpose of safety consideration, the negative pole is to be connected to the hull.

4.13.8 Cathodic protection

4.13.8.1 Consideration is to be given to the use of sacrificial anode or impressed current systems of corrosion control to protect aluminum alloy hull structure.

4.13.8.2 Details of sacrificial anodes, such as material, the number, dimensions, locations and the way of fixation, are to be submitted to CCS for approval. When impressed current systems are used, adequate precautions are to be taken so that the negative voltage is not excessive. Details of anode type, voltage and arrangements, etc., are to be submitted to CCS for approval. Where necessary, electrical potential test may be required by the Surveyor.

4.13.8.3 The cathodic protection arrangements are to be effective for at least five years. If found necessary at annual inspection, they may be renewed or repaired.

4.13.9 Corrosion prevention for steel structures

4.13.9.1 All surfaces of steel structures, except for inner surface of oil tanks, are to be coated against corrosion. The coating process is to be carried out in accordance with the manufacturer's instructions.

4.13.10 Corrosion protection design of FRP craft

4.13.10.1 For hull structure made of FRP material, proper means of corrosion protection are to be taken for the metal connections.

CHAPTER 5 EQUIPMENT AND OUTFITS

Section 1 Rudders

5.1.1 General requirements

5.1.1.1 The requirements of this Section apply to steam-lined spade rudders (including flap-type rudder) and flat plate rudders in water.

5.1.1.2 Special considerations are to be made for other types of equipment to control course of a craft such as air rudders and jets.

5.1.1.3 The rudder area is to be sufficient to ensure the craft keeping steady course with only one engine running.

5.1.1.4 The requirements of this section are applicable to ordinary steels having a yield strength σ_s of 235 N/mm^2. Where it is proposed to use the steel of other yield strength, equivalent scantlings are to be calculated.
The conversion factor is defined as:

$$f_1 = \left(\frac{\sigma_s}{235}\right)^a$$

where: σ_s – yield strength of steel, in N/mm^2;
$a = 0.75$ for $\sigma_s > 235$N/mm^2;
$a = 1$ for $\sigma_s \leq 235$ N/mm^2.

5.1.1.5 Forged steel materials with minimum specified tensile strength lower than 400 N/mm^2 or higher than 900 N/mm^2 will normally not be accepted in rudder stock, keys and bolts. Materials of rudder, in addition, are to comply with the relevant requirements of CCS Rules for Materials and Welding.

5.1.2 Rudder force

5.1.2.1 The rudder force F of the water rudders (excluding flap-type rudder) specified in 5.1.1.1 may be determined from the following formula:

$$F = 0.145KAV^2 \quad \text{kN}$$

where: A – area of rudder blade, in m^2;
V – speed for calculation, V is to be taken as 0.9 times the service speed defined in 2.1.3.1(30), in kn;
K – factor, depending on the aspect radio λ of the rudder area;
$K = \frac{\lambda + 2}{3}$, radio λ is to be calculated from the following formula:

$$\lambda = \frac{2l_1}{C_1 + C_2}$$

where: l_1, C_1, C_2 – see Figure 5.1.2.1, in m;

λ - is not to be greater than 2.

5.1.2.2 The rudder force of the rudder outside the propeller jet is to be taken as 0.8 times the force obtained from the formula in 5.1.2.1.

5.1.2.3 The rudder force during backward running is to be taken as 0.8 times the force obtained from the formula in 5.1.2.1, but the speed V in the formula is to be taken as the maximum astern speed of the craft.

5.1.2.4 The rudder force of the flap-type rudders is to comply with the relevant requirements of CCS Rules for Classification of Sea-going Steel Ships.

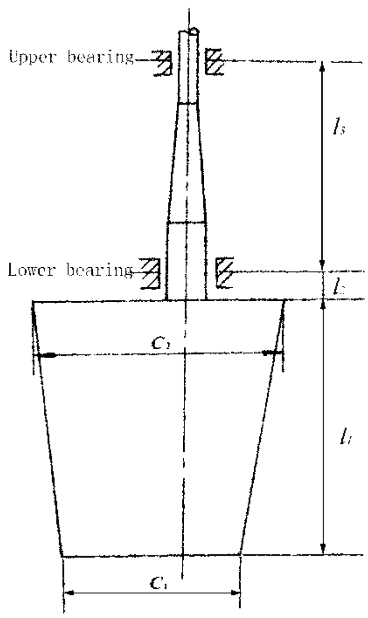


Figure 5.1.2.1

5.1.3 Rudder stock

5.1.3.1 Torque M_T acting on the rudder stock may be calculated by the following formula:

$$M_T = FR \qquad \text{kN} \cdot \text{m}$$

where: F – rudder force, in kN, according to the formula in 5.1.2;

R – arm distance, in m, calculated by the following formula:

$$R = C(\alpha - \beta) \qquad \text{m}$$

$R_{min} = 0.1C$ for ahead condition

where: C – mean breadth of the rudder blade, in m, calculated by the following formula:

$$C = \frac{1}{2}(C_1 + C_2)$$

C_1 and C_2 – see Figure 5.1.2.1;

α – factor, α = 0.33 for ahead condition,

$\alpha = 0.66$ for astern condition.

For flap-type rudders, factor α is to be specially considered if no test data are given, α is to be taken as 0.40 for ahead condition, and 0.66 for astern condition;

$\beta = A_f / A$, where: A_f = portion of the rudder blade area situated ahead of the centre line of the rudder stock, in m^2;

A = area of rudder blade, in m^2.

5.1.3.2 Bending moment M_B acting on the rudder stock at lower bearing is to be taken as follows:

$$M_B = F\left[l_2 + \frac{l_1(2C_1 + C_2)}{3(C_1 + C_2)}\right] \quad \text{kN} \cdot \text{m}$$

where: F – rudder force, in kN, according to the formula in 5.1.2;

l_1, l_2, C_1, C_2 – see Figure 5.1.2.1, in m.

5.1.3.3 The diameter D_1 of the rudder stock at the lower bearing and the diameter D_1 of the rudder stock at the upper bearing may be respectively calculated by the following formulae:

$$D_1 = 42 \times \sqrt[6]{1 + \frac{4}{3}\left(\frac{M_B}{M_T}\right)^2} \times \sqrt[3]{\frac{M_T}{f_1}} \quad \text{mm}$$

$$D_2 = 42 \times \sqrt[3]{\frac{M_T}{f_1}} \quad \text{mm}$$

The above-mentioned formulae are also applicable to rudder stock of flat plate rudder.

5.1.3.4 In rudder design, it is to be considered that the rudder is not damaged at the maximum astern speed.

5.1.3.5 The diameter of the rudder stock in way of the lower bearing is to be maintained to a point above as far as practicable, and then this diameter may be tapered to the diameter required in way of the tiller. The length of the taper is not to be less than three times the reduction in diameter.

5.1.4 Rudder blade of steam-lined rudders (including flap-type rudder)

5.1.4.1 The thickness t of shell plating, including side, top and bottom plating, is not to be less than that calculated by the following formula:

$$t = \frac{5.5}{\sqrt{f_1}} CS\sqrt{d + \frac{0.1F}{A}} + t_1 \quad \text{mm}$$

where: C – factor, to be calculated as follows:

$C = \left(1.1 - 0.25\frac{s}{b}\right)^2$, C is not to exceed 1.0;

d – maximum design draft of the rudder blade, in m;

S – smallest unsupported width of plating, in m;

b – greatest unsupported width of plating, in m;

t_1 = 2 mm for ordinary steel;

t_1 = 0 mm for stainless steel.

5.1.4.2 The thickness of the horizontal web plates and the vertical web plates is not to be less than 70% the thickness of shell plating of rudder.

5.1.4.3 Internal surfaces of double plate rudders are to be efficiently coated with anticorrosive coatings; and hole fitted with plugs made of non-corrodible metals are to be provided both on the top and bottom parts of the rudder for draining.

5.1.5 Rudder blade of flat plate rudder

5.1.5.1 The thickness t of rudder blade is not to be less than that calculated by the following formula:

$$t = (1.7eV + 2.5)\frac{1}{\sqrt{f_1}} \quad \text{mm}$$

where: e – spacing of horizontal stiffeners for rudder blade, in m, e is not to exceed 1.0 m;

f_1 – material factor of rudder blade, see 5.1.1.4;

V – speed for calculation, see 5.1.2.1.

5.1.6 Connection of rudder stock and rudder blade of steam-lined rudder

5.1.6.1 Where the rudder stock is connected to the rudder blade by horizontal coupling flanges:

(1) The diameter d_b of coupling bolts is not to be less than that calculated from the following formula:

$$d_b = 0.62\sqrt{\frac{f_{1s}}{f_{1b}}\frac{D_1^3}{nl_b}} \quad \text{mm}$$

where: f_{1b} – material factor for the bolts;

f_{1s} – material factor for the rudder stock;

n – total number of bolts, but is not to be less than 6;

l_b – mean distance of the bolt axes from the center of bolt system, in mm;

D_1 – diameter of the rudder stock at the lower bearing, in mm.

(2) The mean distance of the bolt center from the center of the flange is not to be less than 0.9 D_1.

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

(4) The coupling bolts are to be fitting bolts, and their nuts are to be securely fastened by efficient means.

(5) The thickness t of coupling flanges is not to be less than the greater of:

$$t = d_b\sqrt{\frac{f_{1b}}{f_{1f}}} \quad \text{mm}$$

$$t = 0.9d_b \quad \text{mm}$$

where: f_{1f} – material factor for the coupling flanges;

f_{1b} – material factor for the bolts.

(6) Where the rudder stock and coupling flanges are connected by welding, the welds are to be completely penetrated throughout the whole connecting surface.

5.1.6.2 Where the rudder stock and the rudder blade are connected by nut and key with cone coupling:

(1) The taper of the cone frustum is to be 1/8 to 1/12, and the length of the inserted part is not to be less than 1.5 D_1.

(2) The key is to be fitted in the cone coupling, and it is to be in the bow-stern direction. The shear area A_s of the key is not to be less than:

$$A_s = \frac{16M_{TS}}{D_s\sigma_s} \times 10^3 \quad \text{cm}^2$$

where: M_{TS}– design yield torque of rudder stock, in kN·m;

D_S – mean diameter of rudder stock at key, in mm;

σ_S– yield stress of key's material, in N/mm^2.

(3) The design yield torque of rudder stock M_{TS} is to be calculated by the following formula:

$$M_{TS} = 26.64 D_2^3 f_1 \times 10^{-6} \quad \text{kN·m}$$

where: D_2 – diameter of rudder stock at upper bearing obtained from 5.1.3.3, in mm, where the practical diameter of the stock is greater than D_2, the practical diameter is to be taken, but not more than 1.15 D_2;

f_1 – material factor of rudder stock.

(4) The abutting surface between key and rudder stock or between key and inner bearing of blade is not to be less than that calculated by the following formula:

$$A_a = \frac{0.3A_S}{f_1} \quad \text{cm}^2$$

where: f_1 is to be taken as the smallest of the material factors of the key, stock and inner bearing.

(5) Where the lower end of rudder stock is secured by a nut, the length of the nut is to be 0.6 times the major diameter of the thread, the major diameter is not to be less than 0.65 D_1 and the nut is to be securely fastened by split pins or other means.

5.1.7 Connection of rudder stock and rudder blade of flat plate rudder

5.1.7.1 The rudder stock is to be extended at least to a position at half height of the rudder blade.

5.1.7.2 The connection of rudder stock and rudder blade by welding is to comply with the requirements of CCS Rules for Materials and Welding.

5.1.8 Bearings

5.1.8.1 The load area of bearing A_b= $D_{11}h_b$. The area is to comply with the requirement of the following formula:

$$A_b \nless \frac{P}{[P]} \times 10^6 \quad \text{mm}^2$$

where: D_{11} – diameter of rudder stock at liners, in mm;

h_b – height of touching surface of bearing, in mm;

P – reaction force at the bearing, in kN.

The reaction force P at upper and lower bearings may be taken as given in the following:

$$P = \frac{M_B}{l_3} \quad \text{kN, at upper bearing;}$$

$$P = F + \frac{M_B}{l_3} \quad \text{kN, at lower bearing.}$$

where: M_B – bending moment acting on the stock, in kN·m, it may be obtained from the formula in 5.1.3.2;

l_3 – distance between upper bearing center and lower bearing center, in m, see Figure 5.1.2.1;

F – rudder force acting on the stock, in kN, it may be obtained from the formula in 5.1.2;

$[P]$ – maximum allowable surface pressure for various bearings, in kN/m^2, it is dependent on the materials of the stock and bearing as follows:

$[P]$ = 7000 kN/m^2 for steel against stainless steel or bronze;

$[P]$ = 4500 kN/m^2 for steel against white metal, oil lubricated;

$[P]$ = 5500 kN/m^2 for steel against synthetic material with hardness① between 60 and 70 Shore D, water lubricated;

$[P]$ = 2500 kN/m^2 for steel or bronze against lignum vitae.

5.1.8.2 The thickness t of any bushings in rudder bearings is not to be less than:

$$t = 0.32\sqrt{P} \quad \text{mm}$$

where: P – reaction force at the bearing, in kN, it is to be calculated from 5.1.8.1;

t is not to be less than 8 mm in general;

t_{min} = 22 mm for lignum vitae.

5.1.8.3 The width of bearing material outside bushing is not to be less than 1/4 of the rudder stock diameter.

5.1.8.4 The bearing clearance on diameter is not to be less than:

$\delta = 0.001d_{b1} + 1$ mm for metal bearing material;

$\delta = 0.002d_{b1} + 1$ mm for synthetic bearing material.

where: d_{b1} – inner diameter of bushing, in mm.

Section 2 Anchoring and Mooring Equipment

5.2.1 Equipment number

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

---

① Indentation hardness test is to be made at 23℃ and with 50% moisture, according to a recognized standard. Synthetic bearing materials are to be of approved type.

$$N = (\Delta^{2/3} + 2BH + \frac{A}{10})K$$

where: Δ – fully loaded displacement, in t;

B – breadth, see 2.1.3.1(23), in m;

H – effective height from the waterline corresponding to Δ to the top of the uppermost deckhouse whose breadth exceeds $B/4$, in m, to be calculated as follows:

$$H = a + \sum h_i \sin\theta_i$$

a – vertical distance amidships from the waterline corresponding to Δ to the upper deck, in m;

h_i – height of each tier of the deckhouse whose breadth exceeds $B/4$, in m;

A – area in profile view of the hull, superstructures and the deckhouses whose breadth exceeds $B/4$ above the waterline corresponding to Δ, in m^2;

θ_i – angle (°) of inclination aft of the front bulkhead of each deckhouse tier corresponding to h_i;

K – coefficient, it is 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 catamarans, the cross-section area of the tunnel above the waterline is to be reduced from BH in the formula.

5.2.2 Anchoring equipment

5.2.2.1 At least an approved high holding power anchor is to be arranged at the bow. The weight of the anchor is not to be less than that obtained from Table 5.2.2 based on the equipment number. Where the anchor provided is not high holding power anchor, its weight is not to be less than 1.3 times the weight obtained from Table 5.2.2. Where two anchors are provided at the bow, the weight of each anchor is not to be less than 0.7 times the weight of the single anchor.

5.2.2.2 Chain cables and anchor ropes

(1) The chain cables may be adopted in total length. The materials of chain cables are to be of Grade 2 chain steel (CCS AM2) or Grade 3 chain steel (CCS AM3) as listed in CCS Rules for Materials and Welding. However Grade 3 chain steel is not allowed to be used for the chain cables having a diameter less than 20.5 mm.

(2) The chain cables may be substituted by steel wire or synthetic fibre rope, where one of the following cases is complied with:

where $N < 440$, the chain cables may be substituted by the steel wire rope of equivalent breaking strength;

where $N < 80$, the chain cables may be substituted by the fiber rope of equivalent breaking strength.

In these cases, a short length of chain cables is to be fitted between the anchor and the rope. The length is to be taken at least as the distance between anchor in stowed position and windlass, and not to be less than $0.2L$.

(3) The diameter of stud chains and the length of chain cables (or anchor ropes) are not to be less

than the values obtained from Table 5.2.2 based on equipment number *N*. Where stud chains are substituted by rope, the breaking strength of the rope is not to be less than that of the stud chains. The breaking strength of stud chains may be obtained from the following formula based on the diameter of chain cables:

$$\text{CCS AM2: breaking strength} = 13.73 d_c^{\,2}(44 - 0.08 d_c)10^{-3} \quad \text{kN}$$

$$\text{CCS AM3: breaking strength} = 19.61 d_c^{\,2}(44 - 0.08 d_c)10^{-3} \quad \text{kN}$$

where: d_c – diameter of chain cables, in mm, obtained from Table 5.2.2.

5.2.2.3 The anchoring arrangements are to be such that any surfaces against which the chain cables may chafe (for example, hawse pipes and hull obstructions) are designed to prevent the chain cables from being damaged and folded. Adequate arrangements are to be provided to secure the anchor under all operational conditions.

5.2.2.4 The craft is to be protected so as to minimize the possibility of the anchor and chain cables damaging the structure during normal operation.

5.2.2.5 Where the weight of single anchor exceeds 50 kg, the anchoring arrangement is to be fitted.

5.2.3 Mooring equipment

5.2.3.1 The length and breaking strength of fibre ropes for mooring are to be obtained from Table 5.2.2 based on the equipment number N. However, the coefficient K in the formula of 5.2.1 to calculate *N* is to be taken as 1. The diameter of mooring ropes is not to be less than 15 mm. The total length of mooring ropes is not to be less than 4 times the length of craft in any cases.

Table 5.2.2

Equipment number N		Weight of high holding power anchor (kg)	Dia. of stud chains (mm)		Length of chains or ropes (m)	Mooring ropes	
Exceed	Not exceed		AM2	AM3		Number × length (m)	Breaking strength(kN)
30	40	37	8.0	—	90	2 × 40	32
40	50	48	8.0	—	97	2 × 40	32
50	60	59	8.5	—	104	3 × 40	34
60	75	74	9.0	—	108	3 × 50	35
75	85	91	9.5	—	112	3 × 50	36
85	100	101	11.2	—	117	3 × 55	38
100	115	120	11.2	—	122	3 × 55	41
115	135	140	12.5	—	128	3 × 55	45
135	160	170	12.5	—	134	3 × 60	50
160	185	194	14	—	140	3 × 60	56
185	210	227	16	—	146	3 × 60	62
210	240	260	17.5	—	152	4 × 60	69
240	270	293	17.5	—	158	4 × 60	75
270	300	330	19	—	165	4 × 70	80
300	335	370	20.5	—	165	4 × 70	85
335	365	400	22	20.5	165	4 × 70	90
365	400	442	22	20.5	165	4 × 70	95
400	440	490	24	22	192.5	4 × 70	100.2
440	480	534	26	24	192.5	4 × 70	105.6
480	520	575	26	24	192.5	4 × 80	110
520	560	620	28	24	192.5	4 × 80	115

560	605	674	28	24	220	4 × 80	120
605	655	730	30	26	220	4 × 80	126
655	705	786	30	26	220	4 × 80	131
705	760	850	32	28	220	4 × 85	137
760	820	914	34	30	220	4 × 85	143
820	890	1000	34	30	247.5	4 × 85	150.5
890	960	1076	36	32	247.5	4 × 85	158
960	1050	1183	38	34	247.5	4 × 90	166
1050	1170	1315	40	36	247.5	4 × 90	176

CHAPTER 6 MACHINERY INSTALLATIONS

Section 1 General Requirements

6.1.1 Application

6.1.1.1 The design, construction, installation as well as the testing and trial of prime movers, propulsions devices, auxiliary systems, machinery equipment, etc., of the high speed craft to be classed are to comply with the relevant requirements in this Chapter. The design, construction, installation and testing of other devices or equipment (such as gearings, boilers, pressure vessels, etc.) not specified in this Chapter are to comply with the relevant requirements of CCS Rules for Classification of Sea-going Steel Ships.

6.1.1.2 Installations not complying with the requirements in this Chapter may be accepted provided that they are approved and deemed by CCS to be equivalent to those required by this Chapter.

6.1.2 Ambient conditions

6.1.2.1 The main and auxiliary engines, shafting and machinery equipment essential to safety are to be so designed, type-selected and arranged as to ensure that they are capable of continuous operation without failure under the ambient conditions as specified in Table 6.1.2.1.

Angle of Inclination **Table 6.1.2.1**

Installation and equipment	Angle of inclination① (°)			
	Athwartships		Fore-and-aft	
	Static	Dynamic	Static	Dynamic
Main and auxiliary machinery	15	22.5	5	7.5
Safety equipment: Emergency generators, emergency fire pumps and prime movers to drive them	22.5	22.5	10②	10

Notes: ① Athwartships and fore-and-aft inclinations may occur simultaneously.

② Where it is impractical to meet this requirement, the smaller may be taken subject to agreement of CCS.

6.1.2.2 In general, the rated power of engine (except gas turbine) means the maximum continuous power generated by the engine under ambient reference conditions with total barometric pressure of 0.1 MPa, air temperature of 45℃, relative humidity of 60% and sea water temperature of 32℃. In the case of craft for restricted service, the rating is to be suitable for the ambient conditions associated with the geographical limits of the restricted service.

6.1.3 Vibration

6.1.3.1 The propulsion installations and hovering system are to be so designed, constructed and installed that any mode of their vibrations is not to cause undue stresses in them in the normal operating ranges.

6.1.3.2 All machinery is to be designed to operate with the craft pitching and surging in respectively vertical and horizontal direction, and with accelerations of not less than 0.5 *g*, in which g= 9.81 m/s^2.

6.1.3.3 All machinery is to be designed to operate under relevant vertical slamming acceleration a_v= 1.0 *g*.

6.1.4 Astern power

6.1.4.1 In order to maintain sufficient manoeuvrability of craft in all normal circumstances, the main propulsion machinery system is to be capable of running astern.

6.1.4.2 For the main propulsion machinery, the output astern which may be developed under transient conditions is to be such as to enable the braking of the craft within reasonable time.

6.1.4.3 For the main propulsion systems with reversing gears, controllable pitch propellers or electric propeller drive, running astern is not to lead to the overload of propulsion machinery.

6.1.5 Prime movers

6.1.5.1 The propulsion machinery is to be designed for frequent load changes and accelerations from idle to maximum continuous rating within 30 s.

6.1.5.2 Propulsion prime movers driving waterjets in the propulsion system are to be designed for possible sudden load drops from maximum continuous power down to 20% of this power and by controlled governing accelerated up to maximum continuous power again.

6.1.5.3 Prime movers of electric generators are to be capable of developing 10% overload for a short period of time (15 min).

6.1.6 Dead ship starting

6.1.6.1 Craft's machinery is to be so arranged that it can be brought into operation from the dead craft condition using only the facilities available on board without external aid.
Dead craft condition is understood to mean a condition under which the main propulsion plant and auxiliaries are not in operation and in restoring the propulsion, no stored energy is assumed to be available for starting and operating the propulsion plant, the main source of electrical power and other essential auxiliaries. It is assumed that means are available at all times to start the emergency generator or one of the main generators when the main source is arranged according to the requirements in 7.4.3.2 of the Rules.
Where the emergency source of power is an emergency generator which complies with the requirements in 7.4.2 of the Rules, or a main generator meeting the requirements in 7.4.3.2 of the Rules, it is assumed that means are available to start this generator and consequently this generator

may be used for restoring operation of the main propulsion plant and auxiliaries where any power supplies necessary for engine operation are also protected to a similar level as the starting arrangements.
Where there is no emergency generator installed or an emergency generator does not comply with the requirements in 7.4.2 of the Rules, the arrangements for bringing main and auxiliary machinery into operation are to be such that initial charge of starting air or initial electrical power and any power supplies for engine operation can be developed on board the craft without external aid.
If for this purpose an emergency air compressor or electric generator is required, these units are to be powered by a hand-starting oil engine or a hand-operated compressor.
The arrangements for bringing main and auxiliary machinery into operation are to have capacity such that the starting energy and any power supplies for engine operation are available within 30 min of a dead craft condition.

6.1.6.2 High speed craft engaged on domestic voyages with sheltered water service restriction or calm water service restriction may be exempted from the provisions of 6.1.6.1 above.

6.1.7 Limitations in use of oils as fuel

6.1.7.1 Except as otherwise permitted, no oil fuel with a flashpoint of less than 60℃ are to be used.

6.1.7.2 In emergency generators, oil fuel with a flashpoint of not less than 43℃ may be used.

6.1.7.3 The use of oil fuel having a flashpoint of less than 60℃ but not less than 43℃ may be permitted subject to the following:
(1) fuel oil tanks except those arranged in double bottom compartments are to be located outside of machinery spaces of category A;
(2) provisions for the measurement of oil temperature are provided on the suction pipe of the oil fuel pump;
(3) stop valves and/or cocks are provided on the inlet side and outlet side of the oil fuel strainers;
(4) pipe joints of welded construction or of circular cone type or spherical type union joint are applied as much as possible.

6.1.7.4 In gas turbines, the use of fuel having a lower flashpoint but not less than 35℃ may be permitted provided that such fuel complies with the conditions in respects of system design, tank arrangement, ventilation, explosion protection, etc., equivalent to those for fuel having a lowest flashpoint of not less than 43℃.

6.1.8 Protection

6.1.8.1 In the design and installation of machinery containing high-speed rotating parts, consideration is to be given to the likelihood of ejection of high energy debris in the event of failure, so as to protect against hazard to the craft and personnel. Protective means, such as the external guards, are to be provided as far as possible.

6.1.8.2 All surfaces of machinery and pipes where the hot surfaces may injury personnel are to be protected by handrails or shields. Where the surface temperature may exceed 220℃, they are to be effectively shielded to prevent ignition caused by flammable liquids. Where the insulation covering these surfaces is oil absorbent or may permit the penetration of oil, such insulation is to be encased in steel sheathing or equivalent material.

6.1.8.3 The source of excessive noise is to be insulated and reduced to an acceptable level in the machinery spaces where requires manned. Otherwise, a refuge from noise is to be provided and ear protectors are to be provided for personnel required to enter such spaces.

6.1.8.4 For the air-cushion vehicle, necessary protection equipment is to be provided in the inlet of air propeller to prevent personnel from being absorbed into the propeller.

6.1.9 Communication

6.1.9.1 Means are to be provided for communication between machinery spaces and/or control room from which the engines are normally controlled and bridge room.

6.1.10 Information and data

6.1.10.1 For aluminum alloy or fibre reinforced plastic high-speed craft, the relevant technical information and data such as the maximum deformation of hull construction are to be submitted to CCS, if necessary, in order to evaluate the safety of shafting.

6.1.11 Flexible mount

6.1.11.1 Main engine is flexibly mounted, the following requirements are to be complied with:
(1) the flexible support is to be so designed and mounted as to ensure that the normal operation of machinery will not be affected by extra loads caused by possible deformations of machinery or hull structures;
(2) all the external connection parts for machinery flexible mounted are to be flexibly connected.

6.1.12 Marine products

6.1.12.1 The marine products used on the sea-going high speed craft are to comply with the relevant requirements in Section 2, Chapter 3 of the Rules.

6.1.13 Trials

6.1.13.1 The mooring trials and sea trials for the machinery installations, after completion of mounting, are to be carried out according to the relevant requirements of the Rules and the test programmes approved by CCS.

Section 2 General Requirements for Pumping and Piping System

6.2.1 Grades of pipes

6.2.1.1 Pressure piping systems are divided into three grades in accordance with their design pressure and design temperature, as indicated in Table 6.2.1.1.

Piping System Class **Table 6.2.1.1**

Piping system	Class I		Class II		Class III	
	Design pressure (MPa)	Design temperature (℃)	Design pressure (MPa)	Design temperature (℃)	Design pressure (MPa)	Design temperature (℃)
Steam	> 1.6	or > 300	≤ 1.6	and ≤ 300	≤ 0.7	and ≤ 170
Thermal oil	> 1.6	or > 300	≤ 1.6	and ≤ 300	≤ 0.7	and ≤ 150
Fuel oil, lub oil, flammable hydraulic oil	> 1.6	or > 150	≤ 1.6	and ≤ 150	≤ 0.7	and ≤ 60
Other media	> 4.0	or > 300	≤ 4.0	and ≤ 300	≤ 1.6	and ≤ 200

Notes: ① For Classes II and III pipes, both parameters for design pressure and design temperature are to be met, for Class I pipes, only one of the parameters is sufficient.

② Toxic or corrosive media, flammable media heated above flash point, media with flash point below 60℃ and liquefied gas belong to class I. If means of special safeguards for preventing leakage and its consequences are provided, they may also belong to class II, but except toxic media.

③ Class III pipes may be used for open ended piping, e.g. drains, overflows, vents, boiler waste steam pipes, etc.

④ Thermal oil means the circulating oil used in the thermal oil system as specified in Section 8, Chapter 4, PART THREE of CCS Rules for Classification of Sea-going Steel Ships.

⑤ Other media mean air, water, and non-flammable hydraulic oil.

6.2.2 Design

6.2.2.1 The design of pumping and piping systems is to be such that the capacity of the systems is properly greater than that of the actual needs of the systems, except the case of accessory pump of machinery.

6.2.2.2 The design pressure for piping is the maximum permissible working pressure and it is not to be less than the highest set pressure of any safety valve or relief valve. For pipes containing fuel oil, the design pressure may be taken as given in Table 6.2.2.2.

Design pressure for pipes containing fuel oil **Table 6.2.2.2**

Working temperature / Working pressure	T ≤ 60℃	T > 60℃
$P \leq 0.7$ MPa	0.3 MPa or highest working pressure, whichever is greater	0.3 MPa or highest working pressure, whichever is greater
$P > 0.7$ MPa	Highest working pressure	1.4 MPa or highest working pressure, whichever is greater

6.2.2.3 The design temperature of piping system is to be taken as the maximum temperature of internal fluid, but in no case is it to be less than 50℃.

6.2.3 Arrangement

6.2.3.1 Penetration pieces of steel pads or plates are to be provided for pipes passing through gastight or watertight structures.

6.2.3.2 Fresh water pipes are not to be led through oil tanks, nor oil pipes through fresh water tanks. Where it is impracticable to do so, the pipes are to be led inside an oil-tight tunnel or sleeve pipe. For other pipes passing through fuel oil tanks, their thicknesses are to be increased, and no detachable pipe joint is permitted inside these tanks.

6.2.3.3 Air, overflow and sounding pipes for fuel oil tanks are not to be led through accommodations. Where this is not practicable, no detachable pipe joint is permitted in these spaces.

6.2.3.4 Where the following tanks are arranged adjacently, they are to be separated by cofferdams or equivalent means:
(1) lubricating oil tank and fuel oil tank;
(2) lubricating oil tank and fresh water tank;
(3) fuel oil tank and fresh water tank.
Suitable drainage device and air pipe are to be provided for cofferdams and the equivalent means.

6.2.3.5 Piping systems are normally to be made of rigid pipes. The use of flexible hoses of approved type suitable for their intended use may be accepted in lieu of rigid piping upon special consideration. Pipes and fittings are to be supported in such a way that their weight is not taken by the machinery connected with them. Heavy valves and fittings are not to cause large additional stresses in adjacent pipes.
The support of the piping system is to be such that detrimental vibrations will not arise in the system.

6.2.3.6 Axial forces due to internal pressure, change in direction or cross-sectional area and movement of the craft are to be taken into consideration when mounting the piping system.

6.2.3.7 Metallic pipes are to be connected by welding or brazing or by detachable connections of approved type.

6.2.3.8 Water pipes and air and sounding pipes through freezing chambers are to be avoided.

6.2.4 Protection

6.2.4.1 All steam, oil and water pipes as well as oil and other liquid tanks are not to be placed above or behind the switchboard. If this is not practicable, suitable protective means are to be provided.

6.2.4.2 Oil pipes and oil tanks are not to be directly placed above the exhaust gas pipes, silencers and main switchboard. If necessary, effective means are to be made to prevent oil dropping onto the hot surfaces of the above-mentioned pipes and equipment.

6.2.4.3 The pipes which may be subject to a pressure greater than the design value are to be fitted with relief valves at the delivery side of pumps. The discharge from relief valves fitted in oil pipe lines is to be led to the suction of pumps or tanks. For the water piping, if the drainage of relief valve leads to the bottom of tank, the said valve is to be in a visible position so as to observe the drainage.

6.2.4.4 Where pressure-reducing valves are fitted in the pressure piping, a relief valve and a pressure gauge are to be fitted behind the pressure reducing valve and by-pass pipe is to be provided. Or, an additional spare pressure reducing valve in parallel is to be provided.

6.2.4.5 If necessary, drainage devices are to be provided for the piping.

6.2.5 Corrosion protection

6.2.5.1 Steel pipes are to be protected against corrosion and protective coatings are to be applied on the outside surface after completion of all fabrication, i.e. bending, forming and welding of the steel pipes.

6.2.6 Valves and control

6.2.6.1 Valves at the craft's side and bottom are to be of approved type.

6.2.6.2 Sea suction and discharge valves, bilge valves and valves on the fuel oil and lubricating oil tanks which are situated higher than the double bottom tanks, are to be arranged for local mechanical manual operation. The change over to manual operation from possible remote control arrangement is to be simple to execute.

6.2.6.3 For remotely controlled valves, failure in power supply is not to cause:
(1) opening of closed valves;
(2) closing of open valves;
(3) closing of open valves on fuel oil tanks and in cooling water system for propulsion and power generating machinery.

6.2.6.4 Remotely controlled valves are to be provided with indications for open or closed valve positions at the control station. In cases where possibility of direct manual operation is required in addition to the remote control, means of observing the valve position at the valve location is to be provided.

Section 3 Materials and Tests of Pump and Piping

6.3.1 Materials

6.3.1.1 In general, the melting point of metal material for piping is to be greater than 900℃.

6.3.1.2 Carbon, low alloy and stainless steel pipes or valves are to comply with the following.

(1) Class I and II pipes are to be seamless steel pipes or welded pipes fabricated with a welding procedure approved by CCS.

(2) In general, carbon, and carbon-manganese steel pipes, valves and fittings are not to be used for media of temperatures above 400℃. If the metallurgical performance and endurance strength of high temperature (the maximum tensile strength for above 100,000 h) comply with the requirements of national or international regulations and standards and these data are ensured by steel manufacturers, they can apply for the piping of higher temperature.

(3) The following means are to be taken for connection of pipe lengths:

① welded butt-joints between pipes or between pipes and valve chests or other fittings. The butt welding is to be full-penetration type with special provisions for the root or full-penetration type without special provisions for the root;

② slip-on sleeve welded joints, the slip-on sleeve welding is to comply with the requirements of CCS Rules or recognized standards and it is to be carried out with slip-on sleeve in suitable dimension and the relevant welding procedure;

③ threaded sleeve joints and other joints of approved type.

(4) The application of the aforesaid types of connection is as follows:

butt welded joints and slip-on sleeve and socket welded joints are to comply with Table 6.3.1.2; slip-on threaded joints are to comply with requirements of a recognized standard; slip-on threaded joints may be used for outside diameters as stated below except for piping systems conveying toxic or flammable media or services where fatigue, severe erosion or crevice is expected to occur; threaded joints in CO_2 systems are to be allowed only inside protected spaces and in CO_2 cylinder rooms.

① Threaded joints for direct connectors of pipe lengths with tapered thread are to be allowed for Class I, outside diameter not more than 33.7 mm as well as Class II, outside diameter not more than 60.3 mm.

② Threaded joints for parallel thread are to be allowed for Class III, outside diameter not more than 60.3 mm.

③ In particular cases, sizes in excess of those mentioned above may be accepted by CCS.

Connection of pipe lengths **Table 6.3.1.2**

<table>
<tr><th>Type of connection</th><th>Allowed for classes</th><th>Allowed for outside diameter</th></tr>
<tr><td>Butt welded joints with special provision for a high quality of root side</td><td>I, II, III</td><td rowspan="3">No restriction</td></tr>
<tr><td>Butt welded joints without special provision for a high quality of root side</td><td>II, III</td></tr>
<tr><td rowspan="2">Slip-on sleeve and socket welded joints</td><td>III</td></tr>
<tr><td>I, II, except for piping systems conveying toxic media or where fatigue, severe erosion is expected to occur</td><td>$D \leq 88.9$ mm</td></tr>
</table>

6.3.1.3 The copper and copper alloy pipes, valves and fittings are to comply with the following requirements:

(1) copper and copper alloy pipes used in Classes I and II piping systems are to be seamless;

(2) in general, copper and copper alloy pipes, valves and fittings are not to be used for media having a temperature above the following limits:

copper and aluminum brass: 200℃;

copper nickel: 300℃;

special bronze suitable for high temperature services: 260℃;

(3) where copper or copper alloy pipes are arranged to pass through watertight or fire-resisting bulkheads or decks, provision is to be made for maintaining the integrity of the bulkheads or decks in the event of pipe failure;

(4) copper or copper alloy pipes are not permitted to use where the external diameter of air starting pipe is greater than 44.5 mm;

(5) copper or copper alloy pipes are not permitted to use in the systems for containing aviation grade kerosene.

6.3.1.4 The nodular graphite cast iron pipes, valves and fittings are to comply with the following requirements:

(1) ferritic nodular graphite cast iron pipes, valves and fittings are not to be used in piping systems for conveying media having temperatures exceeding 350℃;

(2) ferritic nodular graphite iron castings in Class II and Class III piping systems are to be made in a class having specified minimum elongation not less than 12% on a gauge length of $5.65\sqrt{A}$, where A is the cross-sectional area of the test piece;

(3) where ferritic nodular graphite iron casting are used for craft's side pipes and valves, the properties of this material are to comply with the relevant requirements of CCS Rules for Materials and Welding.

6.3.1.5 In general, the use of aluminum pipes is to be restricted to the service systems as mentioned in 6.3.1.6, but for craft engaged on domestic voyages, aluminum pipes may also be used in fuel oil filling pipes as well as air pipes, overflow pipes and sounding pipes in fuel oil tanks.

6.3.1.6 The approved non-metallic pipes may be used in the following service systems. However non-metallic pipes for non-essential service may be the daily sanitary pipes approved by CCS:

(1) sea water cooling system;

(2) fresh water cooling system;

(3) bilge system;

(4) ballast system;

(5) air pipes and sounding pipes of sea water ballast tanks and fresh water ballast tanks;

(6) piping for non-essential service not containing flammable fluids.

6.3.1.7 The application of pipes of non-metallic materials such as plastic pipes and flexible hoses on board is to comply with the relevant requirements of Chapter 2, PART THREE of CCS Rules for Classification of Sea-Going Steel Ships.

6.3.2 Wall thickness of metal pipes

6.3.2.1 The minimum wall thickness required in Table 6.3.2.2 and 6.3.2.3 in this Section is not to be reduced due to negative tolerance or bending of pipes.

6.3.2.2 The minimum nominal wall thickness of steel pipes and aluminum pipes is to comply with the value in Table 6.3.2.2.

6.3.2.3 The minimum wall thickness of copper or copper alloy pipes is to comply with the requirement of Table 6.3.2.3.

6.3.2.4 The requirements for the minimum wall thickness of stainless steel pipes are the same as that of copper alloy pipes in Table 6.3.2.3.

Minimum nominal wall thickness of steel pipes and aluminum pipes Table 6.3.2.2

External diameter D (mm)	Minimum wall thickness t (mm)
10.2~12	1.6
13.2~17.2	1.8
20.0~44.5	2.0
48.5~63.5	2.3
70.0~82.5	2.6
88.9~108	2.9
114.3~127	3.2
133~139.7	3.6
152.4~168.3	4.0
177.8	4.5

Notes: ① For pipes with effective anti-corrosive means, the minimum wall thickness can be suitably reduced, but the value reduced is not to exceed 1 mm.

③ The wall thickness of screw pipes is to be measured to the root of the thread.

Minimum nominal wall thickness of copper or copper alloy pipes Table 6.3.2.3

External diameter D (mm)	Minimum wall thickness (mm)	
	Copper	Copper alloy
$D \leq 10$	1.0	0.8
$10< D \leq 20$	1.2	1.0
$20< D \leq 44.5$	1.5	1.2
$44.5< D \leq 76.1$	2.0	1.5
$76.1< D \leq 108$	2.5	2.0
$108< D \leq 159$	3.0	2.5
$159< D \leq 267$	3.5	3.0

Note: The wall thickness of pipes in remote control systems for valves in ballast tanks is not to be less than 3 mm for aluminum brass pipes, 2mm for stainless steel pipes.

6.3.3 Tests

6.3.3.1 All pipes for Classes I and II piping systems, and feed pipes, compressed air pipes and fuel oil pipes having a design pressure greater than 0.34 MPa together with their fittings are to be hydraulically tested after completion of manufacture and before insulating and coating. Test pressure is not to be less than 1.5 times of design pressure.

6.3.3.2 For pipes with an internal diameter less than 15 mm, the hydraulic test may be waived with the consent of CCS.

6.3.3.3 After assembly on board, all piping systems are to be checked for leakage under working conditions. Fuel (oil or gas) piping, heating coils in tanks, bilge pipes in way of double bottom tanks or deep tanks and hydraulic piping are to be tested by hydraulic pressure in accordance with Table 6.3.3.3.

Hydraulic tests after assembly on board **Table 6.3.3.3**

Piping system	Test pressure
Fuel (oil or gas) piping	1.5 times design pressure, but not less than 0.4 MPa
Heating coils in tanks	
Bilge pipes in way of double bottom tanks or deep tanks	Not less than test pressure of the tank
Hydraulic piping	1.25 times design pressure, but no need to exceed design pressure plus 7 MPa

6.3.3.4 All the components of valves and fittings subject to pressure except mentioned in 6.3.3.5 are to be subjected to hydraulic tests in workshop prior to assembly. The hydraulic test pressure is to be 1.5 times the design pressure, but need not exceed the design pressure plus 7 MPa.

6.3.3.5 Hydraulic testing is to be carried out for side valves and bottom valves with the pressure not less than 0.5 MPa. If they are butterfly valves, each side of butterfly clack is to be hydraulically tested with a pressure not less than 0.5 MPa.

6.3.3.6 Valves, cocks and distance pieces intended to be fitted on the craft side below the static flooding water line are to be tested by hydraulic pressure not less than 0.5 MPa.

Section 4 Craft's Piping and Ventilating Systems

6.4.1 General requirements

6.4.1.1 Valves, cocks, pipes or other fittings attached direct to the plating of tanks, and to bulkheads, decks, flats or tunnels which are required to be of watertight construction, are to be secured by means of studs screwed into but not penetrating through the pads welded on the plating.

6.4.1.2 All valves which are provided with remote control are to be arranged for local manual operation, independent of the remote operating mechanism. Opening and/or closing of the valve by local manual means is not to render the remote control system inoperable.

6.4.2 Craft-side valves and fittings (other than those on scuppers and sanitary discharges)

6.4.2.1 All sea inlet and overboard discharge pipes are to be fitted with valves or cocks secured direct to the shell plating, or to the plating of fabricated steel sea chests attached to the shell plating. The valves or cocks are to be secured by means of studs screwed into but not penetrating through the pads welded on the shell plating or sea chests.

6.4.2.2 If impractical, the valves or cocks mentioned in 6.4.2.1 may also be secured to the distance piece welded to the shell plating. The wall thickness and diameter of the distance piece are to be so chosen that the distance piece can reach equivalent strength of adjacent hull structure, and the corrosion-resistance capability of the material for the distance piece is also to be considered.

6.4.2.3 Craft-side valves and fittings as well as sea chest, if made of steel, are to be suitably protected against wastage.

6.4.2.4 Sea chests are to be so arranged as to avoid the formation of air pocket. Where a vent pipe is fitted on the top of the sea chest, a screw-down valve is to be fitted at the root of the vent pipe. The open end of the vent pipe is to be extended to a position above the bulkhead deck or to be led overboard in the vicinity of the bulkhead deck and a craft-side screw-down valve is to be fitted.

6.4.2.5 Sea inlet valves and sea outlet valves without non-return means in unattended spaces are to be capable of being closed above the waterline.

6.4.3 Bilge pumping system

6.4.3.1 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.

6.4.3.2 The system is to be so designed from the very beginning as to consider that it is to be capable of operating under all possible states of trimming or listing in case of flooding not damaging the craft's safety.

6.4.3.3 For individual compartment, the drainage can be exempted with the consent of CCS provided that the safety of the craft is not affected by drainage of this compartment through calculation or necessary demonstration.

6.4.3.4 At least two bilge suctions are to be provided in each machinery space. An independent bilge pump is to have one direct bilge suction from the space in which it is situated.

6.4.3.5 The bilge suctions in machinery space are to be arranged as follows:
(1) for single hull craft, the suction is to be arranged in the center longitudinal section;
(2) for twin-hull craft, side-wall hovercraft, the suction is to be arranged in the center longitudinal section of each hull;

(3) for air-cushion vehicle, each machinery space may have only one section.

6.4.3.6 The device for preventing rubbish from being sucked (such as mud box or strum) is to be provided for bilge suction in machinery space and it can be easily removed and replaced for cleaning.

6.4.3.7 At least one bilge suction is to be provided for each compartment in which bilge pumping system is necessary except machinery spaces and the said suction is to be so arranged as to drain the water effectively from the compartment.

6.4.3.8 The open ends of bilge suction pipes in those compartments other than the machinery space are to be enclosed in strum boxes, which can 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.

6.4.3.9 For the accommodation used portable drainage pumping, raceways are to be provided to drain the bilge water facilitatedly in the aforesaid accommodation.

6.4.3.10 In no case is the internal diameter of the bilge main to be less than that required for the largest branch bilge line.

6.4.3.11 In general, the internal diameter of the branch bilge line is not to be less than 25 mm.

6.4.3.12 Screw-down non-return valves are to be provided in the following pipes or fittings to prevent water flowing coracle between watertight compartments, watertight compartment and machinery space, dry compartment and sea water or tank:
(1) direct bilge suction pipe;
(2) connection pipe of bilge pump to bilge main line;
(3) distribution bilge valve chest;
(4) bilge suction hose directly connected with bilge pump or bilge main line.

6.4.3.13 The collision bulkhead between the bulkhead deck and inner bottom may be pierced by one pipe only for dealing with the fluid in the fore peak tank. The pipe is to be provided with a valve which can be operated above the bulkhead deck and an indicator to show the opening or closing state. The valve is to be secured to the bulkhead inside the fore peak. Hand pump may be used for drainage for the fore peak with the consent of CCS.

6.4.3.14 The bilge main line is not to be arranged within the possible damaged penetration scope of the craft. Provision is to be made to prevent the compartment served by and bilge suction pipe being flooded in the event of the breaking of the pipe, or otherwise damaged by collision or grounding in any other compartment. For this purpose, where the pipe is at any part situated within the aforesaid damaged penetration scope, a non-return valve is to be fitted to the pipe in the compartment containing the open end.

6.4.3.15 For the chain locker and the watertight compartment (if any), above the fore peak tank, steering gear compartments or other small enclosed spaces situated above the after peak tank, drainage is to be provided either by hand pump or power pump bilge suctions.

6.4.3.16 Necessary valves for controlling the bilge suctions are to be capable of being operated from above the datum①.

6.4.3.17 All distribution boxes and manually operated valves in connection with the bilge pumping arrangements are to be in positions which are accessible under ordinary circumstances. The spindles of manually operated valves are to be easily accessible and all valves are to be clearly marked.

6.4.3.18 The spindles of the sea inlet valves are to extend well above the engine room floor plates.

6.4.3.19 All bilge suction piping up to the connection to the pumps are to be independent of other piping system.

6.4.3.20 Spaces situated above the water level in the worst anticipated damage conditions may be drained directly overboard through scuppers fitted with non-return valves.

6.4.3.21 Any unattended space for which bilge pumping arrangements are required is to be provided with a bilge alarm.

6.4.3.22 All power bilge pumps are to be of the self-priming type.

6.4.3.23 An emergency bilge suction is to be provided for each main machinery space. The suction is to be led to the largest available power pump other than a bilge pump, propulsion or oil pump, such as main cooling water pump which need not be of the self-priming type.

6.4.3.24 The bilge pump complying with the following requirements is to be provided for each hull of twin-hull craft and each monohull craft:

(1) at least two bilge pumps are to be provided, one of them may be pump driven engine;

(2) the bilge pump is to be of fixed type or portable type and to be driven by power. For the craft with the length less than 20 m, only one power bilge pump is to be provided. However, a bilge pump with output of less than 1.5 m^3/h may be hand pump;

(3) the output Q of each bilge pump is not to be less than the value calculated by the following formula:

$$Q = 3.75(1+L/36)^2 \qquad m^3/h$$

where: L – length of the rigid hull measured on the design waterline in the displacement mode, in m;

(4) for twin-hull craft, if bilge water of one certain hull can be drawn by the bilge pump of other

① Datum means a watertight deck or equivalent structure of a non-watertight deck covered by a weathertight structure of adequate strength to maintain the weathertight integrity and fitted with weathertight closing appliances.

hull, the aforesaid hull may only be provided with one bilge pump;
(5) independent power sanitary, ballast and general service pumps may be accepted as independent power bilge pumps, provided that they are of the required capacity of the self-priming type or with the self-priming arrangement and connected to the bilge main.

6.4.3.25 The arrangement of bilge pumping system in the machinery space for hovercraft may be specially considered subject to agreement of CCS.

6.4.3.26 The passenger craft of category B are to comply with the following requirements.
(1) The arrangement of bilge pumping system is to be so arranged that at least one power bilge pump is to be available for use in all flooding conditions which the craft is required to withstand as follows:

① one of the required bilge pump is to be an emergency pump of a reliable submersible type having an emergency source of power; or

② the bilge pumps and their sources of power are to be so distributed throughout the length of the craft that at least one pump in an undamaged compartment will be available.

(2) Distribution boxes, cocks and valves in connection with the bilge pumping system are to be so arranged that, in the event of flooding, one of the bilge pumps may be operative in any compartment. In addition, damage to a pump or its connecting to the bilge main is not to put the bilge system out of action. When, in addition to the main bilge pumping system, an emergency bilge pumping system is provided, it is to be independent of the main system and so arranged that a pump is capable of operating in any compartment under flooding conditions. In that case only the valves necessary for the operation of the emergency system need to be capable of being operated from above the datum.
(3) All cocks and valves referred to in 6.4.3.26(2) which can be operated from above the datum are to have their controls at the place of operation clearly marked and are to be provided with means to indicate whether they are open or closed.

6.4.4 Scuppers and sanitary discharges

6.4.4.1 Scuppers sufficient in number and size to provide effective drainage are to be fitted in all decks.

6.4.4.2 Scuppers draining spaces within superstructures or deckhouses not fitted with efficient weathertight doors are to be led overboard.

6.4.4.3 Scuppers and discharges which drain spaces below the freeboard deck, or spaces within intact superstructures or deckhouses on the freeboard decks fitted with efficient weathertight doors, may be led to the bilges in the case of scuppers, or to suitable sanitary tanks in the case of sanitary discharges.

6.4.4.4 Discharges led through the shell from spaces below the datum or from within superstructures and deckhouses above the datum are to be fitted with efficient and accessible means for preventing water from passing inboard. Normally each separate discharge is to have one automatic non-return valve with a positive means of closing it from a position above the datum. Where, however, the vertical distance from the design waterline to the inboard end of the discharge pipe exceeds $0.01L$ (L being craft length), the discharge may have two automatic non-return valves without means of closing, provided that the inboard valve is always accessible for examination under service conditions. Where that vertical distance exceeds $0.02L$, a single automatic non-return valves without means of closing may be accepted. The means for operating the positive action valves is to be readily accessible and fitted with an indicator showing whether the valve is open or closed.

6.4.4.5 The wall thickness and diameter of deck scuppers drainage pipes led directly overboard are to be selected in accordance with the requirements for distance pieces on the shell plating in 6.4.2.2 of this Chapter.

6.4.5 Air pipes

6.4.5.1 Air pipes are to be fitted in all oil tanks, water tanks and cofferdams. Air pipes are to be fitted at the highest part of the tanks and far apart from the filling pipes.

6.4.5.2 Where only one air pipe is fitted to a tank, it is not to be used as a filling pipe.

6.4.5.3 Air pipes are not to be used as sounding pipes.

6.4.5.4 The arrangement of the air piping is to be such that in the event of any one of the tanks being damaged, tanks situated in other watertight compartments of the craft can not be flooded from the sea through combined air pipes.

6.4.5.5 The termination of air pipes is to comply with the following requirements.

(1) Air pipes of fuel oil tanks, cofferdams adjacent to fuel oil tanks, and tanks situated outside machinery spaces, which are not fitted with overflow pipes and can be pumped up are to be led to the open above the freeboard deck.

(2) Air pipes of cofferdams, double bottom tanks and tanks which can be run up from the sea other than those prescribed in 6.4.5.5(1) are to be led to above the bulkhead deck.

(3) The open ends of air pipes of fuel oil tanks are to be situated where no danger will be incurred from issuing oil or vapour and furnished with a wire gauze diaphragm of corrosion-resistant material which can be readily removed for renewal.

(4) The open ends of all air pipes extending above the exposed deck are to be provided with efficient and suitable closing appliances to prevent any entry of water from the sea under heavy weather conditions.

(5) Air pipes of lubricating oil storage tanks may terminate in the machinery space, provided that the open ends are so situated that issuing oil cannot come into contact with electrical equipment or heated surfaces.

(6) Air pipes extending to exposed decks are to have a height from the deck to the point where water may have access below of at least 300 mm, and 150 mm on other decks. All air pipes are to be equipped with weathertight closing devices that close automatically.

6.4.5.6 The size of air pipes is to comply with the following requirements.
(1) For all tanks which can be pumped up by the pumps through a filling main, the total cross-sectional area of the air pipes to each tank is to be at least 25% greater than the effective area of the respective filling pipes. In any case, the internal diameter of air pipes is not to be less than 50 mm.
(2) Where overflow pipes are fitted in tanks, the sectional area of the air pipes is to be at least 20% of that of the filling pipes. When an air pipe serves several tanks all having overflow pipes, the sectional area of the air pipe is to be at least 20% of the combined area of the two largest filling pipes for the separate tanks.

6.4.6 Overflow pipes

6.4.6.1 All tanks which can be pumped up are to be fitted with overflow pipes, when the liquid pressure head corresponding to the height of the air pipe is greater than that for which the tanks are suitable, or when the sectional area of the air pipe is less than that required by 6.4.5.6(1). The sectional area of the overflow pipe(s) from each tank is not to be less than 1.25 times that of the filling pipe(s). In the case of oil fuel and lubricating oil tanks, the overflow pipe is to be led to an overflow tank of adequate capacity or to a storage tank having a space reserved for overflow purposes.

6.4.6.2 A well illuminated sight glass is to be provided in the overflow pipe, or alternatively, an alarm device is to be provided.

6.4.6.3 Shut-off valves or cocks are not allowed to be fitted to the overflow pipes.

6.4.6.4 The arrangement of the overflow pipe is to be such that in the event of any one of the tanks being damaged, tanks situated in other watertight compartments of the craft cannot be flooded from the sea through the overflow main.

6.4.7 Sounding pipes

6.4.7.1 Sounding pipes are to be provided for all tanks, cofferdams. All sounding pipes other than the short ones are to be led to positions above the bulkhead deck which are accessible. The sounding pipes to fuel oil tanks and lubricating oil tanks are to be led to safety positions on the open deck.

6.4.7.2 Liquid level indicators or remote sounding devices of approved type may be used in lieu of sounding pipes to tanks. Cylindrical gauge glasses may be used, subject to the approval by CCS, for small tanks which are not greater than 500*l* in capacity and provided that special consideration has been paid to the construction, strength and protection from mechanical damages of the glasses.

6.4.7.3 All sounding pipes exposed to sea and weather are to be provided with permanently attached effective means of closing to prevent the free entry of water.

6.4.7.4 The bottom plating at the open ends of sounding pipes is to be protected by striking plates of adequate thickness and size.

6.4.7.5 Self-closed cocks complying with the requirements are to be fitted for short sounding pipes in fuel oil tanks and lubricating oil tanks.

6.4.7.6 The internal diameter of sounding pipes is not to be less than 32 mm.

6.4.8 Ballast system

6.4.8.1 The arrangement of ballast system and the suction number of ballast tanks are to enable discharging and pouring into under the normal operation condition.

6.4.8.2 The ballast piping system is to be so arranged as not to make the water outside the craft or inside the ballast tanks flood into cargo hold, machinery spaces or other accommodations.

6.4.8.3 The ballast pipes are not to pass through the drinking tanks and lubricating oil tanks. And the ballast piping system is not to be connected with the bilge pipes of dry cargo compartments and machinery spaces and pipes of oil tanks, except the joint pipes between pumps and valve chests as well as the main pipes for the pump draining to overboard.

6.4.8.4 Where the drinking tanks are used as ballast tanks, too, blind plate or other separating devices are to be provided for ballast piping system in order to avoid of the connection of these two systems.

6.4.8.5 Where an oil fuel transfer system is used for a ballast purpose, the system is to comply with the following requirements:
(1) relevant requirements for oil fuel systems in this Chapter;
(2) the system is to be properly isolated from any water ballast system.

6.4.9 Ventilation

6.4.9.1 The ventilating ducts are not to be led through watertight bulkhead below the bulkhead deck.

6.4.9.2 Ventilator coamings having a height greater than 900 mm are to be specially supported.

6.4.9.3 Ventilators passing through non-enclosed superstructures are to have substantially constructed coamings of steel or other equivalent material on the freeboard decks. The thickness of coaming is not to be less than that of the deck.

6.4.9.4 The ventilation system is to comply with the relevant requirements for fire safety.

6.4.9.5 Machinery spaces are to be adequately ventilated so as to ensure that when machinery therein are operating at full power in all weather conditions including heavy weather, an adequate supply of air is maintained to the spaces for the safety and comfort of personnel and the operation of the machinery.

6.4.9.6 Effective means of ventilation are to be provided for all compartments used for the storage of inflammable substances, explosives or where toxic or inflammable gases may accumulate.

6.4.9.7 Ventilator cowls are to be placed on the exposed deck and located as far remote from exhaust outlets and skylights as possible.

6.4.9.8 Effective weathertight closing appliances are to be provided at the vent which is to comply with the relevant provisions of the International Code of Safety for High-speed Craft.

Section 5 Machinery Piping Systems

6.5.1 Oil fuel systems

6.5.1.1 The fuel oil used for high-speed craft is to comply with the provisions of 6.1.7.1 of this Chapter. Where fuel oil with a flashpoint of 35℃ to 43℃, the oil fuel system is to be in compliance with the following requirements in addition to those as required in this Section.
(1) Tanks for the storage of such fuel is to be located outside any machinery space and at a distance of not less than 760 mm inboard from the bulkheads, deck, shell top and bottom plating.
(2) Flame trap is to be fitted at the exhaust ends of all safety valves, air pipes and overflow pipes.
(3) The spaces in which fuel oil tanks are located are to be mechanically ventilated using exhaust fans providing not less than 6 air changes per hour. The fans are to be such as to avoid the possibility of ignition of flammable gas air mixtures. Suitable wire mesh guards are to be fitted over inlet and outlet ventilation openings. The outlets for such exhausts are to be discharged to a position which, in the opinion of CCS, is safe. “No smoking” signs are to be posted at the entrances to such spaces.
(4) Earthed electrical distribution systems are not to be used, with the exception of earthed intrinsically safe circuits.
(5) Suitable certified safe type electrical equipment is to be used in all spaces where fuel oil leakage could occur including ventilation system. Only electrical equipment and fittings essential for operational purposes are to be fitted in such spaces.
(6) A fixed gas detection system is to be installed in each space through which fuel lines pass, with alarms provided at the continuously manned control station.

6.5.1.2 Drip trays are to be provided under the oil tanks which do not form part of the hull structure, pumps, filters and all other oil fuel appliances which are required to be opened up frequently for cleaning or adjustment. Oils in the drip trays are to be drained to special sludge tanks.

6.5.1.3 The gaskets used for fuel oil piping system are to be made of oil-proof and heat-resistant material.

6.5.1.4 The oil fuel tanks are not to be located in the positions where danger may occur by the fuel oil leaking onto the heat surfaces. The spaces in which the oil fuel settling and service tanks are fitted are to be well ventilated and easy of access.

6.5.1.5 For oil fuel tanks, if sounding pipes are used as sounding devices for oil fuel, the following are to be met.
(1) They are not to be terminated in any space where the risk of ignition of spillage from the sounding pipe might arise. In particular, they are not to be terminated in public spaces, crew accommodation or machinery spaces.
(2) Terminations are to be provided with a suitable means of closure and provision to prevent spillage during refuelling operations.

6.5.1.6 Other oil-level gauges may be used in place of sounding pipes mentioned in 6.5.1.5. However such means are to be subject to the following conditions.
(1) In passenger craft, such means do not require penetration below the top of the tank and their failure or overfilling of the tanks do not permit release of fuel.
(2) In cargo craft, CCS may permit the use of oil-level gauges with flat glasses and self-closing valves between the gauges and fuel tanks.

6.5.1.7 Provision is to be made to prevent overpressure in any oil tank or in any part of the oil fuel system, including the filling pipes. Any relief valves and air or overflow pipes are to discharge to a safe position.

6.5.1.8 In addition to the local controls, the power supply to all independently driven oil fuel transfer pumps is to be capable of being stopped from a readily accessible position outside the spaces in which they are situated.

6.5.1.9 At least two filters or one duplex-filter is to be fitted in the oil fuel supply line and the arrangement is to be such that any filter can be cleaned without interrupting the supply of filtered oil fuel to the engines.

6.5.1.10 Valves or cocks are to be interposed between the pumps and the suction and discharge pipes, in order that any pump may be shut off for opening up and overhauling.

6.5.1.11 Oil fuel piping is to be entirely separated from other piping systems.

6.5.1.12 The joint number of oil fuel pipes and other flammable oil piping systems is to be maintained minimum and piping is to be sheltered or suitable protected in order to prevent oil frog or leakage spouting onto the heat surfaces, electrical equipment, air inlet of machinery or other fire sources. Where this is impracticable, the pipes are to be led in well lighted and readily visible positions and detachable pipe connections are to be effectively shielded with suitable drainage arrangements.

6.5.1.13 Fuel oil and other flammable oils are not to be carried forward of public spaces and crew accommodation.

6.5.1.14 Fuel oil tanks are not to be located in or contiguous to major fire hazard areas. However, flammable fluids of a flashpoint not less than 60℃ may be located within such areas provided that the tanks are made of steel or other equivalent material. For the arrangement of aluminum alloy fuel tanks, special consideration is to be given to the hull damage. The lubricating oil storage tanks of engines or the lubricating oil filter casings installed on engines may be made of aluminum.

6.5.1.15 Oil fuel pipes and their valves and fittings are to be of steel or other approved material, nodular graphite cast iron may be used for valves under static head fitted on the outside of fuel tank walls. Grey cast iron valves may be used in oil fuel piping with design pressure of less than 0.7 MPa and design temperature of less than 60℃. Restricted use of flexible pipe is permissible in positions where necessary, subject to agreement of CCS. Such flexible pipes and end attachments are to be of approved fire-resisting materials of adequate strength and are not to penetrate the watertight tanks.

6.5.1.16 Oil fuel piping is not permitted to pass through the passenger, crew, baggage compartments or cargo compartments.

6.5.1.17 Oil fuel piping is to be so arranged as to be visible and accessible, proper fixed or elastic securing means are to be provided against excessive movements and vibrations.

6.5.1.18 Every oil fuel pipe, which, if damaged, would allow oil to escape from a storage, settling or daily service tank situated above the double bottom are to be fitted with a cock or valve directly on the tank.
The above-mentioned valves or cocks are to be capable of being closed locally as well as capable of being remotely closed from safe and easily accessible positions outside the spaces where these tanks are situated. In the case of tanks less than 500*l*, remotely controlled closing devices may be omitted except for the valves or cocks on daily service tanks.

6.5.1.19 Settling tanks are to be provided with means for draining water. If settling tanks are not provided, the oil fuel tanks or daily service tanks are to be fitted with water drains. Drain valves or cocks fitted to the oil fuel tanks are to be of self-closing type, and suitable provision is to be made for collecting the oily discharge.

6.5.1.20 Fuel filling is to be effected by means of permanently installed lines. The filling pipes are to be led to a level as low as practicable inside the tank.

6.5.2 Lubricating oil systems

6.5.2.1 The capacity of the lubricating oil pump and the pipe arrangement are to be such as to maintain the oil supply under full load conditions of the main engine.

6.5.2.2 The lubricating oil piping system is to comply with the provisions of 6.5.1.2, 6.5.1.18 and 6.5.1.4 to 6.5.1.7 except for the following situations:
(1) this does not preclude the use of sight-flow glasses in lubricating systems provided they are shown by test to have a suitable degree of fire resistance;
(2) sounding pipes may be permitted in machinery spaces if fitted with appropriate means of closure; and
(3) lubricating oil storage tanks with a capacity of less than 500*l* may be permitted without remote operated valves as required in 6.5.1.18.

6.5.2.3 The lubricating oil piping system is to be entirely separated from other piping systems.

6.5.2.4 Provision is to be made for the efficient filtration of the lubricating oil. The filters are to be capable of being cleaned without stopping the engine or interrupting normal supply of filtered oil to the engine.

6.5.2.5 The audible and visual safety devices as specified in the following are to be provided for the lubricating oil piping system:
(1) low-pressure alarm device of lubricating oil;
(2) a shut-down protective device for losing pressure of lubricating oil.

6.5.2.6 Where two or more diesel engines are fitted, the drain pipes leading from each engine sumps to the lubricating oil drain tanks are to be independent.

6.5.3 Cooling systems

6.5.3.1 Cooling systems are to be working properly for lubricating oil and hydraulic fluid (if any) under all operation conditions, and to maintain the temperatures within recommended limits.

6.5.3.2 For a closed circuit fresh water cooling system, an expansion tank is to be provided.

6.5.3.3 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 the craft as far as practicable.

6.5.3.4 Strainers are to be provided to the suction pipes between the sea inlets and the suction of sea water cooling pumps. And the strainers are to be so arranged that they can be cleaned without interrupting the cooling water supply.

6.5.3.5 Provision is to be made for the protection of all equipment cooled by sea water against corrosion.

6.5.4 Hydraulic transmission piping systems

6.5.4.1 Hydraulic systems are to be so designed to complete reliably and satisfactorily the purpose intended. The strength of hydraulic pipes and fittings is to be sufficient to withstand the pressure fluctuations which might occur in the system.

6.5.4.2 Strainers and relief valves are to be provided in the hydraulic transmission piping systems. The discharge from the relief valves is in general to be led to the hydraulic fluid tanks.

6.5.4.3 Where hydraulic accumulators are provided in the hydraulic systems, safety valves are to be fitted on the liquid side. For hydro-pneumatic accumulators, safety valves or fuse plugs are to be fitted on the gas side, otherwise they are to be fitted in the pipe line.

6.5.4.4 The hydraulic transmission piping system for essential services is to be provided with a standby power pump which is to be capable of immediate use.

6.5.5 Air starting systems

6.5.5.1 For the diesel engines to drive propulsion units, lift devices, generator or other engines, which the compressed air is used to start, the compressed air system is to be in compliance with the following provisions.

(1) The capacity of air receivers is to be sufficient to provide, without replenishment, not less than 6 consecutive starts.

(2) The total displacement of air charging equipment on the craft is to be sufficient for charging air receivers to the capacity as specified in 6.5.5.1(1) of this Section within an hour from atmospheric pressure.

(3) The exhaust pipe of each air compressor is to be connected directly to the air bottle. Oil-gas separator or filter is to be provided between air compressor and air bottle.

(4) Screw-down non-return valves are to be fitted on air starting pipe extending to each diesel engine.

(5) For the diesel engine with the piston’s diameter greater than 230 mm, flame arrester is to be provided for the air starting system.

(6) The air starting pipes between the air bottle and main & auxiliary engine are to be completely separated from the exhaust pipes of air compressor.

(7) Pressure gauge and safety valve are to be provided for air compressor. The opening pressure of safety valve is not to be greater than 1.1 times of the working pressure.

6.5.5.2 Where the engines of propulsion unit, lift devices or generator are started by electric, the capacity of starting equipment is to be sufficient to provide not less than 6 consecutive starts for each engine.

6.5.6 Exhaust systems

6.5.6.1 In general, the exhaust pipes of diesel engines are to be provided with effective silencers.

6.5.6.2 Each diesel engine is to have a separate exhaust pipe. Where the exhausts of two or more engines are led to a common silencer or economizer, an isolating device is to be provided in each exhaust pipe.

6.5.6.3 Exhaust systems of engines are to be so arranged as to minimize the intakes of exhaust gases to the inlets of engine, fan (if any), manned space and air conditioning systems.

6.5.6.4 The exhaust pipes penetrating the shell plating to the outside of craft are to be so arranged as to prevent sea water flowing to the engines.

6.5.6.5 If necessary, the exhaust pipes are to be provided with drainage facilities.

6.5.6.6 The wall thickness of stainless steel exhaust pipes above summer waterline is not to be less than 2 mm. The material used for the stainless steel exhaust pipes below summer waterline and with sea water cooling is to be the low-carbon stainless steel with chrome & nickel content more than 20% and molybdenum content more than 3%. The wall thickness of stainless steel exhaust pipes is to comply with the requirements in Table 6.5.6.6.

Table 6.5.6.6

External diameter of exhaust pipes (mm)	Minimum wall thickness (mm)
$D < 76.1$	2.0
$76.1 \leq D < 108.0$	2.25
$108.0 \leq D < 159.0$	2.5
$159.0 \leq D < 267.0$	3.0
$267.0 \leq D < 457.0$	4.0
$D \geq 457.0$	4.5

6.5.6.7 The exhaust pipes with expansion bellows are to be adequately adjusted, straightened and secured. In general, the exhaust pipes are to be kept at a sufficient distance from other structures, especially such structures are made of GRP and/or aluminum.

6.5.6.8 The surfaces of exhaust pipes, bellows and couplings are to be insulation-treated.

6.5.6.9 Aluminum alloy material is not to be exposed to high temperature exceeding 150℃ for a long period to prevent reduction of its mechanical properties.

6.5.6.10 If exhaust pipes other than stainless steel exhaust pipes specified in 6.5.6.6 are used, they are to be resistant to high temperature as well as corrosion resistant against seawater and exhaust gas.

6.6.1 Diesel engines

6.6.1.1 The diesel engines are to be so designed and constructed as to ensure its safety and operating reliability.

6.6.1.2 Where the free ends of diesel engines drive the lift devices or important auxiliary machinery, it is to be in compliance with the following provisions.

(1) The gross power of the free ends for crank shaft driving machinery is not to exceed the permissible output power of the fore end of the diesel engine.

(2) The technical data of output power of the fore end is to be submitted to CCS for information in order to ensure the reliable and reasonable design of the fore end transmission.

6.6.1.3 The installation of diesel engines onboard is to be in compliance with the following.

(1) The engine foundation is to be fitted on a suitable rigid base by reliable means.

(2) Where the diesel engine with vibration isolation supports is flexibly installed:

① frequency evaluation is to be made for machinery vibration of the whole engine system supported and the results are to be submitted to CCS in order to prevent the resonance revolution being included in the actual operation speed scopes;

② the bolts of vibration isolation supports are to be strictly tightened in accordance with the pre-stressing moment required by the manufacturers;

③ the external connected parts of diesel engines, e.g. pipes, etc., are to be flexibly connected;

④ shafting alignment is to be considered reasonably in order to ensure the normal operation of shafting.

6.6.1.4 In engine having cylinders exceeding 220 mm bore and having a crankcase gross volume exceeding 0.6 m^3, crankcase explosion relief doors with sufficient relief area are to be provided.

6.6.1.5 The relief valves of crankcases are to open at a pressure not greater than 0.02 MPa. The discharge from the explosion relief valves is to be shielded by flame guard or flame trap to minimize the possibility of danger and damage arising from the emission of flame.

6.6.1.6 Governors and overspeed protective devices of driven propelling units or lift devices for each diesel engine are to comply with the following provisions.

(1) At least two independent means of stopping the diesel engines quickly from the operating compartment under any operating conditions are to be provided. Duplication of the actuator fitted to the diesel engines is not to be required. For craft engaged on non-international voyages, the means capable of stopping the propeller under all operating conditions from the operating compartment may be considered as one of the above-mentioned two means.

(2) Diesel engines are to be provided with efficient governors to ensure that the speed of diesel engines does not exceed 115% of the rated speed.

(3) Overspeed protective devices are to be provided independently from the governors to prevent the speed of diesel engines exceeding 120% of the rated speed.

6.6.1.7 Each diesel engine intended for driving electric generators is to be provided with

governors and safety equipment complying with the following provisions.
(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.

6.6.1.8 All external high-pressure fuel delivery lines between the high-pressure fuel pumps and fuel injectors are to be protected with a jacketed piping system capable of containing fuel from a high-pressure line failure. The jacketed piping system is to include a means for collection of leakages and arrangements are to be provided with an alarm in case of a fuel line failure.

6.6.1.9 The diesel engines driving propulsion units and lift devices are to be provided at least with the audible and visual alarms as follows:
(1) low-pressure alarm devices and loss-pressure automatic stopping safety devices for lubricating oil;
(2) high-temperature alarm devices for cooling water.

6.6.1.10 The diesel engines driving electrical generator with power more than 35 kW, low-pressure audible and visual alarms for lubricating oil are to be provided.

6.6.2 Gas turbines

6.6.2.1 The gas turbines used for high speed craft are to be furnished with the certificates for marine products issued or approved by CCS.

6.6.2.2 The gas turbines are to be so designed, arranged and installed as to operate within the maximum permanent speed and will not damage the craft or endanger the occupants in case of failure.

6.6.2.3 Suitable means are to be provided to discharge the fuel oil which might reach the interior of the jet pipe of exhaust system after a false start or after stopping to a safety place.

6.6.2.4 Turbines are to be safeguarded as far as practicable against the possibility of damage by ingestion of contaminants from the operating environment. Provision is to be made for preventing the accumulation of salt deposits on the compressors and turbines and, if necessary, for preventing the air intake from icing.

6.6.2.5 Where an acoustic enclosure is fitted which completely surrounds the gas generator and the high pressure oil pipes, a fire detection and extinguishing system are to be provided for the acoustic enclosure.

6.6.2.6 Hand trip gear for shutting off the fuel supply in an emergency is to be provided at the manoeuvring platform of the gas turbines.

6.6.2.7 The gas turbines are to be provided with overspeed protective devices independently form governors, in addition to the reliable governors accepted by CCS, in order to prevent the speed of gas turbines exceeding 115% of the rated speed.

6.6.2.8 Intercoolers and heat exchangers are to be tested to a hydraulic pressure equal to 1.5 times the maximum working pressure on each side.

6.6.2.9 Gas turbines are to be provided with low oil pressure protective devices capable of shutting off the fuel supply automatically when lubricating oil pressure is lower than the specified value.

6.6.3 Gearings

6.6.3.1 The gearings used for propulsion units and lift devices of high speed craft are to be furnished with the certificates for marine products issued or approved by CCS.

6.6.3.2 The diameter of gear shafting is not to be less than that of thrust shafting required in Section 7 of this Chapter.

6.6.3.3 Gear casings are to be of adequate strength and necessary rigidity and observed port and suitable venting are to be provided.

6.6.3.4 The maximum speed of gearings at free clutching and declutching (if it is) is not to be less than 50% of the rated speed.

6.6.3.5 For reversible gearings, the time required for reversing is not to be more than 15 s.

6.6.3.6 The lubricating oil temperature in the gearing is not to exceed 70℃, and not to exceed 80℃ if roller bearing is fitted.

6.6.3.7 Pressure lubricating oil system (if it is) of gearing are to be:
(1) provided with low-pressure audible and visual alarms;
(2) provided with high-temperature audible and visual alarms where the input power is more than 1470 kW.

6.6.3.8 Where the lubricating oil for the gearing is circulated under pressure, provision is to be made for efficient filtration of the oil. The filters are to be capable of being cleaned without stopping the supply of filtered oil. The lubricating oil system of gearing for gas turbines and gearings is to be fitted with magnetic strainers.

Section 7 Shafting and Vibration

6.7.1 General requirements

6.7.1.1 The design and arrangement of shafting are to be evaluated for influence on any external or internal forces, thermal expansion, flexible machinery mounting and flexible coupling, etc.

6.7.1.2 The main propulsion shafting together with its transmission gears are to be capable of withstanding sufficient astern power. Running astern is not to lead to the overload of main engines.

6.7.1.3 Materials for shafting are to comply with the relevant requirements of CCS Rules for Materials and Welding. If forged steel is used for shafting, the tensile strength is to be selected within the following general limits:
(1) for carbon and carbon-manganese steel, 400 to 760 N/mm^2;
(2) for alloy steel, not exceeding 800 N/mm^2.

If the tensile strength of material exceeds the limits in 6.7.1.3(1) and (2), the calculation of shaft diameter is to comply with the requirements of 6.7.2.1 of this Chapter.

6.7.1.4 Special consideration is to be given by CCS for the shafting materials other than carbon steel or alloy steel.

6.7.2 Diameter of shafts

6.7.2.1 The shaft diameter d is not to be less than the value determined by the following formula:

$$d = FC\sqrt[3]{\frac{N_e}{n_e}\left(\frac{560}{R_m + 160}\right)} \quad \text{mm}$$

where: F – factor for the type of propulsion installation,
F = 95, for intermediate shafts of turbine propulsion installations and diesel and electric propulsion installations with couplings of sliding type;
F = 100, for all other types of diesel propulsion installations and all screwshafts;
C – factor for design features of different shafts (for details, see Table 6.7.2.1);
N_e – rated power transmitted by the shaft, in kW; rated speed of the shaft at N_e, in r/min;
n_e – rated speed of the shaft at N_e, in r/min;
R_m – tensile strength of the shaft materials, in N/mm^2. If carbon and carbon-manganese steel are used, for intermediate shaft, if R_m >760 N/mm^2, it is to be taken as 760 N/mm^2; for screwshaft and tube shaft, if R_m > 600 N/mm^2, it is to be taken as 600 N/mm^2. If alloy steel or stainless steel is used, for intermediate shaft, screwshaft and tube shaft, if R_m > 800 N/mm^2, it is to be taken as 800 N/mm^2.

Factor *C* for design features of different shafts **Table 6.7.2.1**

Intermediate shaft with following type					Thrust shaft outside engine		Screwshaft with following type			Lift shafting
Integral flange	Hydraulic keyless coupling	Keyway	Longitudinal hole, transverse hole	Longitudinal groove	The part from thrust ring to outside with the same distance as diameter of thrust shaft, other parts may be reduced to the diameter of intermediate shaft according to cone	In way of axial bearing when the roller bearing is used as thrust bearing	Keyless or flanged screwshaft, air screwshaft, jet thrust pump shaft	Screwshaft with key	Diameter from screwshaft or tube shaft to aft peak bulkhead forward of screwshaft length which satisfies the requirements of 6.7.2.4	
1.0 ①	1.0 ⑦	1.10 ②⑤⑧	1.10 ③⑤	1.20 ④⑤	1.10	1.10	1.22	1.26	1.15	1.0

Notes: ① The fillet radius at the base of the flange is not to be less than 0.08*d*.

② For over a length of at least 0.2*d* of the shaft from the ends of keyway and, the diameter of the shaft is to be increased by taking *C* = 1.10. The diameter of the shaft is to be decreased by taking *C* = 1.0 for the range beyond. The fillet radius in the transverse section at the bottom of the keyway is not to be less than 0.0125*d*.

③ For over a length of at least 0.2*d* of the shaft from the ends of hole and, the diameter of the shaft is to be increased by taking *C* = 1.10. The diameter of the shaft is to be decreased by taking *C* = 1.0 for the range beyond. The diameter of the hole is not to be greater than 0.3*d*.

④ For over a length of at least 0.3*d* of the shaft from the longitudinal slot and its ends, the diameter of the shaft is to be increased by taking *C* = 1.20. The diameter of the shaft is to be decreased by taking *C* = 1.0 for the range beyond. In general, the groove is to have length less than 0.8*d*, width more than 0.1*d* and inside diameter less than 0.8*d*. The end fillet of groove is not less than half of the groove width and the amount of groove is not to be more than 3.

⑤ For shaft having several design features, the factor is to be the product of several factors.

⑥ Where, *d* is calculated with *C* = 1.0.

⑦ If torsional vibration stress of shaft exceeds 90% of sustained allowable torsional vibration stress, shrinking diameter is to be increased, e.g. by 1~2%.

⑧ Keyway is not used for shafting with forbidden zone of rotating speed.

6.7.2.2 If the shaft material is of alloy steel or stainless steel, shaft diameter *d* may be taken as 0.9 times of the above-mentioned calculation value.

6.7.2.3 Screwshafts or tube shafts forward of the aft peak bulkhead may be gradually reduced to the diameter of the intermediate shaft.

6.7.2.4 The diameter of the screwshaft from forward of propeller boss to forward edge of the bearing after tube is not to be less than the value specified in 6.7.2.1. If the shaft length is less than 2.5 times the specified diameter, the shaft satisfying the specified diameter is to extend forward from the forward edge of the bearing after tube so that the length of that part is not less than 2.5 time the specified diameter.

6.7.2.5 Where the shafts have central holes with a diameter $d_0 > 0.4d$, the actual outside diameter d_a of the shafts is not to be less than the value obtained from the following formula:

$$d_a = d\sqrt[3]{\frac{1}{1-\left(\frac{d_o}{d_a}\right)^4}} \quad \text{mm}$$

where: d – shaft diameter determined by 6.7.2.1 of this Section, in mm;

d_0 – actual diameter of central hole of the shafts, in mm.

6.7.2.6 The intersection of cylindrical and conical portions of screwshafts is not to be shouldered or rounded. The forward end of the keyway on the shaft is to be smoothed and sled-runner shaped. The shape and size may be in accordance with Figure 6.7.2.6, where, $r_1<r_2<r_3<r_4$, AB＝BC＝CD＝x (x is depth of keyway). r_1, r_2, r_3 and r_4 may refer to the following values:

$$r_1 = x/8,\ r_2 = 3x/8,\ r_3 = 3x/4,\ r_4 = x.$$

For the value of r_5, see Table 6.7.2.6.

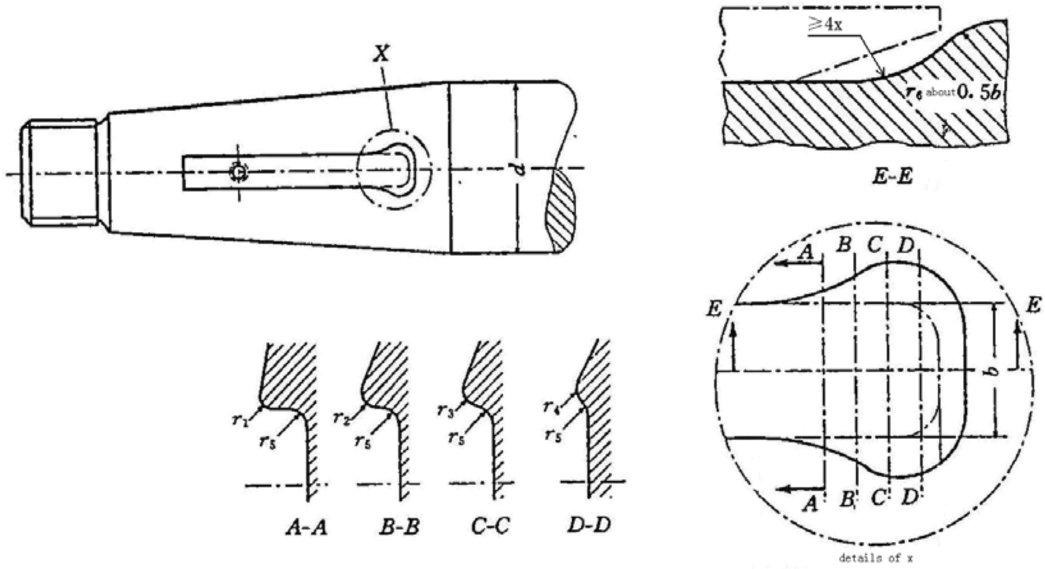


Figure 6.7.2.6

Value of r_5 **Table 6.7.2.6**

d (mm)	r_5 (mm)
$d \leq 150$	3
$150 < d \leq 250$	4

6.7.3 Shaft liners

6.7.3.1 The thickness t of bronze shaft liners shrunk on screwshafts, in way of the bushes, is not to be less than:

$$t = 0.03d + 7.5 \quad \text{mm}$$

where: d – diameter of screwshaft in way of the bushes, in mm.

The thickness of stainless steel liners, where used, is to be one half of that required for bronze

liners but not less than 6 mm.
The thickness of a continuous liner between the bushes may be somewhat reduced, but is not to be less than 0.75t.

6.7.3.2 Continuous liner is generally to be cast in one piece. Where necessary, it may consist of two or more pieces, but these are to be welded by the methods approved by CCS.

6.7.3.3 Where the portion of the shaft between any two lengths of the liner is protected with fibre reinforced plastic or other equivalent materials, the protection at the junction of the liner ends is to be of such a construction as to prevent the shaft from water ingress.

6.7.3.4 Before liner is fitted on the shaft, hydraulic testing with 0.2 MPa pressure is to be made.

6.7.4 Stern tubes and bearings

6.7.4.1 The length of sea water lubricated after bearing of stern tube is not to be less than 4 times the stipulated diameter of screwshaft.

6.7.4.2 The length of oil lubricated after bearing of stern tube is not to be less than 2 times the stipulated diameter of screwshaft, and
(1) an approved oil sealing gland is to be provided;
(2) means for cooling lubricating oil are to be provided.

6.7.4.3 For new types of composed materials approved by CCS (e.g. "Feilong" and "Sailong", etc.), the length of after bearing of stern tube is to be suitably reduced upon agreement of CCS.

6.7.4.4 Stern tubes are to be subjected to hydraulic test with a pressure of 0.2 MPa before being fitted on board craft.

6.7.5 Shaft transmission units

6.7.5.1 The thickness of coupling flanges is not to be less than 20% of the intermediate shaft diameter required by 6.7.2.1, and it is not to be less than the diameter of the fitting coupling bolts whose tensile strength is equivalent to that of the shafts. The fillet radius at the base of flange is not to be less than 8% of the diameter of the shaft connecting the coupling.

6.7.5.2 Where the propeller is attached to the screwshaft by means of a coupling flange, the thickness of the flange is not to be less than 25% of the actual diameter of the adjacent part of the screwshaft. The fillet radius at the base of coupling flange is not to be less than 12.5% of the actual diameter of the shaft at the coupling.

6.7.5.3 The fillet radius at the base of coupling flange is to be smooth and no indent formed between bolt and nut.

6.7.5.4 For clamp couplings provided with a key, the clamping length is not to be less than 1.2 times the actual shaft diameter in way of the coupling and the friction moment produced after clamping is not to be less than the rated torque and the total vibration torque is to be considered.

6.7.5.5 Where coupling is fitted to the shaft completely with a key, the tensile strength of the key material is to be equal to or greater than that of the shaft material, the effective sectional area of the key in shear is to be not less than determined by the following formula:

$$BL \geq \frac{d^3}{2.6d_m} \qquad \text{mm}^2$$

where: B – breadth of key, in mm;

L – effective length of key, in mm;

d – diameter of immediate shaft determined by 6.7.2.1 of this Section, in mm;

For alloy steel shafts, σ_b= 400 N/mm^2 is taken, and to calculate d in accordance with the formula in 6.7.2.1, in mm;

d_m – diameter of shaft at mid-length of the key, in mm.

6.7.5.6 Keyless coupling fitted by oil shrink method are to be met with the following requirements.

(1) In general, the couplings which are approved by CCS are to be pulled up to the shafts by oil shrink method.

(2) Muff couplings are to have a capacity of transmitting a torque which is 2.7 times the rated torque and their equivalent stress of the maximum shrinkage allowance is to be not more than 70% of the yield stress of the muff material.

6.7.5.7 The bolts at the jointing faces of couplings are to comply with the following requirements.

(1) The diameter d_f of the fitting bolts is not to be less than that determined by the following formula:

$$d_f = 15.92 \times \sqrt{\frac{N_e \times 10^6}{n_e \times Z \times D \times \sigma_b}} \qquad \text{mm}$$

where: N_e – the maximum continuous output transmitted by the shaft, in kW;

n_e – speed of the shaft at N_e , in r/min;

Z – number of bolts;

D – diameter of pitch circle of bolts, in mm;

σ_b – specified tensile strength of bolt material, in N/mm^2 . The tensile strength is not to be less than 400 N/mm^2. It is not to be less than the specified tensile strength of the intermediate shaft material but not greater than 1000 N/mm^2.

(2) If general bolts are used:

① the diameter d_n at the root of thread of the bolts is to be not less than that determined by the following formula:

$$d_n = 25 \times \sqrt{\frac{N_e \times 10^6}{n_e \times Z \times D \times \sigma_b}} \qquad \text{mm}$$

where the symbols are as defined in 6.7.5.7(1);

② the pre-stressing force calculation is to be submitted to CCS for approval before the installation of bolts.

6.7.5.8 In single screw craft, necessary means for the hydraulically operated clutch are to be provided to ensure that at least 1/3 rated torque can be transmitted in the emergency cases.

6.7.6 Shafting alignment

6.7.6.1 The alignment of propelling shafting and hovering shafting are to give reasonable bearing reaction and bending stresses which are acceptable by CCS under all operation conditions.

6.7.6.2 The number and arrangement of bearings are to be reasonable to minimize the effects to shaft alignment due to hull deflection.

6.7.6.3 Where shafting is aligned by a reasonable alignment method, the alignment calculations and installation procedures of shafting are to be submitted to CCS for approval.

6.7.7 Shafting vibration

6.7.7.1 Only after the calculations of shafting vibration have been approved, can the whole shafting be effectively approved.

6.7.7.2 Torsional vibration characteristics of shafting for all high speed craft are to be submitted to CCS for approval and in compliance with the requirements of CCS.

6.7.7.3 Torsional vibration characteristics of lift shafting with the power more than 220 kW are to be submitted to CCS for approval, and the portion of shafting (including shafts, couplings and gear boxes, etc.) is to be in compliance with the requirements of the propulsion shafting stipulated by CCS.

6.7.7.4 Whirling vibration characteristics of propelling shafting for all high speed craft are to be submitted to CCS for approval. In general, for a whirling vibration, the blade order clockwise whirling resonant speed is not to be within the rated speed scopes (0.8 to 1.0). The one order clockwise whirling resonant speed is to exceed the rated speed by 20%.

6.7.7.5 The whirling vibration characteristics of lift shafting for air-cushion vehicles are to be submitted to CCS for approval. In general, for a whirling vibration, the 1 order clockwise whirling resonant speed is not to be within the rated speed scopes (0.8 to 1.2).

6.7.7.6 Where the torsional vibration stress or vibration torque is greater than the continuous running permissible value stipulated by CCS, “restricted speed range” is to be imposed. In this range, the engines can not be operated continuously. In general, no restricted speed range be within the rated speed scope (0.8 to 1.0). The following speed range is to be avoided:

$$\frac{16n_c}{18-r} \sim \frac{(18-r)n_c}{16}$$

where: n_c – critical speed , in r/min;

n_e – rated speed, in r/min;

$r = n_c/n_e$.

Section 8 Propulsor

6.8.1 General requirements

6.8.1.1 The propulsors intended for high speed craft include the water propellers, air propellers, waterjet units or other equivalent propelling units.

6.8.1.2 Blade fastening studs of built-up propellers are to be made of forged steel having a minimum tensile strength not less than 400 N/mm^2.

6.8.2 Water propeller

6.8.2.1 Fasteners (studs, nuts, etc.) for propellers and for their accessories are to be fitted with reliable means to prevent loosening and corrosion.

6.8.2.2 For the purpose of modifying the effect of propeller excitation on hulls, the necessary minimum clearances between the propeller and the hull are to be provided.

6.8.2.3 Thickness of propeller blades

(1) The thickness of propeller blades t (at 0.25 R and 0.6 R for solid propellers, and at 0.35 R and 0.6 R for controllable pitch propellers) is not to be less than that calculated by the following formula:

$$t = \sqrt{\frac{Y}{K-X}} \quad \text{mm}$$

where: Y – power coefficient, to be calculated as follows:

$$Y = \frac{1.36 A_1 N_e}{Z b n_e}$$

where: $A_1 = \frac{D}{P}\left(K_1 - K_2 \frac{D}{P_{0.7}}\right) + K_3 \frac{D}{P_{0.7}} - K_4$

D – propeller diameter, in m;

P – pitch at the section under consideration, in m;

$P_{0.7}$ – pitch at 0.7R, in m;

R – propeller radius, in m;

N_e – maximum continuous power of the main engine, in kW;

Z – number of blades;

b – blade width at the section under consideration, in m;

n_e – speed of the propeller at maximum continuous power of the main engine, in r/min;

K_1, K_2, K_3, K_4 – coefficients given in Table 6.8.3.2(1);

K – material coefficient given in Table 6.8.2.3(2).

For materials other than those specified in the Table, the value of K may be determined by making reference to those given in the Table, but is subject to the consent of CCS;

X – speed coefficient, to be calculated by the following formula:

$$X = \frac{A_2 G A_d n_e^2 D^3}{10^{10} Zb}$$

where: $A_2 = \frac{D}{P}(K_5 + K_6\varepsilon) + K_7\varepsilon + K_8$

D, P, n_e, Z, b — as defined in 6.8.2.3(1);

ε – backward rake angle, in °;

G – density of the propeller material, g/cm³;

A_d – developed area ratio;

K_5, K_6, K_7, K_8 – coefficients given in Table 6.8.2.3(1).

Table 6.8.2.3(1)

r \ K_i	K_1	K_2	K_3	K_4	K_5	K_6	K_7	K_8
0.25R	634	250	1410	4	82	34	41	380
0.35R	520	285	1320	16	64	28	57	420
0.60R	207	151	635	34	23	12	65	330

Table 6.8.2.3(2)

Material	Tensile strength σ_b N/mm²	Material density G g/cm³	Material coefficient K
Carbon and alloy steel	440	7.9	0.57
Ferritic or Martensitic stainless steel	500	7.7	1.04
Austenitic stainless steel	450	7.9	1.04
Cu1 Manganese bronze	440	8.3	1
Cu2 Ni-Manganese bronze	440	8.3	1
Cu3 Ni-Aluminum bronze	590	7.6	1.38
Cu4 Mn-Aluminum bronze	630	7.5	1.17

(2) For aerofoil sections with trailing edge washback, a value of ΔA_1 is to be increased based on the value of A_1 calculated by the formula in 6.8.2.3(1) of this Section, the value of ΔA_1 may be obtained as 30% of the value of A_1 , or calculated as per the actual modulus W of the washback section as follows:

$$\Delta A_1 = \left(\frac{11.25t^2 b}{W} - 95\right)\% A_1$$

where: t – blade thickness at the section under consideration, in mm;

b – blade width at the section under consideration, in mm;

W – actual modulus at the section under consideration, in mm³.

(3) Where propellers are designed according to the reliable data of wake measurement and the

thorough fatigue analysis and the blade thickness obtained is less than that specified in 6.8.2.3(1), a detailed calculation sheet for the blade stress is to be submitted to CCS for approval.

(4) According to the operation conditions of propellers, CCS may require a detailed data of following wake to be submitted, or blade thickness to be increased.

(5) For propellers with the speed (n_e) exceeding 1000 r/min and the included angle between shafting and base line exceeding 5º, holes for reducing pressure are to be made at each blade root so as to avoid cavitation corrosion at the root. Where there is no cavitation found at the blade root after a model test for propeller, it may not be necessary to make holes. However, the model test report is to be submitted to CCS. Where the holes have been made at the blade root, a sectional loss of holes is to be taken into account while a blade thickness at the root section is being determined.

(6) The materials of the propellers are to be approved by CCS.

6.8.2.4 The controllable pitch propellers are to be in compliance with the following provisions.

(1) The hydraulic transmission system of controlled pitch propeller actuators is to be provided with a separate stand-by pump having a capacity of not less than that required for normal operation of one propeller.

(2) The hydraulic transmission and operating systems of propellers are to be ensured in normal and reliable operating conditions.

(3) Under any working conditions, the blade position of controllable pitch propellers is to be stable. Its fluctuation at 0 pitch angle is not to exceed ±0.5°.

(4) At the rated speed of the propeller, the time required for the change of pitch angle from 1/3 positive maximum (or 1/3 negative maximum) to 1/3 negative maximum (or 1/3 positive maximum) is not to exceed 15 s.

(5) The sealing devices are to be provided to prevent water and sand-penetration, lubricating oil leakage between blade and hub of the controllable pitch propellers.

6.8.2.5 The installation of propellers and screwshafts is to be in compliance with the following.

(1) Bolts connecting propellers and screwshafts are to be fitting bolts, the diameter of which is to be at least 1.05 times that determined by 6.7.5.7(1).

(2) The taper of the coned end of screwshaft is not to exceed 1/12, and for keyless propellers fitted by oil injection method, such taper is not to exceed 1/15.

(3) The intersection of cylindrical and conical portions of screwshafts or hub holes is to be smooth without shoulder or round angles.

(4) Where it is proposed to fit the propeller to the screwshaft with a key, the length of the forward fitting surface is to be about the diameter of the screwshaft. The forward end of the keyway in the screwshaft is to be smoothed. The distance from the forward end of the keyway to the big end of conical portion of the shaft is not to be less than 0.2 times the diameter of the big end. Keys are to be secured to the shafts by screws. The forward screw is to be placed at least 1/3 of the length of the key from the end. The depth of the screw holes is not to exceed the diameter of screw holes, and the edges of the holes are to be beveled.

(5) Where the torque is transmitted completely by the keys, the tensile strength of the material is to be equal to or greater than that of the shaft material, the effective sectional area of the key in shear is not to be less than the value determined by the following formula:

$$BL \geq \frac{d^3}{2.35 d_m} \qquad \text{mm}^2$$

where: B – breadth of the key, in mm;

L – effective length of the key, in mm;

d – diameter required for the intermediate shaft stipulated in 6.7.2.1, in mm;

For alloy steel shafts, σ_b=400 N/mm^2 and obtained by the formula in 6.7.2.1;

d_m – diameter of shaft at mid-length of the key, in mm.

(6) Fitting of keyless propeller by oil shrink method

① The pull-up S on the screwshaft is to meet with the following requirements:

$$S_1 \leq S \leq S_2 \qquad \text{mm}$$

$$S_1 = \frac{1}{K}\left[47750 \times 10^4 \frac{N_e}{A n_e}\left(\frac{C_1}{E_1} + \frac{C_2}{E_2}\right) + (\alpha_2 - \alpha_1)(35 - t) d_1 + 0.03\right] \qquad \text{mm}$$

$$S_2 = \frac{1}{K}\left[0.7 \sigma_s d_1 \frac{K_2^2 - 1}{\sqrt{3K_2^4 + 1}}\left(\frac{C_1}{E_1} + \frac{C_2}{E_2}\right) - (\alpha_2 - \alpha_1) d_1 t\right] \qquad \text{mm}$$

where: S_1 – minimum axial pull-up, in mm;

S_2 – maximum axial pull-up, in mm;

K – taper of the screwshaft cone, $K \leq 1/5$;

N_e – rated output transmitted to the screwshaft, in kW;

n_e – speed at rated output N_e, in r/min;

A – theoretical contact area of propeller boss and screwshaft, in mm;

$C_1 = \frac{1 + K_1^2}{1 - K_1^2} - \mu_1$;

$C_2 = \frac{K_2^2 + 1}{K_2^2 - 1} - \mu_2$;

$K_1 = \frac{d_0}{d_1}$;

$K_2 = \frac{d_2}{d_1}$;

d_0 – bore diameter of screwshaft, in mm;

d_1 – mean diameter of the shaft within the contact length, in mm;

d_2 – mean outside diameter of the propeller boss, in mm;

μ_1 – 0.30;

μ_2 – Poisson's ratio for propeller material. For copper propeller in general, μ_2 =0.34;

E_1=20.6×10^4 N/mm^2;

E_2 – modulus of elasticity of propeller material, for copper propeller, in general, E_2= 11.77×10^4 N/mm^2 ;

t – temperature at time of fitting propeller on shaft, in ℃;

α_1=11×10^4 N/mm^2;

α_2 – coefficient of linear expansion of propeller material. For copper propeller, in general, α_2=18×10^{-6} 1/℃;

σ_s – specified yield stress of propeller material, in N/mm^2.

② Prior to final pull-up, the actual contact area of the propeller boss and conical portion of the shaft is not to be less than 70% of the theoretical contact area. In general, it may be examined by means of blue oil test.

③ Prior to final pull-up, the propeller and shaft are to be at the same temperature and the mating surfaces are to be clean and free from oil or grease. The bedding of the propeller with the shaft is to be demonstrated in the work shop.

④ A copy of the fitting curve relative to temperature, and data of corresponding loads are to be kept onboard. Special tools for fitting and dismantling purposes are also to be provided onboard.

6.8.3 Waterjet units

6.8.3.1 The waterjet units intended for high speed craft are to be furnished with the marine product certificates issued by CCS.

6.8.3.2 The waterjet units are to be capable of withstanding loads under all possible working conditions.

6.8.3.3 Pumps and shafts of the waterjet units are to comply with the relevant provisions of 6.7.2.

6.8.3.4 The installation of a waterjet unit, including alignment, is to give safety performance under all working conditions.

6.8.3.5 The pump body of waterjet units are subject to hydraulic testing with 1.5 times the maximum working pressure.

6.8.3.6 An approved shaft sealing box is to be installed to prevent sea water from gaining access to oil lubricated parts of the waterjet unit.

6.8.3.7 Relevant requirements for directional control unit given in Section 9 of this Chapter are to be complied with. And the control unit is to be capable of being operated both inside and outside the bridge room for craft on international voyages.

6.8.3.8 Where the hull is made of aluminum alloy, waterjet units onboard are to be effectively protected from electrochemical corrosion between units and hull of the craft.

6.8.3.9 Indicators are to be provided in the bridge room to show speed or pressure of waterjet pumps and the position of waterjet asterning bucket.

Section 9 Directional Control Systems

6.9.1 General requirements

6.9.1.1 The requirements of this Section apply for water rudder, air rudder, rudder-propeller device and other equivalent rudder equipment.

6.9.1.2 The directional control systems are to be furnished with the certificates for marine products issued by CCS.

6.9.1.3 The hydraulic systems of steering gears are to comply with the relevant requirements in Section 5 of this Chapter.

6.9.2 Reliability

6.9.2.1 Each high speed craft is to be provided with main steering gear and auxiliary steering gear to ensure that a single failure in one of them will not render the other one inoperative.

6.9.2.2 Where a main steering gear comprises two or more identical power units, an auxiliary steering gear need not be fitted, provided that:
(1) the main steering gear is capable of being operated to the satisfaction of CCS while any one of the power units is out of operation;
(2) the main steering gear is so arranged that a single failure in its piping system or in one of the power units can be quickly remoted after isolation and the steering gear can return to normal.

6.9.2.3 The high speed craft having waterjet units with steering function, auxiliary steering gears can be exempted.

6.9.2.4 Where the main steering gears use steering without dynamical operating, auxiliary steering gears can be exempted.

6.9.2.5 As soon as the power for steering gear is restored after its failure, the power unit is to be capable of starting at once for operation.

6.9.3 Alarms

6.9.3.1 The low level alarms are to be provided for the circulating oil boxes of each hydraulic system of hydraulic steering gears and to give audible and visual alarms in machinery spaces and bridge room.

6.9.3.2 Where the power source is in failure, audible and visual alarms are to be given in bridge room.

6.9.4 Miscellaneous

6.9.4.1 Manually operated gears are only acceptable provided that its operation does not require an effort exceeding 160 N under the normal conditions and it is to ensure that its construction will not result in a destroying reaction against the wheel.

6.9.4.2 All steering gears in high speed craft, including head-propellers for air-cushion vehicles, are to be so constructed that any failure in transmissions is not to make any hazard to the safety of craft.

CHAPTER 7 ELECTRICAL INSTALLATIONS

Section 1 General Requirements

7.1.1 General requirements

7.1.1.1 The provisions of this Chapter apply to the electrical installations intended for various marine high speed craft. For high speed craft of less than 20 m in length, the provisions of CCS Rules for Construction of Coastal Boats may be complied with.

7.1.1.2 The system design and installation of the electrical equipment in relation to the safety of high speed craft are to comply with the requirements of this Chapter. The construction and testing of the electrical equipment intended for high speed craft are to comply with the relevant requirements in PART FOUR of CCS Rules for Classification of Sea-going Steel Ships. However the ambient conditions are to comply with the requirements of this Chapter.

7.1.1.3 Electrical installations① are to be such that:
(1) all electrical auxiliary services necessary for maintaining the craft in normal operation and habitable conditions will be ensured without recourse to the emergency source of electrical power;
(2) electrical services essential for safety will be ensured under various emergency conditions; and
(3) the safety of passengers, crew and craft from electrical hazards will be ensured.

7.1.1.4 The electrical system is to be so designed and installed as to minimize the probability of the craft being at the risk due to failure of power supply during navigating.

7.1.1.5 Precautions are to be taken to minimize risk of supplies to essential and emergency services being interrupted by the inadvertent or accidental opening of switches or circuit-breakers.

7.1.1.6 The securing arrangements for heavy items, i.e. accumulator batteries, are to, as far as practicable, prevent excessive movement during the accelerations due to grounding or collision.

7.1.2 Environmental conditions and operating conditions

7.1.2.1 All electrical equipment is to be operated satisfactorily under the following environmental conditions.
(1) The ambient air temperatures are as given in Table 7.1.2.1(1), but the upper limit of ambient air temperature for the electronic equipment is to be 55℃.

Ambient air temperatures **Table 7.1.2.1(1)**

Medium	Location	Temperature (℃)	
		Unrestricted service	Restricted service except craft navigating in the tropical zone
Air	Enclosed spaces	0 to 45	0 to 40

① Refer to IEC Publication 60092: "Ship's Electrical Equipment".

	In spaces subject to temperature exceeding 45℃（or 40℃）and below 0℃	According to specific local conditions	According to specific conditions
	On the open deck	−25 to 45	−25 to 40
Seawater		32	25

(2) The inclination of craft from the normal position is as given in Table 7.1.2.1(2).

Angle of inclination **Table 7.1.2.1(2)**

Equipment, components	Angle of inclination (°)			
	Athwartships		Fore-and-aft	
	static	dynamic	static	dynamic
Emergency electrical installations, switchgear, electrical and electronic equipment	22.5	22.5	10	10
Electrical installations excluding stated above	15	22.5	5	7.5

(3) Moisture, sea air, oil vapour and mould.
(4) The vibration and shock likely to arise under normal service of craft.

7.1.2.2 Electrical equipment is to be operated satisfactorily under the voltage and frequency fluctuations as given in Table 7.1.2.2.

Voltage and frequency fluctuations **Table 7.1.2.2**

Equipment	Parameters	Permanent (%)	Transient	
			(%)	Max. recovery time (s)
General 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		

7.1.2.3 A.C. electrical equipment is to be operated satisfactorily under the harmonics content of distribution systems not exceeding 5% in relation to the peak value of the sinusoidal fundamental. When supplied by static converters, it is to be operated satisfactorily under harmonics content which may exceed 5%.

7.1.3 Design and installation

7.1.3.1 Electrical equipment is to be so designed and installed as to ensure safe operation and to be easy for inspection and repair.

7.1.3.2 All nuts and screws used for the connection and fastening of electrical equipment are to be effectively locked so that they cannot work loose by vibration, and to be provided with a means to protect galvanic corrosion.

7.1.3.3 The controls for emergency alarms are to be marked in red colour and to be provided with durable name plates indicating their purposes.

7.1.3.4 Rheostats, starting and charging resistors, heating appliances and other apparatus likely to cause high temperatures are to be so placed or provided with suitable means that they will not cause excessive heat to adjacent materials or a risk of fire.

7.1.3.5 All electrical equipment are not to be in direct contact with the surfaces of oil compartments, oil tanks or double bottom tanks intended for carrying oil. If necessary, electrical equipment is to be installed at a minimum distance of 50 mm from these surfaces, but the electrical apparatus mentioned in 7.1.3.4 is strictly prohibited to be installed in such a manner.

7.1.3.6 Socket outlets are not to be installed in machinery spaces below the floor plate, and in the closed fuel oil separator rooms.

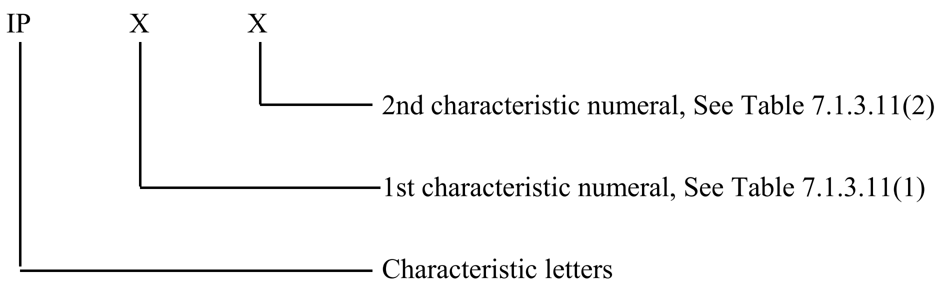
7.1.3.7 For all electrical equipment having a working voltage or a voltage to earth exceeding 50V, other than those installed in a separate compartment, the live parts are to be so protected that they cannot be inadvertently touched.

7.1.3.8 Where the temperature of the enclosures of the electrical equipment is in excess of 80°C, suitable means are to be provided or suitable arrangement is to be made so as to protect the operators from being burnt due to inadvertent touching.

7.1.3.9 Holes are not to be drilled in watertight bulkheads or decks for the purpose of fitting the securing screws for the electrical equipment and cables.

7.1.3.10 Electrical equipment and cables are not to be fitted on the shell plating below the uppermost continuous deck.

7.1.3.11 The type of protective enclosures for electrical equipment is to comply with the requirements of IEC Publication 60529 "Classification of Degrees of Protection Provided by Enclosures" or to comply with an equivalent national standard. The designation to indicate the degrees of protection consists of the characteristic letters IP followed by two numerals as follows:



Degrees of protection indicated by the first characteristic numeral Table 7.1.3.11(1)

First characteristic numeral	Degree of protection	
	Brief description	Definition
0	Non-protected	No special protection

1	Protected against solid objects greater than 50 mm	A large surface of the body, such as a hand (but no protection against deliberate access). Solid objects exceeding 50 mm in diameter
2	Protected against solid objects greater than 12 mm	Fingers or similar objects not exceeding 80 mm in length. Solid objects 12mm in diameter
3	Protected against solid objects greater than 2.5 mm	Tools, wires, etc., of diameter, or thickness greater than 2.5 mm. solid objects exceeding 2.5 mm in diameter
4	Protected against solid objects greater than 1 mm	Wires or strips of thickness greater than 1 mm. Solid objects exceeding 1 mm in diameter
5	Dust-protected	Ingress of dust is not totally prevented, but dust does not enter in sufficient quantity to interfere with satisfactory operation of the equipment
6	Dust-tight	No ingress of dust

Degrees of protection indicated by the second characteristic numeral Table 7.1.3.11(2)

Second characteristic numeral	Degree of protection	
	Brief description	Definition
0	Non-protected	No special protection
1	Protected against dripping water	Dripping water (vertically) is to have no harmful effect
2	Protected against dripping water when tilted water up to 15°	Vertically dripping water is to have no harmful effect when the enclosure is tilted at any angle up to 15° from its normal position
3	Protected against spraying water	Water falling as a spray at an angle up to 60℃ from the vertical is to have no harmful effect
4	Protected against splashing water	Water splashed against the enclosure from any direction is to have no harmful effect
5	Protected against water jets	Water projected by a nozzle against the enclosure from any direction is to have no harmful effect
6	Protected against heavy seas	Water from heavy seas or water projected in powerful jets is not to enter the enclosure in harmful quantities
7	Protected against immersion	Ingress of water in a harmful quantity is not to be possible when the enclosure is immersed in water at required pressure for required period of time
8	Protected against submersion	The equipment is suitable for continuous submersion in water under conditions which are to be specified by the manufacturer Note: The equipment is normally completed sealed. However, for certain types of equipment, it can mean that water can enter but only in such a manner that it produces no harmful effects

7.1.3.12 The type of protective enclosures selected for electrical equipment is to be appropriate to the conditions of the location at which such equipment is installed. The minimum degree of protection is to comply with the requirements given in Table 7.1.3.12.

Minimum requirements for the degree of protection Table 7.1.3.12

(1) Location	(2) Condition in location	(3) Degree of protection	(4) Equipment							
			Switchboards control gear motor starters	Generators	Motors	Transformers semi-conduct or connectors	Luminaries	Heating appliances	Cooking appliances	Accessories e.g. Switches Branch boxes
Dry accommodation spaces	Danger of touching live parts only	IP20	×	—	×	×	×	×	×	×
Dry control rooms			×	—	×	×	×	×	×	×
Control rooms (navigating bridge)	Danger of dripping water and/or moderate mechanical damage	IP22	×	—	×	×	×	×	×	×
Engine and boiler rooms above floor			×	×	×	×	×	×	×	IP44

Steering gear rooms			×	×	×	×	×	×	—	IP44
Refrigerating machinery spaces (excluding ammonia plants)			×	—	×	×	×	×	—	IP44
Emergency machinery spaces			×	×	×	×	×	×	—	IP44
General stores			×	—	×	×	×	×	—	×
Pantry			×	—	×	×	×	×	×	IP44
Provision stores			×	—	×	×	×	×	—	×
Bathrooms	Increased danger of water and/or mechanical damage	IP34	—	—	—	—	×	IP44	—	IP55
Engine and boiler rooms below floor			—	—	IP44	—	×	IP44	—	IP55
Closed fuel oil separator rooms			IP44	—	IP44	—	×	IP44	—	IP55
Closed lubricating oil separator rooms			IP44	—	IP44	—	×	IP44	—	IP55
Ballast pump rooms	Increased danger of water and mechanical damage	IP44	×	—	×	×	IP34	×	—	IP55
Refrigerating chambers			—	—	×	—	IP34	×	—	IP55
Galleys and laundries			×	—	×	×	IP34	×	×	×
Shaft tunnels or ducts in double bottom	Danger of water spraying pressure of cargo dust, serious mechanical damage, aggressive fumes	IP55	×	—	×	×	×	×	—	IP56
Holds for general cargo			—	—	—	—	×	—	—	×
Open decks	Danger of water in massive quantities	IP56	×	—	×	—	IP55	×	—	×

7.1.3.13 Where electrical equipment is installed in areas where explosive gas or vapour atmospheres may be present, it is to be of a certified safe type complying with the following requirements.

(1) The construction and type testing of safe type electrical equipment is to be in accordance with IEC Publication 60079: “Electrical Apparatus for Explosive Gas Atmospheres”, or an equivalent standard.

(2) The safe type electrical equipment is to be certified by a competent testing authority recognized by CCS.

7.1.3.14 Unless expressly provided otherwise, certified safe type equipment normally used on board craft includes the following types of protection:

(1) intrinsically safe Ex “i”;

(2) flameproof Ex “d”;

(3) increased safety Ex “e”;

(4) pressurized enclosure Ex “p”;

(5) powder filling Ex “q”;

(6) encapsulation Ex “m”.

In addition, lighting fittings of the air driven type with pressurized enclosures are considered as a “safe type” of lighting fitting.

7.1.3.15 The electrical equipment allowed to be fitted in spaces subject to explosion hazard, e.g. battery rooms, paint stores and stores for welding-gas bottles (including ventilation ducts) is to comply with the following requirements.

(1) The group and temperature class of certified safe type equipment listed in 7.1.3.14 are to at

least comply with the requirements in Table 7.1.3.15.

(2) Cables (through-runs or terminating cables) of armoured type or installed in metallic conduits are to be used.

(3) The switches, protective devices and motor control gear for the equipment installed in such spaces are to interrupt all poles or phases and preferably are to be located in non-hazardous spaces.

The group and temperature class **Table 7.1.3.15**

Location	Group①	Temperature class①
Battery rooms	IIC②	T1
Paint stores	IIB	T3
Stores for welding-gas bottles	IIC	T2
Holds classified as hazardous	According to the mode of carriage of dangerous goods	According to the mode of carriage of dangerous goods

Notes: ① The group and temperature class of certified safe type equipment listed in this Table and hereinafter in this Part is according to the relevant requirements of IEC Publication 60079: "Electrical Apparatus for Explosive Gas Atmospheres", or an equivalent standard.

② Groups IIA, IIB and IIC of certified safe type equipment specified in this Part are applicable only to intrinsically safe apparatus and flame-proof apparatus. When other types of certified safe type equipment are used, Group II is accepted.

7.1.4 Earthing

7.1.4.1 Exposed metal parts of electrical equipment which are not intended to be live are to be earthed unless these equipment are:

(1) supplied at a voltage not exceeding 50 V direct current or 50 V root mean square between conductors; auto-transformers are not to be used for the purpose of achieving this voyage; or

(2) supplied at a voyage not exceeding 250 V by safety isolating transformers supplying only one consuming device; or

(3) Constructed in accordance with the principle of double insulation.

7.1.4.2 When the electrical equipment is directly fixed on the craft's metal structures or securely fixed on bedplates (or supports) which have a good electrical contact with craft's metal structures, a special earthing conductor may not be required.

7.1.4.3 Whether the earthing is achieved through a special conductor or by the equipment bedplates (or supports), 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.

7.1.4.4 When special earthing conductors are used, they are to be of copper or other corrosion-resistant materials of good conductivity, and are to be protected against mechanical damage and corrosion where necessary. The nominal cross-sectional area of every copper earthing conductor is not to be less than that required in Table 7.1.4.4.

Sizes of earthing conductors **Table 7.1.4.4**

Type of earthing conductor	Cross-sectional area of associated	Minimum cross-sectional area of

	current carrying conductor S (mm^2)	copper earthing conductor Q (mm^2)
Earthing-continuity conductor in flexible cable or flexible cord	$S \leq 16$	$Q = S$
	$S \geq 16$	$Q = S/2$, but at least 16
Earthing-continuity conductor incorporated in fixed cable	$S \leq 16$	$Q = S$, but at least 1.5
	$S \geq 16$	$Q = S/2$, but at least 16
Special fixed earthing conductor	$S \leq 2.5$	$Q = S/2$, but at least 1.5
	$2.5 < S \leq 120$	$Q = S/2$, but at least 4
	$S > 120$	$Q = 70$

7.1.4.5 Metal parts of movable or portable appliances, other than the current-carrying parts, are to be earthed by means of an earth-continuity conductor in the flexible cable or cord, which is earthed through the associated plug and socket outlet, and the cross-sectional area of the earth conductor is to comply with the requirements of Table 7.1.4.4.

7.1.4.6 Metal sheathing or covering of cables are to be effectively earthed at both ends of the cable, except in final sub-circuits where earthing at the supply end only will be considered adequate. This does not necessarily apply to control and instrumentation cables where single point earthing may be desirable for technical reasons.

7.1.4.7 The electrical continuity of all metal sheathings or coverings of cables throughout the length of the cable, particularly at joints and tapping, is to be ensured.

7.1.4.8 The lead sheath of lead-sheathed cables in not to be used as the sole means of earthing the non-current carrying parts of equipment.

7.1.4.9 The cross-sectional area of service earthing conductors which do not normally carry current is to be 50% of that of the current carrying conductors, but not less than 1.5 mm^2.

7.1.4.10 The requirements for non-metal structure craft are to be as follows.
(1) The metal parts of all electrical equipment on board craft are to be bonded together to form a continuous electrical conducting system. And the system is to be connected to an earthing bedplate of any metal surfaces with not less than 0.2 m^2 in area and 2 mm in thickness, the location of bedplate is to be so arranged to ensure it immersed in water under any navigating conditions. Consideration of galvanic corrosion between dissimilar metals is to be given so far as possible.
(2) The isolated components inside the metal parts in fuel tanks are also to be connected to the earthing conductor.
(3) Each pressure refueling point is to be provided with a means of bonding the refueling equipment to the craft's continuous earthing conductor.
(4) Metallic pipes capable of generating electrostatic discharges are to be bonded so as to be electrically continuous throughout their length and to be adequately earthed.
(5) The conductors provided for electrostatic discharge or bonding of equipment, which connect all metal parts of craft, are to be copper with a minimum cross section of 5 mm^2 or aluminum with the equivalent surge current carrying capacity.
(6) It is to be provided with reliable lightning spikes.
(7) Lightning spikes are to be made of copper rod not less than 12 mm in diameter or of aluminum

with equivalent surge current carrying capacity. The lightning spike is to be projected at least 300 mm above the top of the mast.

(8) The lightning spike is to be connected effectively to and in good electrical contact with the metal earthing plate as mentioned in (1) by means of a copper bar not less than 70 mm^2 in cross section or aluminum bar with equivalent surge current carrying capacity;

(9) The electrical resistance between earthing conductors and the metal parts is not to exceed 0.02Ω except where it can be demonstrated that a higher resistance will not cause a hazard. The bonding objects are to have sufficient cross-sectional area to carry the maximum current likely to be imposed on it without excessive voltage drop.

7.1.4.11 For the metal hull structure craft with non-metal mast, the lightning means is to comply with the requirements of 7.1.4.10(6), (7), (8) and (9).

7.1.4.12 For craft with aluminum hull structure, their equipment are to be earthed according to the following requirements.

(1) Floating ground systems between the propulsion engines and related machinery components may be installed where required.

(2) In principle, A.C. power supplies are to be well isolated from the hull at all times.

(3) Batteries, other than engine starting batteries, are generally not to be grounded to propulsion engines and related machinery components. Where it is necessary for batteries to be grounded to the hull, the negative poles are to be connected to the hull.

Section 2 Distribution Systems

7.2.1 Distribution systems

7.2.1.1 The following systems of distribution may be used:

(1) D.C.

two wire insulated system;

(2) A.C.

two wire insulated system;

three wire insulated system;

four wire insulated system;

three-phase four-wire neutral earthed systems.

Note: For craft intended for using fuel oil having a flashpoint of 35℃ to 43℃, the distribution systems are to comply with the requirements of 6.5.1.1(4) and (5).

7.2.1.2 The maximum voltages of D.C. or A.C. distribution systems are not to exceed the values given in Table 7.2.1.2.

Maximum voltage of distribution system **Table 7.2.1.2**

Application		Max. voltage (V)	
		D.C.	A.C.
1	(1) For power, heating and cooling equipment permanently installed, connected to	500	500

	fixed wiring, except space heater in accommodation spaces; (2) For power and heating equipment (other than space heater in accommodation spaces) permanently installed where connection by flexible cable is necessary because of the application; (3) For portable equipment, which is not hand-held during operation connected by socket-outlets and flexible cable which incorporates an earth continuity conductor of a size in accordance with 7.1.4.4 of this Chapter		
2	(1) For lighting and heaters in accommodation and public spaces; (2) For socket-outlets supplying the following types of apparatus: ① with double insulation; ② earthed by means of an earth-continuity conductors of a size in accordance with 7.1.4.4 of this Chapter	250	250
3	For socket-outlets of portable apparatus used in spaces where particular risks due to conductivity may exist, e.g. exceptionally damp or confined spaces: (1) supplied from or not from isolating-transformer; (2) supplied from a safety isolating-transformer supplying one consuming apparatus only, the two wiring for these socket-outlets are to be insulated to earth	50 250	50 250

Subject to agreement of CCS, the higher voltage may be used for the purpose of propulsion.

7.2.1.3 The standard frequency for A.C. distribution system is to be 50 Hz or 60 Hz.

7.2.1.4 The insulated distribution system for power, heating and lighting, whether primary or secondary, is to be provided with a device capable of monitoring the insulation level to earth and of giving an audible and visual indication of abnormally low insulation values. For limited secondary distribution system CCS may accept a device for manual checking of the insulation level.

7.2.1.5 For A.C. three-wire or four-wire systems, the current-consuming units are to be so grouped in the final sub-circuits that the load on each phase will, under normal conditions, be balanced as far as possible within 15% of their respective rated load at the individual distribution and section boards as well as the main switchboard.

7.2.2 Protection

7.2.2.1 Electrical installations are to be protected against accidental overcurrent, including short-circuit by appropriate devices. Performance and arrangement of the protective devices are to provide complete and coordinated automatic protection in order to ensure:
(1) continuity of service through the discriminative action of the protective devices to maintain supply to the healthy circuits of essential equipment, in the event of a fault elsewhere;
(2) elimination of the effect of faults to reduce damage to the system and the hazard of fire as much as possible.
Under these conditions, the elements of the system are to be so designed and constructed withstand the thermal and electrodynamic stress caused by the possible overcurrent, including short-circuit, for the admissible duration.

7.2.2.2 Short-circuit protection is to be provided in each non-earthed pole or phase in the distribution systems.

7.2.2.3 Overload protection is to be provided in:

(1) D.C. two-wire or A.C. single-phase insulated system — at least one pole or phase;
(2) A.C. three-phase insulated system — at least two phases.

7.2.2.4 Generators are to be protected against short-circuit and overload by circuit breakers arranged to open simultaneously all insulated poles or phases, and in particular, the overload protection is to be adequate for the thermal capacity of the generator and meet the following requirements:
(1) for overloads between 10% and 50%, the circuit breaker is to be tripped with a time delay of less than 2 min. It is recommended that the circuit breaker be set within the limits of 125% to 135% of the rated current of the generator and with a time delay of 15 s to 30 s;
(2) for overcurrent in excess of 50% but less than the steady short-circuit current of the generator, instantaneous tripping after a short-time delay is to be coordinated with the discriminative protection of the system. It is recommended that the pick-up current of the circuit breaker be set at 200% to 250% of the rated current of the generator and with a maximum time delay of 0.2 s for D.C., 0.6 s for A.C.

7.2.2.5 For generators rated at less than 50 kW (or kVA) and not arranged to operate in parallel, a multi-pole linked switch with a fuse in each insulated pole may be fitted for protection.

7.2.2.6 The primary windings of power and lighting transformers are to be protected against short-circuit and overload by multi-pole circuit breakers or fuses. Overload protection may also be provided in the secondary windings.

7.2.2.7 Each distribution circuit is to be protected against overload and short-circuit by means of multi-pole circuit breakers, or multi-pole switch and fuses, arranged to open simultaneously all poles or phases.

7.2.2.8 When a multi-pole switch and fuses are used, the following requirements are to be met:
(1) the fuses in the distribution circuits from the main switchboard are to be installed between the busbar and the switch;
(2) for final sub-circuit from the distribution board, having a rated current not exceeding 60 A, and the consumers supplied by such sub-circuit can be cut-out at a nearby position, the switch may be omitted.

7.2.2.9 Circuits supplying consuming devices having individual overload protection (e.g. motors) may be provided with short – circuit protection only.

7.2.2.10 The protection of the steering gear circuits is to comply with the requirements of 7.5.2.2.

7.2.2.11 Permanently fixed cables between the shore connection box and the main switchboard are to be protected by a circuit breaker or an isolating switch and fuses. Such protection devices are to be fitted in the shore connection box.

7.2.2.12 In general, the interconnection feeder supplying the emergency switchboard from the main switchboard is to be protected at the main switchboard against overload and short-circuit. Where the system is arranged for feed-back operation, the interconnection feeder is also to be protected at the emergency switchboard at least against short-circuit.

7.2.2.13 Motors of rating exceeding 0.5 kW and all motors for essential services are to be protected individually against overload, short-circuit and under-voltage. The short-circuit protection can be provided by the same protective device for the motor and its supply cable.

7.2.2.14 Each lighting circuit is to be protected against overload and short-circuit.

7.2.2.15 Storage batteries, other than engine starting batteries, are to be protected against short-circuit with devices placed as near as practicable to the batteries.

7.2.2.16 Charging facilities are to be protected against reversal of current due to the reduction or loss of charging voltage.

7.2.2.17 Voltmeters, voltage coils of measuring instruments, earth indicating devices and pilot lamps, together with their connecting leads are to be protected by fuses. A pilot lamp need not be individually protected provided that the following conditions are satisfied:
(1) the pilot lamp is installed in the same enclosure and as an integral part of another item of equipment;
(2) the pilot lamp is supplied from the interior circuit of the enclosure of the equipment;
(3) the protection device in the circuit is rated less than 25 A;
(4) a fault in a pilot lamp is not to jeopardize the supply to essential equipment.

7.2.2.18 The voltage coils of control and protective devices and equipment are to be protected by fuses. The coils need not be individually protected provided the following conditions are satisfied:
(1) coils are installed in the same enclosure and as an integral part of another item of equipment, and are protected by a main protective device;
(2) the coils are supplied from circuits of the equipment and the protective device of such circuits is rated less than 25 A.

7.2.2.19 Power electronic devices are to be protected against overload and short circuit.

7.2.2.20 The rating or appropriate setting of the overload protective device for each circuit is to be permanently indicated at the location of the protective circuit.

7.2.3 Requirements for passenger craft

7.2.3.1 Separation and duplication of electrical supply are to be provided for duplicated consumers of essential services. During normal operation the systems may be connected to the same power-bus, but facilities for easy separation are to be provided. Each system is to be able to supply all equipment necessary to maintain the control of propulsion, steering, stabilization, navigation, lighting and ventilation, and allow starting of the largest essential electric motor at any load. Automatic load-dependent disconnection of non-essential consumers may be allowed.

7.2.4 Requirements for cargo craft

7.2.4.1 Separation and duplication of electrical supply are to be provided for duplicated consumers of essential services. During normal operation these consumers may be connected to the same power-bus directly or via distribution boards or group starters, but are to be separated by removable links or other approved means. Each power-bus is to be able to supply all equipment necessary to maintain the control of propulsion, steering, stabilization, navigation, lighting and ventilation, and allow starting of the largest essential electric motor at any load. However, having regarded to 7.1.1.4, partial reduction in the capability from normal operation may be accepted. Non-duplicated consumers of essential services connected to the emergency switchboard directly or via distribution boards may be accepted. Automatic load-dependent disconnection of non-essential consumers may be allowed.

Section 3 Main Source of Electrical Power

7.3.1 General requirements

7.3.1.1 A main source of electrical power of sufficient capacity to supply all those services mentioned in 7.1.1.3 is to be provided. The main source of electrical power is to consist of at least two generating sets.

7.3.1.2 The capacity of these generating sets is to be such that, in the event of any one generating set being stopped or failing, it will still be possible to supply those services necessary to provide the normal operational conditions of propulsion and safety. Minimum comfortable conditions of habitability are also to be ensured which include at least adequate services for cooking, heating, domestic refrigeration, mechanical ventilation, and sanitary and fresh water.

7.3.1.3 The main sources of electrical power may be either:
(1) generators driven by main independent prime movers; or
(2) generators driven by main engine.

7.3.1.4 The main source of electrical power as mentioned 7.3.1.3 may be used in any combination, but is to be designed so that:
(1) power sources function properly when independent and when connected in combination;
(2) no failure or malfunction of any power source can create a hazard or impair the ability of remaining sources to supply all essential loads.

7.3.1.5 For craft provided with two or above constant voltage propulsion generating sets in parallel connection to supply power for propulsion and also for necessary daily loading, the

generator set for daily service need not be additionally provided where the following conditions are to be met:
Where one generating set is out of order, the remains are to be capable of supplying power to all essential equipment onboard craft and maintaining the effective propulsion simultaneously.

7.3.1.6 The arrangement of the craft's main source of electrical power is to be such that the service referred to in 7.1.1.3 can be maintained regardless of the speed and direction of the propulsion machinery or shafting.

7.3.1.7 Where generators driven by main engines at various speeds during the operation of the craft are used as main sources of electrical power, it is so designed that:
(1) generators are to be provided with control facilities;
(2) the variation of the terminal voltage and frequency is to be maintained practically constant so as to ensure normal operation of the power consuming equipment when the shaft speed varies within the specified ranges;
(3) the equipment is to be capable of delivering the rated output at least within the range of 75% to 100% of the rated speed of the main engine;
(4) the equipment is to have a certain overload capacity; and
(5) the factor of distortion of the waveform from a sinusoidal fundamental of line-to-line voltage may exceed 5%, if measures are taken to ensure that this does not interfere with the operation of the consumers or other requirement such as radio and navigation facilities, apply to A.C. generator only.

7.3.1.8 Where the electrical power is normally supplied by more than one generator set simultaneously in parallel operation, provision of protection, including automatic disconnection, etc., are to be made to ensure that, in case of loss of any of these generating sets, the remaining ones are kept in operation to permit propulsion and steering and the equipment necessary for ensuring the safety of the craft.

7.3.1.9 Where the electrical power is normally supplied by one generator provision is to be made, upon loss of power, for automatic starting and connecting to the main switchboard of stand-by generators of sufficient capacity with automatic restarting of the essential auxiliaries, in sequential operation if required. Starting and connection to the main switchboard of one generator is to be as rapid as possible, preferably within 30 s after loss of power, and subject to a maximum of 45 s. For high speed craft engaged on non-international voyage with total capacity of generator sets not exceeding 250 kVA, the requirement of this paragraph may be exempted.

7.3.1.10 The generating sets are to be such as to ensure that with any one generator or its primary source of power out of operation, the remaining generating set is to be capable of providing the electrical sources necessary to start the main propulsion plant from dead craft condition. The emergency source of electrical power may be used for the purpose of starting from a dead craft condition, if its capability either alone or combined with any other source of electrical power is sufficient to provide those service required to be provided by 7.4.4.1(1) to 7.4.4.1(3) or 7.4.5.1(1) to 7.4.5.1(4).

7.3.1.11 The number, capacity and arrangement of power transformers are to meet the following requirements if they constitute the necessary parts of main electric power source system.

(1) The power transformers are to be such that when any one of them is out of operation, the remaining transformer(s) is (are) sufficient to ensure the safe operation of those services necessary to provide normal operational conditions of propulsion, safety, and the minimum comfortable conditions of habitability are also to be ensured, which include at least adequate services for cooking, heating, domestic refrigeration, mechanical ventilation, sanitary and fresh water.

(2) Each transformer required is to be located as a separate unit with separate enclosure or equivalent, and is to be served by separate circuits on the primary and secondary sides.

(3) Each primary circuit is to be provided with switch-gear and protection devices in each phase.

(4) Each of the secondary circuits is to be provided with a multi-pole isolating switch.

7.3.1.12 The main busbars are normally to be subdivided into at least two parts which are to be connected by a circuit-breaker or other approved means. So far as is practicable, the connection of generating sets and any other duplicated equipment are to be equally divided between the parts. For category B craft, each part of the main busbars with its associated generators is to be arranged in separate compartments. For high speed craft engaged on non-international voyage with total capacity of generator sets not exceeding 250 kVA, the requirement of this paragraph may be exempted.

7.3.2 Installation of switchboard

7.3.2.1 The main switchboard is to be so placed relative to one main generating station that, as far as is practicable, the integrity of the normal electrical supply may be affected only by a fire or other casualty in one space. An environmental enclosure for the main switchboard, such as may be provided by a machinery control room situated within the main boundaries of the space, is not to be considered as separating the switchboards from the generators. For craft with specially arranged machinery space, this provision may be dispensed with where it is considered to be unreasonable or impracticable.

7.3.2.2 Water, oil or steam pipes, oil tanks or other liquid containers are not to be installed above or behind the switchboards, if they are unavoidable, suitable protection is to be provided in these positions.

7.3.2.3 Non-slipping and oil-proof non-conducting mats or grating of impregnated wood are to be fitted in front and at the rear of the main switchboard.

7.3.2.4 An ample space is to be left in front and at the rear of switchboards. The space to be left in the front is generally to be 0.8 m wide, and if impracticable, it may be adequately reduced upon agreement but it is at least to be 0.6m. The space to be left at the rear is to be at least 0.6 m wide. If the construction of switchboards is such as to permit maintenance, inspection and replacement of parts both from the front side and from the ends, passageways behind switchboards may be dispensed with.

7.3.2.5 Except that main switchboards are installed in machinery control room, a door with lock is to be provided at the access to the passageway behind switchboards. Where the length of switchboard is greater than 4 m, access doors are to be provided at both ends of the passageway behind switchboards.

Section 4 Emergency Source of Electrical Power

7.4.1 General requirements

7.4.1.1 A self-contained emergency source of electrical power is generally to be provided.

7.4.1.2 The emergency source of electrical power, transitional source of emergency electrical power and emergency switchboard are to be located above the waterline in the final condition of damage as referred to in Chapter 4, and readily accessible.

7.4.1.3 The location of the emergency source of electrical power, the transitional source of emergency electrical power and the emergency switchboard in relation to the main source of electrical power is to be such as to ensure that a fire or other casualty in space containing the main source of electrical power or in any machinery space will not interfere with the supply and distribution of emergency source of electrical power. As far as practicable, the space containing the emergency source of electrical power, the transitional source of emergency electrical power and the emergency switchboard are not to be contiguous to the boundaries of main machinery spaces or those spaces containing the main source of electrical power.

7.4.1.4 Provided that suitable measures are taken for safeguarding independent emergency operation under all circumstances, the emergency generator may be used exceptionally, and for short periods, to supply non-emergency circuits.

7.4.1.5 Where emergency source of electrical power is a generator, it is to be:
(1) driven by a suitable prime mover with an independent cooling device and supply of fuel having a flash point which meets the requirements of Chapter 6;
(2) started automatically upon failure of the electrical supply from main source of electrical power and is to be automatically connected to the emergency switchboard. Those services referred to in 7.4.6.2 are then to be transferred to the emergency generating set. The automatic starting system and the characteristic of the prime mover are to be such as to permit the emergency generator to carry its full rated load as quickly as is safe and practicable, subject to a maximum of 45 s; and
(3) provided with a transitional source of emergency electrical power according to 7.4.6.1 for passenger craft. For cargo craft, where the emergency generator is unable to satisfy the requirement in above (2), a transitional source of emergency electrical power is to be provided.

7.4.1.6 For the category A passenger craft with S.W.S.R. or C.W.S.R. complying with the requirements of 7.4.3.1 to exempt from the emergency source of electrical power, the transitional source of emergency electrical power may not be provided.

7.4.1.7 The emergency source of electrical power may also be an accumulator battery, it is to be capable of:
(1) carrying the emergency electrical load without recharging while maintaining the voltage of the battery throughout the discharge period within 12% above or below its nominal voltage;
(2) automatically connecting to the emergency switchboard in the event of failure of the main source of electrical power;
(3) immediately supplying at least those services specified in 7.4.6.2.

7.4.1.8 Where accumulator batteries are installed to supply emergency services, provisions are be made to charge them in site locally from a reliable on-board supply. Charging facilities are to be so designed to permit the supply of services, regardless of whether battery is on charge or not. Means are to be provided to minimize the risk of overcharging or overheating the batteries. Means for efficient air ventilation are to be provided.

7.4.1.9 The emergency switchboard is to be installed as near as is practicable to the emergency source of electrical power, and is to comply with the following requirements.
(1) Where the emergency source of electrical power is a generator, the emergency switchboard is to be located in the same space unless the operation of the emergency switchboard would thereby be impaired.
(2) The batteries as emergency source of electrical power or transitional source of emergency electrical power are not to be installed in the same space of emergency switchboard, unless the means to draw the exhaust gas from batteries are provided, or seal type batteries are used, and subject to agreement of CCS.

7.4.1.10 An indicator is to be mounted at a suitable position in the craft's operating compartment to indicate when the batteries constituting either the emergency source of electrical power or the transitional source of emergency electrical power are being discharged.

7.4.1.11 The emergency switchboard is to be supplied during normal operation from the main switchboard by an interconnection feeder which is to be adequately protected at the main switchboard according to the requirements of 7.2.2.13 and which is to be disconnected automatically at the emergency switchboard upon failure of the main source of electrical power. Failure of the emergency switchboard, when being used in other than an emergency, is not to put at risk the operation of the craft.

7.4.1.12 In order to ensure ready availability of the emergency source of electrical power, arrangements are to be made where necessary to disconnect automatically non-emergency circuits from the emergency switchboard to ensure that electric power is available to the emergency circuits.

7.4.1.13 The emergency generator and its prime mover and any emergency accumulator battery are to be so designed and arranged as to ensure that they will function at rated power when the craft is upright and when the craft has a list or trimming accordance with 7.1.2.1 including any damage cases considered in Chapter 4, or is in any combination of angles within those limits.

7.4.2 Starting arrangements for emergency generating sets

7.4.2.1 Emergency generating sets are to be capable of being readily started in their cold condition at a temperature of 0^oC. If this is impracticable, or if lower temperatures are likely to be encountered, provision is to be made for heating arrangements to ensure ready starting of the generating sets.

7.4.2.2 Each emergency generating set is to be equipped with starting device with a stored energy capability of at least three consecutive starts. The source of stored energy is to be protected to preclude critical depletion by the automatic starting system, unless a second independent means of starting is provided. A second source of energy is to be provided for an additional three starts within 30 min, unless manual starting can be demonstrated to be effective.

7.4.2.3 The stored energy is to be maintained at all times, as follows:
(1) electrical and hydraulic starting systems is to be maintained from the emergency switchboard;
(2) compressed air starting systems may be maintained by the main or auxiliary compressed air received through a suitable non-return valve or by an emergency air compressor which, if electrically driven, is supplied from the emergency switchboard;
(3) all of the starting, charging and energy storing devices are to be located in the emergency generator space. These devices are not to be used for any purpose other than the operation of the emergency generating set. This does not preclude the supply to the air receiver of the emergency generating set from the main or auxiliary compressed air system through the non-return valve fitted in the emergency generator space.

7.4.3 Exemption for emergency source of electrical power

7.4.3.1 For the category A passenger craft and cargo craft with S.W.S.R or C.W.S.R, may not be required to provide an emergency source of electrical power as that required by 7.4.1, but it is required to provide an independent battery as an additional source of electrical power which is to be so arranged to not located at the same space with the main source of electrical power, and is to be capable of supplying the following equipment for 1 h:
(1) the not-under command lights;
(2) general alarm system; and
(3) VHF radiotelephone set.

7.4.3.2 Where the main source of electrical power is located in two or more compartments which are not contiguous, each of which has its own self-contained system, including power distribution and control systems, completely independent of each other and such that a fire or other casualty in any one of the spaces will not affect the power distribution from the others, or to the services required by 7.4.4.1 and 7.4.5.1, the requirement of 7.4.1.1, 7.4.1.2 and 7.4.1.4 may be considered satisfied without an additional emergency source of electrical power, provided that:

(1) there is at least one generating set, meeting the requirements of 7.1.2.1 and each of sufficient capacity available to the services required by 7.4.4.1 and 7.4.5.1, in each of at least two non-contiguous spaces;
(2) the arrangements required by (1) in each such space are to meet to those required by 7.4.1.9 to 7.4.1.12 and 7.4.2, so that a source of electrical power is available at all times to the services required by 7.4.4.1 and 7.4.5.1;
(3) the generating sets referred to in (2) are installed such that one of them remains operable after damage or flooding in any one compartment.

7.4.4 Scope and period of supply from the emergency source of electrical power for craft on non-international voyage and category A passenger craft on international voyages

7.4.4.1 The emergency source of electrical power is to be sufficient to supply all those services that are essential for safety in an emergency, due regard being paid to such services as may have to be operated simultaneously. The emergency source of electrical power is to be capable, having regard to starting currents and the transitory nature of certain loads, of supporting simultaneously at least the following services for the periods specified hereinafter:
(1) For a period of 5 h of emergency lighting:
① passenger craft: at the stowage, preparation, launching and deployed positions of survival craft and equipment for embarkation into those craft;
② cargo craft on non-international voyage: at the stowage positions of life-saving appliances;
③ at all escape routes, such as alleyways, stairways, exits from accommodation and service spaces, embarkation points;
④ in the public spaces;
⑤ on the machinery spaces and main emergency generating spaces, including their control positions;
⑥ in control stations;
⑦ at the stowage positions for fireman's outfits; and
⑧ at the steering gear.
(2) For a period of 5 h:
① main navigation lights, except for the not-under-command lights;
② electrical internal communication equipment for announcements for passengers and crew required during evacuation;
③ fire-detection and general alarm system and manual fire alarms; and
④ remote control devices of fire-extinguishing systems, if electrical.
(3) For a period of 4 h of intermittent operation:
① the daylight signalling lamps, if they have no independent supply from their own accumulator battery; and
② the craft's whistle, if electrically driven.
(4) For a period of 5 h:
① essential electrically powered instruments and controls for propulsion machinery, if alternate sources of power not available for such devices; and
② craft radio facilities and other loads in an emergency.
(5) For a period of 12 h, the not-under-command lights.

(6) For a period of 10 min, power drives for directional control devices including those required to direct thrust forward and astern, unless there is a manual alternative acceptable to CCS. For craft provided with twin-screw propulsions, where the source of emergency electrical power is unable to supply power to the steering gear, at least two independent circuits are to supply from the main source of electrical power.

7.4.5 Scope and period of supply from the emergency source of electrical power for category B passenger craft and cargo craft on international voyages

7.4.5.1 The emergency source of electrical power is to be sufficient to supply all those services that are essential for safety in an emergency, due regard being paid to such services as may have to be operated simultaneously. The emergency source of electrical power is to be capable, having regard to starting currents and the transitory nature of certain loads, of supporting simultaneously at least the following services for the periods specified hereinafter:

(1) For a period of 12 h of emergency lighting:

① category B passenger craft: at the stowage, preparation, launching and deployed positions of survival craft and equipment for embarkation into those craft;

② cargo craft on international voyage: at the stowage positions of life-saving appliances;

③ at all escape routes, such as alleyways, stairways, exits from accommodation and service spaces, embarkation points;

④ in the passenger compartments, and public spaces (if fitted) of cargo craft;

⑤ on the machinery spaces and main emergency generating spaces, including their control positions;

⑥ in control stations;

⑦ at the stowage positions for fireman's outfits; and

⑧ at the steering gear.

(2) For a period of 12 h:

① the navigation lights, and other lights required by International Regulations for Preventing Collisions at Sea in force;

② electrical internal communication equipment for announcements for passengers and crew required during evacuation;

③ fire-detection and general alarm system and manual fire alarms; and

④ remote control devices of fire-extinguishing systems, if electrical.

(3) For a period of 4 h of intermittent operation:

① the daylight signalling lamps, if they have no independent supply from their own accumulator battery; and

② the craft's whistle, if electrically driven.

(4) For a period of 12 h:

① the navigation equipment. Where such provision is unreasonable or impracticable, CCS may waive this requirement;

② essential electrically powered instruments and controls for propulsion machinery, if alternate sources of power are not available for such devices;

③ one of the fire pumps required by 7.7.5.1 of the International Code of Safety for High-speed Craft, 2000;

④ the sprinkle pump and drencher pump, if fitted;

⑤ the emergency bilge pump and all the equipment essential for the operation of electrically powered remote controlled bilge valves as required by Chapter 6;

⑥ craft radio facilities and other loads in an emergency.

(5) For a period of 30 min, any watertight doors, required by Chapter 4 to be power-operated, together with their indicators and warning signals.

(6) For a period of 10 min, power drives for directional control devices including those required to direct thrust forward and astern, unless there is a manual alternative acceptable to CCS.

7.4.6 Transitional source of emergency electrical power

7.4.6.1 The accumulator battery used as transitional source of emergency electrical power is to be capable of:

(1) carrying the emergency electrical load without recharging while maintaining the voltage of the battery throughout the discharge period within 12% above or below its nominal voltage;

(2) automatically supplying power to the equipment specified in 7.4.6.2 in the event of failure of either the main or emergency source of electrical power.

7.4.6.2 Transitional source of emergency electrical power required by 7.4.6.1 is to be sufficient to supply at least the following services for a period of 30 min except from an accumulator battery suitably located for use in an emergency:

(1) equipment specified in 7.4.4.1(1) to 7.4.4.1(3) and 7.4.5.1(1) to 7.4.5.1(3);

(2) with respect to the watertight doors:

① power to operate the watertight doors, but not necessarily simultaneously, unless an independent temporary source of stored energy is provided. The power source is to have sufficient capacity to operate each door at least three times, i.e. closed-open-closed, against an adverse list of 15º; and

② power to the control, indication and alarm circuits for the watertight doors for half an hour.

7.4.7 Supplementary emergency lighting

7.4.7.1 In addition to the emergency lighting required above on passenger craft with special category spaces or ro-ro spaces, the supplementary emergency lighting is to be provided, and it is to comply with the following requirements.

(1) All passenger public spaces and alleyways are to be provided with supplementary emergency lighting that:

① operate for at least 3 h, when all other sources of electric power failed and under any condition of heel;

② illuminates the approach to the means of escape;

③ the source of power for the supplementary lighting consists of accumulator batteries located within the lighting units that are continuously charged from the emergency switchboard. Alternatively, any other means of lighting, which is at least as effective, may be accepted by CCS;

④ any failure of the lighting units will be immediately apparent;

⑤ any accumulator battery provided is to be replaced at intervals having regard to the specified service life in the ambient condition subject to in service.

(2) A portable rechargeable battery operated lamp is to be provided in every crew space alleyway, recreational space and every working space which is normally occupied unless supplementary emergency lighting, as required by (1), is provided.

7.4.7.2 For the craft on non-international voyage and category A craft on international voyage, where the public spaces are small, and the supplementary emergency lighting, which complies with the requirements of 7.4.7.1, is provided in such spaces, it is unnecessary to provide the emergency lighting and temporary emergency lighting.

Section 5 Electrical Drives for Auxiliary Engine and Equipment

7.5.1 General requirements

7.5.1.1 Motors rated at 1 kW or above and motors required for essential services are to be supplied by separate final sub-circuits.

7.5.1.2 Every electrical motor is to be provided with efficient means of starting and stopping which are, in general, placed near the motor, so as to be easily operated by the person controlling the motor.

7.5.1.3 Means are to be provided for the disconnection of the full load from all live poles of supply of every motor rated at 0.5 kW or above and its control gear. Where the control gear is mounted on or adjacent to a main or other distribution switchboards, a disconnecting switch in the switchboard may be used for this purpose. Otherwise, a disconnecting switch within the control gear enclosure or a separate enclosed disconnecting switch is to be provided.

7.5.1.4 When the starter or any other apparatus for disconnecting the motor is remote from the motor, it is required that either:

(1) provision be made for locking the circuit disconnecting in the “OFF” position; or

(2) an additional disconnecting switch be fitted near the motor; or

(3) the fuses in each life pole or phase be so arranged that they can be readily removed and retained by persons authorized to have access to the motor.

7.5.1.5 Where a single master-starter system (i.e. a starter used for controlling a number of motors successively) is used, the apparatus is to provide under-voltage and over-current protection, and means of isolation and a running indicator for each motor not less effective than required for system using a separate starter for each motor. When the starter is of the automatic type, suitable alternative means are to be provided for manual operation. Where the starter is used for motors for essential services, the starting portion is to be duplicated, and means are to be provided for the transfer of the starting duties in the event of failure of one of the starters.

7.5.1.6 All motors with field adjustment speed control are to be provided with a device which renders the motors to be started only when the field is fully excited.

7.5.1.7 The under-voltage, overload and short-circuit protection for motors are to comply with the requirements of 7.2.2 of this Chapter.

7.5.2 Steering and stabilization

7.5.2.1 Where steering or stabilization of a craft is essentially dependent on one device as with a single rudder or pylon, which is itself dependent on the continuous availability of electric power, it is to be served by at least two independent circuits one of which is to be fed either from the emergency source of electrical power or from an independent power source located in such a position as to be unaffected by fire or flooding affecting the main source of electrical power. Failure of either supply is not to cause any risk to the craft or passengers during switching to the alternative supply and such switching arrangements are to meet the requirements in 7.4.1.5 to the starting time of emergency generating set.

7.5.2.2 These circuits are to be provided with short-circuit protection and an overload alarm device. In case that protection against excess current is provided, it is to be set for not less than twice the full load current of the motor or circuit so protected, and arranged to accept the appropriate starting current with a reasonable margin. Where three-phase supply is used, an alarm is to be provided in a readily observed position in the craft's operating compartment that will indicate failure of any one of the phases.

7.5.2.3 Where such systems are not essentially dependent on the continuous availability of electric power but at least one alternative system, not dependent on the electric supply is installed, then the electrically powered or controlled system may be fed by a single circuit protected in accordance with 7.5.2.2.

7.5.2.4 For craft complying with the requirement of 7.4.3 to exempt from the emergency source of electrical power and category A passenger craft engaging on non-international voyages, two independent feeders supplying power to the steering gears may be supplied from the main source of electrical power.

7.5.3 Emergency stops for ventilating fans and oil pumps

7.5.3.1 All ventilating fans are to be capable of being stopped from outside the space being served and installed. Ventilating fans serving areas with high risk of fire and/or spaces covered by fixed fire-extinguishing system are to be capable of being operated from the operating compartment. The means provided for stopping the power ventilation of the machinery spaces are to be entirely separate from the means provided for stopping ventilation of other spaces.

7.5.3.2 Means of control are to be provided for stopping oil fuel transfer pumps, oil fuel unit pumps, lubricating oil service pumps, thermal oil circulating pumps and oil separators (purifiers), so that the electric motors can be stopped in the event of fire in the space they are located. The above-mentioned emergency stopping devices are to be located outside the spaces concerned so they will not be cut off in the event of fire in the space they serve. The above-mentioned stopping device is to be provided in the operating compartment.

7.5.3.3 The galley exhaust fans are to be capable of being shut off within the galley. The shut-off device is to be installed in the position close to the entrance of the galley.

Section 6 Lighting and Navigation Lights

7.6.1 General requirements

7.6.1.1 The lighting fittings fitted in cargo-holds, exterior passageways, or other spaces where they are liable to mechanical damage, are to be provided with robust protective grids.
The lighting fittings located in such spaces where they are liable to considerable vibration are to be provided with means for damping the vibration.
Where lighting fittings are directly fixed on wooden panelling or other inflammable materials, precautions are to be taken against overheating and fire.

7.6.1.2 The notice boards bearing the inscription "DANGER! HIGH VOLTAGE!" are to be provided in the spaces adjacent to the gas discharge lamps which voltage rating is over 250 V and where otherwise necessary.

7.6.2 Supply, control and arrangement for lighting

7.6.2.1 The lighting point supplied by each final sub-circuit of rating of more than 16 A at the lighting distribution boards is not to exceed one. The number of lighting points supplied by each final sub-circuit of rating 16 A or less at the lighting distribution boards is not to exceed:

For 55 V or less circuits	10 points;
For 56 V to 120 V circuits	14 points;
For 121 V to 250 V circuits	24 points.

Except that in final sub-circuits for cornice lighting, panel lighting and electrical signs where lampholders are closely grouped, the number of points supplied is unrestricted provided that maximum operating current in the sub-circuit does not exceed 10 A.

7.6.2.2 Final sub-circuits for lighting are not to supply appliances for heating and power except that small galley equipment (e.g. toasters, mixers, coffee makers), small miscellaneous motors (e.g. desk and cabin fans, refrigerators), wardrobe heaters and similar items.

7.6.2.3 The lighting for engine room, passageways (including exits), public spaces as well as berthing compartments accommodating more than 16 passengers is to be supplied by two final sub-circuits and one may be the final sub-circuit for emergency lighting, so that even when any one of the circuits fails the remaining circuit could still maintain the necessary lighting for such spaces. The lighting points in different circuits for engine room are to be distributed alternately.

7.6.2.4 Switches for the lighting used in wet spaces are to be capable of isolating all insulating poles or phases.

7.6.2.5 All lighting and power circuits terminating in a bunker or cargo space are to be provided with a multiple-pole switch outside the space for disconnecting such circuits.

7.6.2.6 Lighting circuits are to be provided with protection in accordance with the requirements of 7.2.2.15.

7.6.2.7 A main electrical lighting system which provided illumination throughout those parts of the craft normally accessible to and used by passenger or crew is to be supplied from the main source of electrical power.

7.6.2.8 The arrangement of the main electrical lighting system is to be such that a fire or other casualty in spaces containing the main source of electrical power, associated transforming equipment, if any, the main switchboard and the main lighting switchboard will not render the emergency electrical lighting system required by Section 4 of this inoperative.

7.6.3 Special requirements for emergency lighting

7.6.3.1 The arrangement of emergency lighting is to comply with the relevant requirements of Section 4 of this Chapter.

7.6.3.2 All emergency lighting fittings are to be provided with a prominent mark or structurally different from other luminaries.

7.6.3.3 No local switch is to be installed in the emergency lighting circuits specified in 7.4.4.1(1) and 7.4.5.1(1) except for the emergency lights in the navigating bridge and at the stowage of survival craft.

7.6.3.4 No switch is to be installed in the transitional emergency lighting feeders.

7.6.3.5 The arrangement of the emergency lighting system is to be such that a fire or other casualty in spaces containing the emergency source of electrical power, associated transferring equipment, if any, the emergency switchboard and the emergency lighting switchboard will not render the main electrical lighting system inoperative.

7.6.4 Portable luminaries

7.6.4.1 Portable luminaries may be one of the following types:
(1) earthing by means of an earth-continuity conductor;
(2) double or reinforced insulation;

(3) supply at a safety voltage not exceeding 50 V; or
(4) supply from an isolating transformer supplying one luminary only.

7.6.4.2 In spaces where risk of explosion might arise, portable luminaries of the intrinsically safe type, increased safety type or flameproof type with self-contained battery are to be adopted, but portable luminaries of the pressurized enclosure type may be accepted. All portable luminaries are not to be fed through cables.

7.6.5 Supply and control of navigation lights

7.6.5.1 Control box for navigation lights is to be supplied by two circuits, one of which is directly connected to the main switchboard, and the other is supplied from the emergency switchboard. In case that the emergency source of electrical power is not provided as required by 7.4.3 of this Chapter, the control box for navigation lights is to be supplied by the additional sources of electrical power or from the lighting distribution panel in operating compartment.
The change-over switch for the above two supply circuits is to be installed on the control box or at a suitable location in the wheelhouse. Each navigation light is to be connected separately to the control box and is to be controlled and protected in each insulated pole or phase by a switch and fuse or by a circuit breaker fitted in the control box.

7.6.5.2 Each navigation light is to be provided with an automatic indicator giving an audible and visual indication of failure of the light. If a visual signal is used and connected in series with the navigation light, means are to be provided to prevent extinction of the navigation light due to failure of the signal.

7.6.5.3 Control box for navigation light may be extended to the power supply for other lights specified in International Regulations for Preventing Collisions at Sea, other electrical equipment is not to be connected with the control box.

Section 7 Internal Communication Systems

7.7.1 Main engine telegraph system

7.7.1.1 Craft are to be provided with main engine telegraphs for communicating orders from the operating compartment to the normal control position of main engine in the engine room. a visual indicator of order and answer is to be provided in the engine room and operating compartment for the telegraphs.
Audible and visual alarms for power failure for main engine telegraphs are to be provided in the operating compartment, supplied from different source of electrical power than the telegraphs.
Telegraphs are not required for the craft whose main engine is not operable in the engine room.

7.7.2 Important telephone system

7.7.2.1 The important telephone system is to be designed to ensure fully satisfactory vocal intercommunication under all working conditions.

7.7.2.2 The telephone system is to be provided in the following spaces:
(1) operating compartment – main engine normal control position in engine room;
(2) operating compartment – steering gear control position in steering gear compartment;
(3) operating compartment – radio room, not required if communication can be made without telephone.

7.7.2.3 The telephone system required in 7.7.2.2 are to be individual links, although this feature may be dispensed with if it is ensured that the bridge can cut into existing conversations at all times. Important telephone system is to be independent.

7.7.2.4 Two-way calling equipment is to be provided for the telephone systems fitted in the engine room and to be designed hearable at all points of the engine room under the full-power operation condition of main propelling plant, visual signals are to be provided in addition to the audible signals.

7.7.2.5 The important telephone system is to be operable in the case of a failure of the main power supply.

7.7.3 Communication in an emergency

7.7.3.1 An intercommunication system is to be provided which enables commands to be transmitted between strategically important positions, such as the emergency control station, the muster and embarkation station of survival craft, and the bridge room, etc.

7.7.3.2 The communication system may comprise portable or permanently installed equipment, and is to be operable in the case of a failure of the main power supply.

Section 8 Safety Systems for Craft and Persons onboard

7.8.1 Public address system

7.8.1.1 There is to be a public address system covering all areas where passengers and crew have access, escape routes, and places of embarkation into survival craft. The system is to be such that flooding or fire in any compartment does not render other parts of the system inoperable.

7.8.1.2 In the event of failure of supply from the main source of electrical power, the supply to public address system is to be changed automatically to emergency electrical source (if any) or additional electrical source.

7.8.2 General emergency alarms

7.8.2.1 A general emergency alarm system is to be provided. The alarm is to be audible throughout all the public spaces, corridors and stairways, crew accommodation and normal crew working spaces and open decks. The alarm is to continue to function after it has been triggered until it is switched off manually or is interrupted by the public address system.

7.8.2.2 The general emergency alarm system is to be powered from the main source of electrical power and the emergency source of electrical power, in case that the emergency source of electrical power is not provided as required by 7.4.3, the system is to be provided from the additional source of electrical power.

7.8.2.3 Sufficient number of alarm devices for general alarm system are to be provided to ensure that all persons on board craft can hear the emergency alarm signal.

7.8.2.4 If necessary, alarm devices with light or flash light are to be fitted in the compartments where noise may occur loudly.

7.8.3 Watertight doors

7.8.3.1 All watertight doors are to be capable of being operated when the craft is inclined up to 15º, and are to be fitted with means of indication in the operating compartment showing whether they are open or closed. All such doors are to be capable of being opened and closed locally from each side of the bulkhead.

7.8.3.2 Watertight doors are to be capable of being closed by remote control from the operating compartment in not less than 20 s and not more than 40 s, and are to be provided with an audible alarm, distinct from other alarms in the area, which will sound for at least 5 s but no more than 10 s before the doors begin to move whenever the door is closed remotely by power, and continue sounding until the door is completely closed. The power, controls and indicators are to be automatically supplied by an independent source of stored energy or transitional source of emergency electrical power in the event of main power failure and with sufficient capacity to complete the operations as stated in 7.4.6.2(2)①. In passenger areas and areas where the ambient noise exceeds 85 dB the audible alarm is to be supplemented by an intermittent visual signal at the door. If CCS is satisfied that such doors are essential for the safe work of the craft, hinged watertight doors having only local control may be permitted for areas to which crew only have access, provided they are fitted with remote indicators as required by 7.8.3.1.

7.8.4 Shell doors, loading doors and other closing appliances

7.8.4.1 Indicators are to be provided in the operating compartment for all shell doors, loading doors and other closing appliances which, if left open or not properly secured, could lead to major flooding in the intact and damage conditions. The indicator system is to be designed on the fail-safe principle and is to show by visual alarms if the door is not fully closed or if any of the securing arrangements are not in place and fully locked, and by audible alarms if such door or closing appliance becomes open or the securing arrangements become unsecured. The indicator panel in the operating compartment is to be equipped with a mode selection function ‘harbour/sea voyage’ so arranged that an audible alarm is given in the operating compartment if the craft leaves harbour with the bow doors, inner doors, stern ramp or any other side shell doors not closed or any closing device not in the correct position. The power supply for the indicator systems is to be independent of the power supply for operating and securing the doors.

7.8.4.2 Television surveillance and a water leakage detection system are to be arranged to provide an indication to the operating compartment and to the engine control station of any leakage through inner and outer bow doors, stern doors or any other shell doors which could lead to major flooding.

7.8.5 High speed ro-ro craft

7.8.5.1 Special category spaces and ro-ro spaces are to be patrolled or monitored by effective means, such as television surveillance, so that any movement of vehicles in adverse weather conditions and unauthorized access by passengers thereto can be detected whilst the craft is underway.

7.8.6 Video information system

7.8.6.1 All passenger craft are to be equipped with illuminated or luminous notices or video information system(s) visible to all sitting passengers, in order to notify them of safety measures.

Section 9 Batteries

7.9.1 General requirements

7.9.1.1 In direct current systems means are to be provided to isolate the batteries from the low voltage system when being charged from a higher voltage system.

7.9.1.2 The automatic discharging device for emergency batteries is to be so arranged that automatic emergency supply is available whether the battery is on charge or not. Means are to be provided to minimize the risk of overcharging or overheating the batteries.

7.9.2 Protection

7.9.2.1 Batteries and their charging devices are to be protected in accordance with the requirements of 7.2.2.15 and 7.2.2.16 of this Chapter.

7.9.2.2 Where the float charging is adopted or the load is connected to the accumulator batteries under the charging condition, the maximum voltage of charging is not to be over the safety value of any equipment connected to. If these equipment cannot be operated under the maximum allowable charging voltage, the voltage control devices are to be provided.

7.9.3 Arrangements and installation

7.9.3.1 Accumulator batteries are to be suitably housed, and compartments used primarily for their accommodation are to be properly constructed and efficiently ventilated.

7.9.3.2 Storage batteries with a charging capacity of more than 2 kW[①] are to be installed in a room assigned to the batteries only, or in a box or a locker on exposed decks.

Storage batteries with a charging capacity of 0.2 kW to 2 kW may be installed in accordance with the requirements of storage batteries with a charging capacity of more than 2 kW. They may also be installed in a box or a locker in suitable spaces, or may be installed open in a machinery space with a good ventilation.

Storage batteries with a charging capacity of less than 0.2 kW or seal type batteries may be installed in open locations of any suitable spaces or in a box assigned to the batteries only.

7.9.3.3 Supports made of non-absorbent, electrolyte-resistant insulating material are to be provided below each crate of cells to a height of more than 20 mm, and an air gap of more than 20 mm wide is to be provided around each crate of cells by means of spacers made of the same material. Suitable measures are to be taken to prevent any electrolyte from lodging in contact with the craft's structure.

7.9.3.4 Batteries are to be arranged to permit ready access for replacement, inspection, testing, replenishing and cleaning.

7.9.3.5 Lead-acid batteries and alkaline batteries are not to be installed in the same room, box or locker. Lead-acid batteries are not to be installed in the accommodation spaces.

7.9.3.6 Engine starter batteries are to be located as close as practicable to the engine served, and are to be so installed that adequate ventilation is ensured.

7.9.4 Ventilation

7.9.4.1 The interior surfaces of battery room, boxes, lockers or ventilation ducts, etc., liable to corrosion by the electrolyte or by the gas emitted from the electrolyte, are to be protected against corrosion by suitable means.

7.9.4.2 Battery room, boxes or lockers are to be ventilated by an independent ventilating system with outlets on the top and led to the open deck and with the inlets situated at the bottom, and means are to be provided to prevent the ingress of water and flame.

7.9.4.3 Measures are to be established for mechanical ventilators for battery rooms, boxes or

---

① Power output of the charging device is to be calculated from the maximum charging current multiplied by the rated voltage of batteries.

lockers in order to prevent sparking arising from accidental contact of the impeller with the casing. The non-metal blades are made of antistatic materials.

7.9.4.4 All openings to battery room, other than ventilation openings, are to be effectively sealed to prevent the explosive gas from entering into the adjacent compartments.

7.9.4.5 The quantity of air expelled Q of the battery rooms, boxes or lockers containing vented batteries is not to be less than:

$$Q = 0.11\ In \qquad \text{m}^3/\text{h}$$

where: I – the maximum current delivered by the charging equipment during gas formation, but not less than 25% of the maximum obtainable charging current, in A;

n – number of battery cells.

7.9.4.6 The ventilation rate for battery rooms, boxes or lockers containing valve-regulated batteries may be reduced to 25% of that required in 7.9.4.5 of this Section.

7.9.5 Warning notices

7.9.5.1 Warning notices of "NO SMOKING AND NAKED LIGHTS" are to be fitted to the door of battery room, covers of boxes or lockers.

Section 10 Cables

7.10.1 Selection of cables

7.10.1.1 Cables are to be selected according to the environmental conditions of the location, methods of installation, rated current, duty, diversity factor, permissible voltage drop, etc.

7.10.1.2 The rated voltage of any cable is not to be lower than the nominal voltage of the circuit for which it is used.

7.10.1.3 Portable electrical equipment is to be provided with movable flexible cables.

7.10.1.4 The rated maximum operating temperature of the insulating material is to be at least 10℃ higher than the maximum ambient temperature liable to be produced in the space where the cable is installed.

7.10.1.5 Insulation material of cables is generally to be selected in accordance with Table 7.10.1.5. Other insulating material may be used subject to agreement of CCS.

Insulation material of cables **Table 7.10.1.5**

Insulation materials		Maximum operating conductor temperature (℃)	
		Normal working	Short-circuit
Elastometric or thermoset compounds	Ethylene propylene rubber	85	250
	Cross-linked polyethylene	85	250
	Silicone rubber	95	Subject to agreement of CCS
	Halogen-free ethylene propylene rubber	85	250
	Halogen-free cross-linked polyethylene	85	250
	Halogen-free silicone rubber	95	Subject to agreement of CCS
Thermoplastic compounds	Polyvinyl chloride	60	150
	Heat-proof polyvinyl chloride	75	150
Other materials	Mineral	95	Subject to agreement of CCS

7.10.1.6 All cables and external wiring to electrical equipment are to be at least of flame-retardant type. Where necessary for particular applications CCS may permit the use of special types of cables which do not comply with the requirements mentioned above, such as radio frequency cable, or digital computer information transmission system cables.

7.10.1.7 Except as permitted by CCS, all metal sheaths and amour of cables are to be electrically continuous throughout all length of cable and to be earthed.

7.10.1.8 The highest continuous load carried by cable is not to exceed its current rating after the application (ventilation) of correction factors.

7.10.1.9 The voltage drop from the main switchboard or emergency switchboard busbars to any point in the installation when the cables are carrying maximum current under normal conditions of service, is not to exceed 6% of the nominal voltage. There the supply is from batteries with a voltage not exceeding 50 V, this voltage drop may be increased to 10%.
For navigation lights, it is necessary to limit voltage drops to lower values in order to maintain required brightness and colour.

7.10.2 Cable runs

7.10.2.1 Cables are not to be directly installed on the shell plating. Cable runs are to be as far as possible, straight and accessible.

7.10.2.2 Cable runs are to be, as far as possible, remote from the sources of heat, oil or moisture and are to be protected against mechanical damage.

7.10.2.3 Where cables are installed in fire or explosion-hazardous areas, special precautions are to be taken to the satisfaction of CCS to preclude the possibility of fire or explosion due to faults of cables.

7.10.2.4 Termination and joints in all conductors are to be so made as to retain the original electrical, mechanical, flame-retarding and fire-resisting properties of the cable.

7.10.2.5 Cables penetrating bulkheads or decks are not to influence the protection properties of the bulkheads or decks.

7.10.2.6 Cables are to be effectively supported and secured with the exception of cables for portable appliances and of those installed in pipes and trunking.

7.10.2.7 Cables serving essential or emergency power, lighting, internal communication or signals are, so far as practicable, to be routed clear of machinery spaces and their casings, and other high fire risk areas, except for the cables supplying for the equipment in such areas. Where practicable all such cables are to be run in such a manner as to preclude their being rendered unserviceable by heating of the bulkheads that may be caused by a fire in an adjacent space.

7.10.2.8 Cables having insulating materials with different maximum-rated conductor temperatures are not to be bunched together, or, where this is unavoidable, the cables are to be so operated that no cable reaches a temperature higher than that permitted for the lowest temperature-rated cable in the group.

7.10.2.9 Cables for different purpose are not to be bunched together, the signal cables for remote controlling and measuring are to be separately bunched with other power cables.

7.10.2.10 Where a duplicate supply is required for essential electrical equipment, such as the two cables for the supply and control, are to follow different routes which are to be as far apart as practicable, both vertically and horizontally.

7.10.3 Cables installed in ro-ro spaces or special category spaces

7.10.3.1 Cable runs laid in ro-ro spaces or special category spaces are to avoid mechanical damage, and where this is unavoidable, measures are to be provided for protecting against mechanical damage, e.g. sheathed with metallic cover plate or encased in pipe.

7.10.3.2 Cables for the equipment required to be continuously operable in the event of fire in ro-ro spaces or special category spaces, including those for their power supplies, are to be of fire resistant type or other equivalent measures for fire safety are to be provided. Such cables are to at least include supply cables and control cables of the following safety devices:
(1) general emergency alarm system;
(2) fire detection and fire alarm system;
(3) fire extinguishing system and fire extinguishing medium alarm;
(4) public address system;
(5) important telephone system;
(6) control and power systems to power operated fire doors and status indication for all fire doors;
(7) control and power systems to power operated watertight doors and their status indication;
(8) emergency lighting;
(9) low location lighting;
(10) steering gear system;
(11) emergency fire pump;
(12) cable TV monitoring system;

(13) electric propulsion system.

Section 11 Connection to External Power Source

7.11.1 Connection to external power source

7.11.1.1 Where arrangements are made for the supply of power from a source on shore or elsewhere, a suitable connection box is to be installed in a position in the craft suitable for the convenient reception of flexible cables from the external source. Suitable cables having adequate ratings, permanently fixed, are to be provided for connection between the shore connection box and the main switchboard.

7.11.1.2 When three phase A.C. distribution system with neutral earthed is adopted for shore supply, an earth terminal is to be provided for connecting the craft's hull to the shore earth.

7.11.1.3 The shore connection is to be provided with an indicator at the main switchboard in order to show when the cable is energized.

CHAPTER 8 REMOTE CONTROL, ALARM AND SAFETY SYSTEMS

Section 1 General Requirements

8.1.1 General requirements

8.1.1.1 Failure of any remote or automatic control systems is to initiate an audible and visual alarm and is not to prevent normal manual control.

8.1.1.2 Manoeuvring and emergency controls are to permit the operating crew to perform the duties for which they are responsible in correct manner without difficulty, fatigue or excessive concentration.

8.1.1.3 Where control of propulsion or maneuvring is provided at stations adjacent to but outside the operating compartment, the transfer of control is only to be effected from the station which takes charge of control. Two-way voice communication is to be provided between all stations from which control functions may be exercised and between each such station and the look-out position. Failure of the operating control system or of transfer of control is to bring the craft to low speed without hazarding passengers or the craft.

8.1.1.4 For category B and cargo craft, remote control systems for propulsion machinery and directional control are to be equipped with back-up systems controllable from the operating compartment. For cargo craft, instead of a back-up system described above, a back-up system controllable from an engine control space such as an engine control room outside the operating compartment, is acceptable.

8.1.1.5 The control, safety and alarm systems are to be served by feeders from the main switchboard or emergency switchboard (if fitted). The safety and alarm systems and control system (e.g., automated system of electric generating plant) requiring continuously supply of power in the event of failure of main power supply are to be capable of being automatically changed over to a separate standby battery and alarm is to be activated. The capacity of the battery is at least to be sufficient for a period of supply of 15 min.

8.1.2 Definitions

8.1.2.1 “Remote control systems” comprise all equipment necessary to operate units from a control position where the operator cannot directly observe the effect of his actions.

8.1.2.2 “Back-up control systems” comprise all equipment necessary to maintain control of essential functions required for the craft’s safe operation when the main control systems have failed or malfunctioned.

Section 2 Emergency Controls

8.2.1 In all craft, the station or stations in the operating compartment from which control of craft manoeuvring and/or of its main machinery is exercised are to be provided, within easy reach of the crew member at that station, with controls for use in an emergency to:

(1) activate fixed fire-extinguishing systems;

(2) close ventilation openings and stop ventilating machinery supplying spaces covered by fixed fire-extinguishing systems, if not incorporated in (1);

(3) shut off emergency stop devices complying with 7.5.3.2;

(4) disconnect all electrical power sources from the normal power distribution system (the operating control is to be guarded to reduce the risk of inadvertent or careless operation); and

(5) stop main engine(s) and auxiliary machinery.

8.2.2 Where control of propulsion and manoeuvring is provided at stations outside the operating compartment, such stations shall have direct communication with the operating compartment which is to be a continuously manned control station.

8.2.3 In addition, for category B craft control of propulsion and manoeuvring as well as emergency functions referred to in 8.2.1 is to be provided in a station outside the operating compartment. Such stations are to have direct communication with the operating compartment which is to be a continuously manned control station.

Section 3 Alarm Systems

8.3.1 General requirements

8.3.1.1 Alarm systems which announce malfunctions or unsafe conditions at the craft's control position are to be provided.

8.3.1.2 All alarms are to be both audible and visual. Visual signals are to be clearly visible. According to the nature of faults, the colours used for visual signals are to be, in general, red for vital faults and yellow for general ones. Audible signal is to be of an adequate sound level and to be clearly distinguishable from the alarm items specified in 8.3.3.1.

8.3.1.3 The alarm system is to be capable of indicating all faults occurred at the same time, and the operation and/or acknowledgement of any alarm is not to inhibit the operation and/or acknowledgement of other alarms occurred at the same time.

8.3.1.4 Alarms are to be maintained until they are accepted. When alarms are acknowledged, the audible alarms are to be silenced and at the same time the visual alarms are to be altered, for example, from flashing to a steady light, but the visual alarms are to be retained until faults are being rectified. When the fault has been rectified, the alarm system is to be automatically reset to its normal operating condition.

8.3.1.5 The alarm system is to meet appropriate constructional and operational requirements for required alarms[①].

8.3.1.6 All warnings required by 8.3.3 are to be provided at all stations at which control functions may be exercised.

8.3.1.7 Equipment monitoring the passenger, cargo and machinery spaces for fire and flooding are to, so far as is practicable, form an integrated sub-centre incorporating monitoring and activation control for all emergency situations. This sub-centre may require feedback instrumentation to indicate that actions initiated have been fully implemented.

8.3.2 Inspection and self-monitoring of alarm systems

8.3.2.1 The alarm system is to be capable of being tested during normal operation of the machinery and electrical equipment.

8.3.2.2 The alarm system is to be designed, as far as practicable, with self-monitoring properties, i.e., any fault in the alarm system itself should cause it to detect automatically and fall into the alarm (or indication) condition without missing any alarm or activating false alarm. The extent and depth of self-monitoring is to be determined in connection with the measures taken for maintenance and renewal.

8.3.2.3 The alarm system is to be capable of blockading the meaningless signals during certain processes. Manual blockading is to be indicated.

8.3.3 Alarm items

8.3.3.1 Emergency alarms giving indication of conditions requiring immediate action are to be distinctive and in full view of crew members in the operating compartment, and are to be provided for the following:
(1) activation of a fire-detection system;
(2) total loss of normal electrical supply;
(3) overspeed of main engines;
(4) thermal runaway of any permanently installed nickel-cadmium battery.

8.3.3.2 A visual alarm distinct from the alarm referred to in 8.3.3.1 is to be given, indicating conditions requiring action to prevent degradation to an unsafe condition. These are to be provided for at least the following:
(1) exceeding the limiting value of any craft, machinery or system parameter other than engine overspeed;
(2) failure of normal power supply to powered directional or trim control devices;
(3) operation of any automatic bilge pump;
(4) failure of compass system;
(5) low level of a fuel tank contents;

① Refer to the Code on Alerts and Indicators, 2009 adopted by IMO by resolution A.1021(26).

(6) fuel oil tank overflow/high level;
(7) extinction of side, masthead or stern navigation lights;
(8) low level of contents of any fluid reservoir the contents of which are essential for normal craft operation, such as water level of domestic tanks, oil level of daily service oil tanks, water level of M.E. & Aux. E. fresh water expansion tanks;
(9) failure of any connected electrical power source;
(10) failure of any ventilation fan installed for ventilating spaces in which inflammable vapours may accumulate;
(11) failure of diesel engine high-pressure fuel line (fuel delivery lines between the high-pressure fuel pumps and fuel injectors);
(12) detection of bilge water in each watertight compartment (except for liquid tanks) below the design waterline.

Section 4 Safety Systems

8.4.1 The engines are to be provided with safety devices to protect against overspeed, loss of lubricating oil pressure, loss of cooling medium, high temperature, malfunction of moving parts and overload. Safety devices are not to cause complete engine shutdown without prior warning, except in cases where there is a risk of complete breakdown or explosion. Such safety devices are to be capable of being tested.

8.4.2 Where arrangements are fitted for overriding any automatic shutdown system for the main propulsion machinery in accordance with 8.4.1, they are to be such as to preclude inadvertent operation. When a shutdown system us activated, an audible and visual alarm are to be given at the control station and means are to be provided to override the automatic shutdown except in cases where there is a risk of complete breakdown or explosion.

Appendix 1 Calculation for Longitudinal Midcraft Bending Moment of ACV in Cushion-borne Navigating under Impact on Bow①

1. Wave impact pressure when impact on bow

The wave impact pressure P_b when impact on bow is to be calculated by the following formula:

$$P_b = a_{cgb}\Delta \qquad \text{kN}$$

where: Δ – full load displacement, see 2.1.3.1(27), in t;

a_{cgb} – vertical acceleration at gravity center of ACV when impact on bow, in m/s^2, to be calculated as follows:

$$a_{cgb} = \frac{1.5}{\left(1+\gamma_x^2\right)^{\frac{2}{3}}} \times a_{cg} \qquad \text{m/s}^2$$

where: a_{cg} – vertical acceleration at gravity center of ACV when impact on midcraft, in m/s^2, to be calculated by the formula in 4.4.1.2(2);

$\gamma_x = l_1 / \rho_x$

where: l_1 – longitudinal horizontal distance measured from the center for area of bow impact pressure to center of gravity, in m^2, the area of bow impact pressure may be determined by 7% of cushion area;

ρ_x – pitch radius of gyration, in m, to be taken as $\rho_x = 0.25L_{ac}$;

L_{ac} – length of cushion, in m.

2. Vertical acceleration at any point on ACV

The vertical acceleration a_i at any point when wave impact on bow may be calculated by the following formula:

$$a_i = a_{cgb}\left(1+\frac{l_i l_1}{\rho_x^2}\right) \qquad \text{m/s}^2$$

where: l_i – longitudinal horizontal distance measured from the point for calculation i to center of gravity, in m, if the gravity center is located after amidcraft, l_i is to be negative value.

3. Longitudinal midcraft bending moment when impact on bow

The longitudinal midcraft bending moment when impact on bow may be obtained by using the following equilibrium equation:

$$\sum_i \left(a_i + g\right) W_i = \sum_i p_i \Delta s_i + p_b$$

where: W_i – weight of each block section of craft, in t;

p_i – air cushion pressure, in kN/m^2;

Δs_i – cushion area of each block section, in m^2;

p_b – wave impact pressure on bow, in kN, to be calculated according to 1 above;

a_i – vertical acceleration of each block section, in m/s^2 , to be calculated according to 2 above;

g – gravity acceleration, in m/s^2, to be taken as $g = 9.81$ m/s^2.

---

① Impact on bow means the condition of ACV in cushion-borne navigating while wave impacting on its bow only.

Appendix 2 Guidelines for Direct Calculations of Hull Structure Strength of Steel/Aluminum High Speed Craft

1 General requirements

1.1 The purpose of direct calculation for high speed craft structure is to verify hull longitudinal strength, transverse strength, torsional strength and local strength. Loading conditions, structure models and criteria for direct calculation are to comply with the provisions of the Guidelines.

1.2 The wave load of high speed craft may be determined by model test. If there is no model test information, the wave load may be determined by the formulae in 2.2 of the Guidelines.

1.3 Wave loads may also be determined by direct calculation based on hydrodymic theory, provided that influences of wave conditions, ship speed and impact/slamming in respect to service restrictions of high speed craft are to be taken into consideration in calculation.

1.4 This Appendix applies to high speed craft with aluminum alloy or steel hull structure.

2 Loads for calculation of overall strength

2.1 Model test method for global load

2.1.1 Load combination

The global load is the combination of static load and wave load. The static load composed of gravity and static buoyancy is determined by calculation and the wave load is determined by model test.

2.1.2 Static load

Static forces in calculation for hull include gravity and hull static buoyancy in full load seagoing condition. In strength calculation, the longitudinal bending moment of midsection is calculated taking into consideration of the actual load distribution on structure. For catamarans, the transverse bending moment at the longitudinal centerline and the torsional moment of hull are also to be taken into consideration.

2.1.3 Wave load

Wave-induced vertical acceleration, longitudinal bending moment, transverse bending moment, torsional moment at the centre of gravity of hull and other required load parameters are obtained by model test. Regular waves may be applied as a condition for model test, wave parameters are listed in Table 2-1 and the loads used in calculation for structural check are given in Table 2-2.

Conditions for Model Test **Table 2-1**

<table>
<tr><td colspan="2">Wave direction θ (angle with hull longitudinal axis, in degrees)</td><td>Wave length λ</td><td>Wave height Hs and speed V_H</td></tr>
<tr><td colspan="2">0 (head sea)</td><td>L</td><td rowspan="3">H_S and V_H are taken according to 4.4.1</td></tr>
<tr><td>$57.3 \cdot tg^{-1}(\frac{b}{L})$ (oblique sea)</td><td rowspan="2">Only applicable to catamaran</td><td>$LCOS\ (\theta)$</td></tr>
<tr><td>90 (beam sea)</td><td>$2b$</td></tr>
<tr><td colspan="4">L — craft length, in m
b — centre-to-centre distance between hulls, in m
H_S — wave height specified by 4.4.1, H_S need not be greater than $0.17\lambda^{0.75}$</td></tr>
</table>

Loads in Calculation for Structure **Table 2-2**

<table>
<tr><td>Longitudinal bending moment of midsection</td><td>1.67 M_{BY}</td><td></td></tr>
<tr><td>Transverse bending moment at longitudinal centerline</td><td>1.67 M_{BX}</td><td rowspan="2">Only applicable to catamaran</td></tr>
<tr><td>Longitudinal torsional moment</td><td>1.67 M_{ty}</td></tr>
</table>

<table>
<tr><td>Transverse torsional moment</td><td>1.67 M_{tx}</td><td></td></tr>
<tr><td colspan="3">M_{BY} — maximum wave-induced longitudinal bending moment obtained from test
M_{BX} — maximum wave-induced transverse bending moment obtained from test
M_{ty} — maximum wave-induced longitudinal torsional moment obtained from test
M_{tx} — maximum wave-induced transverse torsional moment obtained from test</td></tr>
</table>

2.1.4 Equivalent load

The corresponding vertically distributed equivalent force, based on the above longitudinal bending moment and determined according to the method in 2.2.1, acts on hull structural model;

The transverse split force, based on the above transverse bending moment and calculated according to 2.2.2, acts on hull structural model;

The load distributed on twin hulls, based on the above torsional moment and calculated according to 2.2.3, acts on hull structural model for overall strength analysis.

2.2 Calculation by formulas of total load

2.2.1 Longitudinal bending moment and distribution

The hull longitudinal bending moment is assumed to be distributed according to sine curve along craft length as follows:

$$M(x) = M_{BY} \sin(\frac{\pi x}{L}) \quad \text{KN·m}$$

where: x is the longitudinal ordinate of cross section from stern, and the amplitude of the distribution curve is the longitudinal bending moment, M_{BY}, of midsection. M_{BY} is to be calculated for the two cases of 4.8.2 and 4.8.3, Chapter 4 of the Rules respectively ($M_{BY} = | M_S | = M_h$). $M(x)$ can be obtained by applying the vertical force q (x) distributed along craft length, and q (x)(positive upwards)can be determined by the following formula:

$$q(\text{x}) = q_0(\sin\frac{\pi x}{L} - 0.637) \quad \text{KN/m}$$

where: $q_0 = \frac{46}{L^2} M_{BY}$ KN/m

The two conditions of hogging and sagging are to be calculated respectively, and q (x) distributed along craft length or a series of equivalent concentrated forces are to be applied on calculation model. In order to avoid local bending stresses of structural members on which the force acts, the force is to be applied on longitudinal primary members, such as craft side, longitudinal bulkheads, bottom centre girders or other girders. The force acting on the same cross section may be divided into portions symmetrical to the longitudinal centerline at left and right sides. Where a series of concentrated forces are applied, each concentrated force is to be equal to the product of the distributed force multiplied by the length of areas loaded by the concentrated forces.

After loading, the resultant force all vertical forces acting on the model is to be zero and the error of its absolute value is not to be more than $0.005q_0L$.

2.2.2 Transverse bending moment of catamaran and distribution

The transverse bending moment M_{BX} at the longitudinal centerline of a catamaran is to be calculated according to the requirements in 4.8.6.1 or 4.8.6.2 of Chapter 4 of the Rules. The vertical acceleration a_{cg} at the center of gravity of the craft is to be taken not less than 9.81 m/s^2 in calculation. Based on the above transverse bending moment, the equivalent transverse split force F_y is calculated by the following formula:

$$F_y = \frac{M_{BX}}{z + 0.5d} \quad \text{KN}$$

where: z — the distance from design waterline to neutral axis of midcraft section of cross deck, in m, see Figure 2.2.2;

d — design draught, in m, see Figure 2.2.2.

The transverse split force F_y acts on the model at the height shown in Figure 2.2.2, and is calculated in two separate load conditions as acting outward and inward respectively.

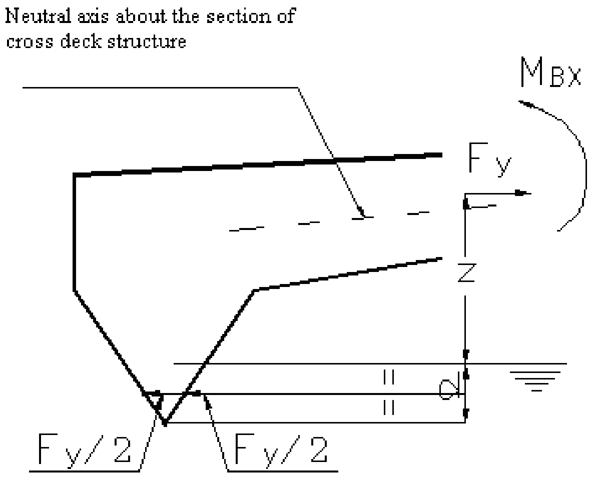


Figure 2.2.2

In actual calculation, F_Y is applied as the load q distributed throughout the length of cross deck, acting on the hull:

$$q = F_Y / L_b \quad \text{KN/m}$$

where L_b is longitudinal length of cross deck, in m.

The distributed load q is to be converted to the equivalent concentrated force P_i and applied at the transverse web framing of hull. The equivalent concentrated force P_i is to be determined by the following formula:

$$P_i = q \cdot \left(\frac{S_1 + S_2}{2}\right) \quad \text{KN}$$

where: S_1 and S_2 are the fore and aft spacing of transverse web framing respectively, in m.

2.2.3 Global torsional moment of catamaran and distribution

For catamarans, the torsional moment M_{ty} about transverse Y-axis is to be calculated according to 4.8.6.4. Its equivalent may be the uniformly distributed load p which is asymmetrically distributed on half length of hull. “Asymmetrically distributed” means that for the same hull, the loading direction before midcraft section is opposite to that after midcraft section and the loading direction of left hull is also opposite to that of right hull, see Figure 2.2.3. Such uniformly distributed equivalent load p can be obtained by the following formula:

$$p = \frac{4M_{ty}}{L^2} \quad \text{KN/m}$$

A distributed force or an equivalent concentrated force may be applied on calculation model. In order to avoid local bending stresses of structural members on which the force acts, the force is to be applied on longitudinal primary members, such as craft side, longitudinal bulkheads, bottom centre girders or other girders. The force acting on the same cross section may be divided into portions asymmetrical to the longitudinal centreline at left and right sides. Where a concentrated force is applied, it is to be equal to the product of the distributed force multiplied by the length of areas loaded by the concentrated force.

After loading, the resultant of all vertical forces acting on the model is to be zero and the error of its absolute value is not to be greater than $0.01pL$.

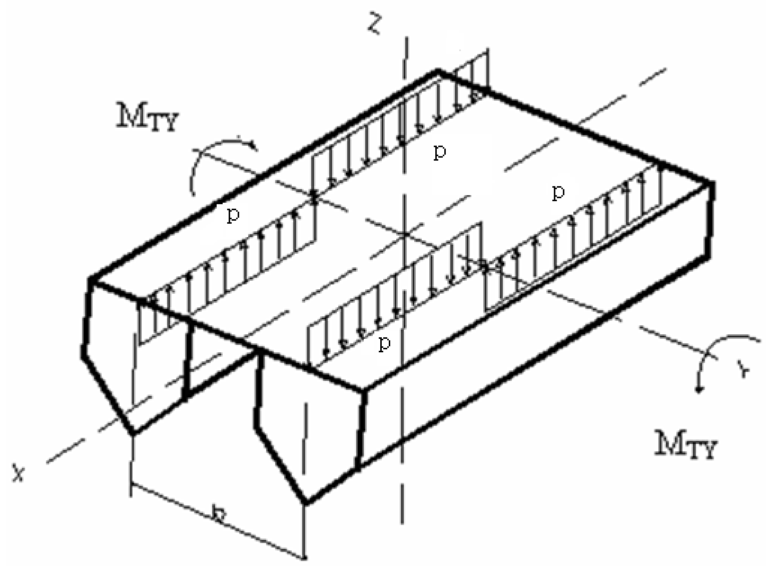


Figure 2.2.3

3 Loads for calculation of local strength

3.1 Application

Loads defined in this Section apply to structural analysis of large area plate-and-beam-combined models (i.e. grillage models), such as those for bottom, side, deck, superstructure and catamaran cross deck bottom.

3.2 Pressure load on local structural area

The pressure load on a local structural area is to be calculated according to Section 4, Chapter 4 of the Rules. If the impact pressure area A is to be calculated, the load width and span of primary members are to be taken as those of transverse primary members.

4 Calculation for check of overall structural strength

4.1 The overall hull strength is to be the objective of analysis.

4.2 Global analysis model

(1) Model extent

A global three-dimensional model is to be adopted for overall structural analysis, and hull shell, bulkheads, decks and platforms, primary members as well as superstructures are all to be represented in the model.

(2) Applicable elements

The real structure is to be simulated by plate elements, beam elements and rod elements. For stiffeners on stiffened panels, equivalent beam taking into account of attached plating may be placed on the neutral plane.

(3) Mesh size of global model

Corresponding to similarity of load distribution, the mesh size of the global model may be taken as the spacing of transverse frames or primary members, whichever is the lesser, and quadrilateral elements with aspect ratio less than 3 are generally to be adopted.

(4) Boundary conditions of global model

Six translation components are to be used to restrain rigid movement of the global model in space, without affecting relative deformation of each part of hull. The recommended restraining mode is shown in Figure 4-2. Points *A* and *B* are taken from fore and aft ends at the longitudinal centreline respectively and point *C* is taken from midcraft side.

Translation components *x*, *y* and *z* restrain point *A*, translation components *y* and *z* restrain point *B*, and translation component *z* restrains point *C*.

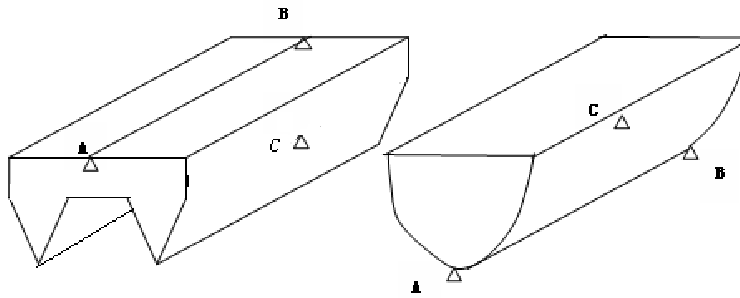


Figure 4-2 Restraints of Global Model (catamaran or monohull)

4.3 Load combination

Calculations are to be carried out in the following load combination conditions for overall strength check:

(1) M_{BY} (hogging)

(2) M_{BY} (sagging)

(3) F_y (outward)

(4) F_y (inward)

(5) 0.8 M_{BY} (hogging) + 0.6 M_{ty}

(6) 0.8 M_{BY} (sagging) + 0.6 M_{ty}

(7) 0.6 M_{BY} (hogging) + 0.8 M_{ty}

(8) 0.6 M_{BY} (sagging) + 0.8 M_{ty}

(9) 0.8 F_y (outward) + 0.6 M_{ty}

(10) 0.8 F_y (inward) + 0.6 M_{ty}

(11) 0.6 F_y (outward) + 0.8 M_{ty}

(12) 0.6 F_y (inward) + 0.8 M_{ty}

Only (1) and (2) conditions are to be checked for monohull craft.

4.4 Overall strength criteria

The stress criteria for overall strength calculation are based on the mesh size specified in 4.2. If finer meshes are used, the average stress value of all fine meshes under the specified mesh size is to be taken.

The stress of structural members for overall strength calculation is to be not greater than the allowable stress listed in Table 4.4.

Allowable Stress for Overall Strength **Table 4.4**

	Steel structure	Aluminum alloy structure
Allowable equivalent stress of plate element	0.70 σ_{sw}	0.75 σ_{sw}
Allowable shearing force of plate element	0.38 σ_{sw}	0.41 σ_{sw}
Allowable normal stress of beam element and rod element	0.67 σ_{sw}	0.73 σ_{sw}

where: σ_{sw} is the yield strength of material in welded condition, see 4.5.1.3, Section 5, Chapter 4 of the Rules. For aluminum alloy structures, however, the yield strength σ_s of material may be taken under the specific condition of complying with 4.5.3.1 or 4.5.3.2 of the Rules.

5 Calculation for check of local strength

5.1 Application

(1) Local strength check is to be carried out to important local structures on which actual loads can not be applied in the global analysis, such as bottom, side, decks, superstructures, catamaran cross deck bottom and wave-piercer craft front hull where local high stress occurs.

(2) Local structures where scantlings of their primary member are to be checked by means of direct calculation.

5.2 Extent of local structure model

A model for local structural analysis is to have the target structure as its center, extending outward to the strength structures. In general, grillage models of bottom, side, deck and cross deck are at least to cover the length of one compartment, reaching in width and height the adjoining main structures of hull, such as bulkhead, side shell or deck.

5.3 Modeling of local structure

5.3.1 Model elements

The stiffened panel structure supported by girders and stiffeners is to be simplified to a plane plated grillage model in the form of cross beams for calculation.

For local structures which are obviously not in the same plane, a three-dimensional structure model is to be adopted. The plates of the structure together with webs of primary supporting members may be represented by plate elements, and the flange of primary supporting members may be represented by beam elements or rod elements. Stiffeners together with attached plating may be represented by beam elements putting on the neutral plane. If stiffeners without attached plating are simulated separately, the eccentricity of beam section center from the neutral plane is to be taken into consideration.

For closely framed stiffened panels, orthotropic plate elements can be used for modeling.

5.3.2 Mesh size

Model mesh size is not to exceed stiffener spacing. When girder web is simulated by plate elements, at least three elements are to be modeled for web height.

The thickness for structural modeling is to be taken as the gross thickness.

5.3.3 Boundary conditions

Simply supported boundary members are to be used at the boundary of a grillage model, unless the peripheral structures are much stronger than that of in the central area under analysis. Structures supported by pillars, short bulkheads and platforms within the model may be represented by simple supports.

5.4 Loads for calculation

The loads for calculation of local strength are to be determined according to the formulas in 3 of the Guidelines.

5.5 Local strength criteria

The stress of structural members for local strength calculation is not to be greater than the allowable stress listed in the following table.

Allowable Stress for Local Strength **Table 5.5**

	Steel structure	Aluminum alloy structure
Allowable equivalent stress of plate element	0.75 σ_{sw}	0.80 σ_{sw}
Allowable shearing force of plate element	0.41 σ_{sw}	0.44 σ_{sw}
Allowable normal stress of beam element and rod element	0.73 σ_{sw}	0.77 σ_{sw}

where: σ_{sw} is the yield strength of material in welded condition, see 4.5.1.3, Section 5, Chapter 4 of the Rules. For aluminum alloy structures, however, the yield strength σ_s of material may be taken under the specific condition of complying with 4.5.3.1 or 4.5.3.2 of the Rules.

6 Local fine mesh analysis

6.1 Application

Areas in the vicinity of structural stress concentration points and other areas with great stress gradient as well as areas whose geometrical features can not be expressed correctly in global and local strength analysis models are to be subject to local structural fine mesh finite element analysis to determine the actual stress. Compared with the conclusions of global and local strength checks, the conclusion of this fine mesh analysis is to be as dominate.

In general, the following areas are to be subject to fine mesh analysis:

(1) Interior angle in connection of the front end bulkhead of cross deck of catamaran to twin hulls;

(2) Interior angle in connection of the after end bulkhead of cross deck of catamaran to twin hulls;

(3) Root of the extending bow of twin hulls of wave-piercer craft;

(4) Positions in the actual structural shape that can not be expressed truly in any coarse mesh model;

(5) Other areas where the stress considered for the global coarse mesh model exceeds 95% of the allowable stress.

6.2 Analysis method

According to forces acting on local structures, one of the following methods is to be selected for local fine mesh analysis:

(1) Analysis by inserting fine mesh model

A local fine mesh model can be inserted into the global model or a coarse-mesh local structural model, thereby carrying out calculation of local fine stresses while calculating global or local strength. In this condition, loads applied on fine mesh areas are to be consistent with those on the coarse mesh model. The calculation results indicate the stress condition of fine mesh areas in calculation for coarse meshes and apply to local positions without any special load.

(2) Fine mesh analysis by independent model

The local structure that needs fine mesh analysis is to be taken out for modeling separately, using displacements at the fine mesh model boundary provided by coarse mesh analysis as boundary conditions and applying local loads in the fine mesh area. The calculation results indicate the stress condition of high stress points of the structure under global deformation and local specific loads.

6.3 Meshes of fine model

The mesh size of a fine model in the target zone is not to be greater than 50 mm × 50 mm, with a gradual transition to large mesh in outside area. Modeling is to be made according to the gross thickness of the structural member.

6.4 Stress criteria of fine meshes

The stress of structural members considered for the fine mesh model is not to be greater than the allowable stress listed in the following table.

Allowable Stress for Fine Mesh Model **Table 6.4**

	Steel structure	Aluminum alloy structure
	Equivalent stress of plate element	Equivalent stress of plate element
Considering global load and local loads	1.50 σ_{sw}	1.60 σ_{sw}
Considering local load or global load	1.20 σ_{sw}	1.30 σ_{sw}

where: σ_{sw} is the yield strength of material in welded condition, see 4.5.1.3, Section 5, Chapter 4 of the Rules. For aluminum alloy structure, however, the yield strength σ_s of material may be taken under the specific condition of complying with 4.5.3.1 or 4.5.3.2 of the Rules.

7 Check of buckling strength

7.1 General requirements

7.1.1 The requirements for buckling/ultimate strength check in this Section apply to verification for direct strength calculation of high speed craft hull structure. If any other method is adopted, it is to be approved by CCS. In addition, the requirements of this Section do not apply to structure of densely stiffened sheet. The requirements for ultimate strength check of stiffened panels in this section only apply to scantlings of the stiffened panel structure which is general to high speed craft hull structure.

7.1.2 Depending on failure modes of structures, the buckling strength check is divided into two types, i.e. elementary panel buckling check and stiffened panel ultimate strength check. The elementary panel buckling check is based on the elastic buckling failure mode with regard to the serviceability buckling limit state and applies to primary supporting members, such as girders, main frames as well as webs, floors and brackets of web beams; Stiffened panel ultimate strength check is based on the failure mode of structural collapse with regard to the ultimate limit state of structural capacity and applies to large-area stiffened panels, such as deck, side plate, bottom structure, and stiffened panel structure in bulkhead structure. For stiffened panels, buckling check for elementary panels may be carried out according to 7.2 initially. For those not meeting the above requirements but complying with the applicable requirements of failure mode of structural collapse, ultimate strength check for stiffened panels may be carried out according to 7.3.

7.1.3 Standard deductions are to be made for the net plate thickness in buckling/ultimate strength check according to this section, not including additional thickness required/offered by the shipowner. The standard deduction of thickness is to be taken as 0.5 mm for steel and 0.25 mm for aluminum. The requirements for standard deduction of thickness in this section only apply to buckling/ultimate strength check in this section.

7.1.4 Symbols and definitions

t_p — net thickness of panel, in mm;

h_w — height of longitudinal, stiffener or stiffener web, in mm;

t_w — net thickness of longitudinal, stiffener or stiffener web, in mm;

b_f — breadth of face plate of longitudinal or stiffener, in mm;

t_f — net thickness of face plate of longitudinal or stiffener, in mm, taken as average net thickness of bulb for bulb flat;

s — length of shorter side of panel, in mm, taken as considered spacing of longitudinals or stiffeners for stiffened panel;

l — length of longer side of panel, in mm; for stiffened panel, taken as considered span of longitudinal or stiffener, in mm;

x — defined as axial direction of longer side of panel;

y — defined as axial direction of shorter side of panel;

E — modulus of elasticity of material. For steel, $E = 2.06\times10^5$ N/mm^2; for aluminum, $E = 0.70 \times 10^5$ N/mm^2;

v — Poisson's ratio for material, $v = 0.3$;

σ_{sw} — yield stress of material in welded condition, in N/mm^2:

$\sigma_{p0.2}$ is to be taken as the yield stress of material in annealed condition for aluminum, see relevant requirements of CCS Rules for Materials and Welding;

$\sigma_{sw} = \sigma_s$ for steel, σ_{sw_p} and σ_{sw_s} are σ_{sw} of plate and stiffener respectively;

$\tau_s — \frac{\sigma_{sw}}{\sqrt{3}}$;

k_x — buckling coefficient for the shorter side subjected to compression and bending, to be calculated according to Table 7.2.2.1.1(1). In general, taken as 4.0 if based on FEM;

k_y — buckling coefficient for the longer side subjected to compression and bending, to be calculated according to Table 7.2.2.1.1(1). Where compressive stress varies in axial direction of the shorter side between panels to a large extent, a linearly distributed stress in axial direction of the longer side, which deviates from the actual stress distribution as small as possible, is to be assumed first, and then taken as in Table 7.2.2.1.1(1) for calculation;

k_t — shear buckling coefficient, to be calculated according to Table 7.2.2.1.1(1);

C_1, C_2 — boundary coefficient, see Table 7.2.2.1.1(2);

β — slenderness coefficient of panel, $\beta = \frac{s}{t_p}\sqrt{\frac{\sigma_{sw}}{E}}$

σ_x, σ_y, τ_{xy} — respectively as calculated value, in N/mm^2, of compressive stress along axes x and y and shear stress within x-y plane for elementary panel in the same condition. The average value (to be negative value when compressive stress is applied) of in-plane stresses (membrane stresses) at the centroid of all plate elements is to be considered in calculation. Where the calculated values of σ_x and/or σ_y are greater than zero, they are to be taken as zero;

σ_{x_max}, σ_{y_max}, τ_{xy_max} — respectively as maximum calculated value, in N/mm^2, of compressive stress along axes x and y and shear stress within x-y plane for stiffened panel in the same condition, to be taken as in the case of σ_x, σ_y and τ_{xy};

σ_e — equivalent (Von Mises) stress of the panel,

$\sigma_e = \sqrt{\sigma_x^2 - \sigma_x\sigma_y + \sigma_y^2 + 3\tau_{xy}^2}$, in N/mm^2;

σ_{xcr_e}, σ_{ycr_e}, τ_{cr_e} — respectively as critical elastic compressive buckling stress along axes x and y under uniaxial stress and critical shear buckling stress within x-y plane for panel, in N/mm^2, see 7.2.2.1.2(1), (2) and (3);

σ_{xcr}, σ_{ycr}, τ_{cr} — respectively as critical compressive buckling stress along axes x and y under uniaxial stress and critical shear buckling stress within x-y plane for panel, in N/mm^2, see 7.2.2.1.2;

σ_{xu}, σ_{yu}, τ_{xyu} — respectively as ultimate compressive stress along axes x and y under uniaxial stress and ultimate shear stress of stiffened panel, in N/mm^2, see 7.3.2.1;

σ_{a_max} — maximum axial compressive stress of longitudinal or stiffener in ultimate limit state, in N/mm^2;

σ_{b_max} — maximum bending stress of longitudinal or stiffener in ultimate limit state, in N/mm^2, see 7.3.3.2;

p_{max} — maximum laterally and uniformly distributed load of the stiffened panel at the ultimate limit state, in N/mm^2;

σ_{cr_a} — critical compressive buckling stress of longitudinal or stiffener, in N/mm^2, see 7.3.3.2;

P_{max} — uniformly distributed load of the panel (obtained from finite element model, and pressure difference value is to be taken when both two sides (internal and external) of the panel are subjected to compression at the same time), in N/mm^2.

7.2 Buckling check of elementary panels

7.2.1 For plate panel structures which are subject to the effect which would result in buckling failure under normal service, the buckling strength of panel is to be checked according to the method in 7.2 of the Guidelines.

7.2.2 "Elementary panel" in this section means that part of plating other than periphery, with no any frame or stiffening member in its area, such as structural unstiffened panel, deep web of a primary supporting member, bottom floor and large bracket. Only rectangular panels are to be considered in calculation of panel buckling.

7.2.2.1 Check of panel buckling

7.2.2.1.1 Critical buckling stress is to be obtained as follows:

(1) The elastic critical buckling stress σ_{xcr_e} of the panel, of which the shorter side is subjected to compression, is defined as follows:

$$\sigma_{xcr\_e} = k_x C_1 \frac{\pi^2 E}{12(1-v^2)} (\frac{t_p}{s})^2 \quad \mathrm{N/mm^2}$$

(2) The elastic critical buckling stress σ_{ycr_e} of the panel, of which the longer side is subjected to compression and bending, is defined as follows:

$$\sigma_{ycr\_e} = k_y C_2 \frac{\pi^2 E}{12(1-v^2)} (\frac{t_p}{s})^2 \quad \mathrm{N/mm^2}$$

(3) The elastic critical buckling stress τ_{cr_e} of the panel, which is subjected to shear force, is defined as follows:

$$\tau_{cr\_e} = k_t C_1 \frac{\pi^2 E}{12(1-v^2)} (\frac{t_p}{s})^2 \quad \mathrm{N/mm^2}$$

7.2.2.1.2 The elastic critical buckling stress of panel is to be corrected as follows:

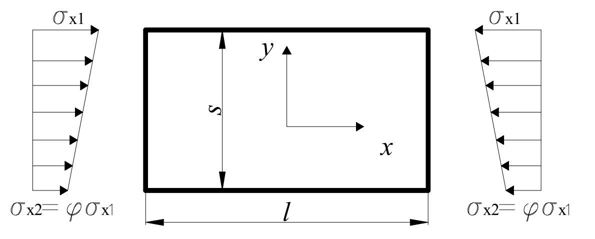
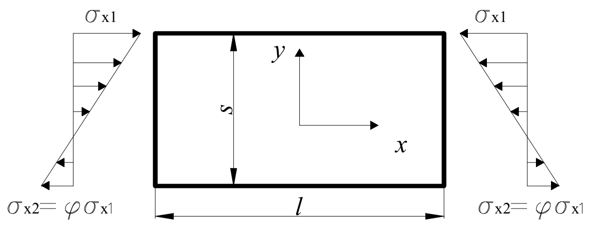
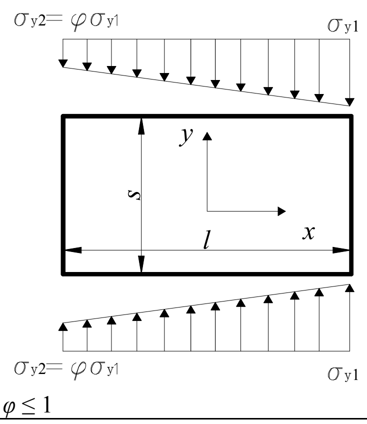
$$\sigma_{\substack{xcr\\(ycr)}} = \begin{cases} \sigma_{\substack{xcr\_e\\(ycr\_e)}} & \text{for} \quad \sigma_{\substack{xcr\_e\\(ycr\_e)}} \le \dfrac{\sigma_{sw}}{2} \\ \sigma_{sw}\left(1-\dfrac{\sigma_{sw}}{4\sigma_{\substack{xcr\_e\\(ycr\_e)}}}\right) & \text{for} \quad \sigma_{\substack{xcr\_e\\(ycr\_e)}} > \dfrac{\sigma_{sw}}{2} \end{cases}$$

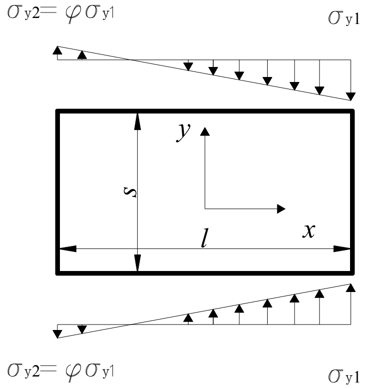
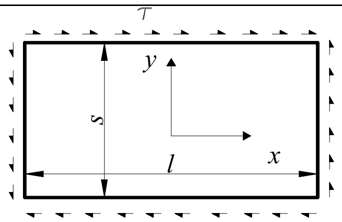
$$\tau_{cr} = \begin{cases} \tau_{cr\_e} & \text{for} \quad \tau_{cr\_e} \le \dfrac{\tau_S}{2} \\ \tau_S\left(1-\dfrac{\tau_S}{4\tau_{cr\_e}}\right) & \text{for} \quad \tau_{cr\_e} > \dfrac{\tau_S}{2} \end{cases}$$

7.2.2.1.3 Criterion for buckling strength of panel

$$\left(\frac{\sigma_x}{\sigma_{xcr}}\right)^2 + \left(\frac{\sigma_y}{\sigma_{ycr}}\right)^2 + \left(\frac{\tau_{xy}}{\tau_{cr}}\right)^2 \le 1$$

Buckling Coefficient of Panel **Table 7.2.2.1.1(1)**

Model of panel subjected to compression, bending and shear forces		Buckling coefficient
Compression on shorter side	 where: $0 \le \varphi \le 1$	$k_x = \dfrac{8.4}{\varphi + 1.1}$
	 where: $-1 \le \varphi < 0$	$k_x = 7.6 - 6.4\varphi + 10\varphi^2$
Compression on longer side	 where: $0 \le \varphi \le 1$	$k_y = \left[1 + \left(\dfrac{s}{l}\right)^2\right]^2 \dfrac{2.1}{\varphi + 1.1}$

Model of panel subjected to compression, bending and shear forces		Buckling coefficient
	where: $-1 \le \varphi < 0$	$k_y = 1.909(1+\varphi)\left[1+(\frac{s}{l})^2\right]^2 - k_p\varphi + 10\varphi(1+\varphi)(\frac{s}{l})^2$ where: $k_y = \begin{cases} 24(\frac{s}{l})^2 & \frac{l}{s} \le \frac{3}{2} \\ 2+16(\frac{s}{l})^2+8(\frac{s}{l})^4 & \frac{l}{s} > \frac{3}{2} \end{cases}$
Edges subjected to shear stress		$k_t = 5.34 + 4(\frac{s}{l})^2$

Panel boundary coefficients C_1, C_2 **Table 7.2.2.1.1(2)**

Boundary condition	C_1	C_2	
		Between double bottom or double skin or double deck	Elsewhere
Angles or T-sections	1.1	1.3*	1.2
Flat bars or bulb flats, plates, stiffener webs	1.0	1.2*	1.1

Note: "*" is applicable to the condition in which the shorter side of panel is supported by the structures of high rigidity, e.g. bottom, inner bottom, side shell, inner shell, double bottom floors/girders, side girders, double deck, etc.

7.2.3 The buckling strength of stiffeners supporting elementary panels is to be checked according to the relevant provisions in Section 9 of Chapter 4 of the Rules.

7.3 Check of ultimate strength of stiffened panel

7.3.1 The check of ultimate strength of stiffened panel is composed of two parts, i.e. check of ultimate strength of panel and check of ultimate strength of stiffener (longitudinal, small beam or bulkhead stiffener).

7.3.2 Check of ultimate strength of panel

7.3.2.1 The ultimate strength of panel is to comply with the following requirements:

$$(\frac{\sigma_{x\_max}}{\sigma_{xu}})^2 + (\frac{\sigma_{y\_max}}{\sigma_{yu}})^2 - \eta(\frac{\sigma_{x\_max}}{\sigma_{xu}})(\frac{\sigma_{y\_max}}{\sigma_{yu}}) + (\frac{\tau_{xy\_max}}{\tau_{xyu}})^2 + \xi\frac{p_{max}}{\sigma_{sw\_p}}(\frac{s}{t_p})^2 \times 10^{-4} \le 1$$

where: $\sigma_{xu} = \sigma_{sw}\frac{b_{eff\_x}}{s}$, and to be taken as not less than σ_{xcr};

$\sigma_{yu} = \sigma_{sw}\frac{b_{eff\_y}}{l}$, and to be taken as not less than σ_{ycr};

$\tau_{xyu} = \tau_{cr} + \left[0.5(\sigma_{sw} - \sqrt{3}\tau_{cr}) \Big/ \sqrt{1+\frac{l}{s}+\left(\frac{l}{s}\right)^2}\right]$, and to be taken as not less than τ_{cr};

b_{eff_x}— effective breadth of axis x of panel in post-buckling condition, in mm, $b_{eff\_x} = C_\beta s$

$$C_\beta = \begin{cases} \frac{2.25}{\beta} - \frac{1.25}{\beta^2} & \text{if } \beta \geq 1.25 \\ 1.0 & \text{if } \beta < 1.25 \end{cases}$$

b_{eff_y}— effective breadth of axis y of panel in post-buckling condition, in mm, to be calculated by the following formula and taken as not greater than l:

$$b_{eff\_y} = C_\beta s + 0.115l(1 - \frac{s}{l})(1 + \frac{1}{\beta^2})^2;$$

η — correlation coefficient for longitudinal stress and transverse stress, $\eta = 1.5 - \frac{\beta}{\chi}$, and may be less than zero;

χ — coefficient, 1.8 for flat bars, 3.6 for bulb flats, 6.9 for angles and 10.0 for T sections;

ξ — coefficient, 1.2 for T sections and 2.0 for other sections.

7.3.2.2 For check of the ultimate strength of a panel subjected to lateral pressure alone or combined with in-plane stresses, the maximum uniformly distributed lateral load p_{max} is also to satisfy the following formula:

$$P_{max} \leq P_u \quad \text{N/mm}^2$$

where: P_u — ultimate value of uniformly distributed lateral load of the stiffened panel, in N/mm^2, to be calculated by the following formula:

$$p_u = 4\sigma_{sw\_p}\left(\frac{t_p}{s}\right)^2\left(1 + \left(\frac{s}{l}\right)^2\right)\sqrt{1 - \left(\frac{\sigma_e}{\sigma_{sw\_p}}\right)^2}$$

7.3.3 Check of ultimate strength of stiffener

7.3.3.1 The check of ultimate strength of stiffener is composed of two parts, i.e. check of beam-column buckling mode and check of torsional buckling mode.

7.3.3.2 In the condition of ultimate strength, the beam-column buckling mode of longitudinal/stiffener is to satisfy the following formula:

$$\frac{\sigma_{a\_max}}{\varphi_c \sigma_{cr\_a} \frac{A_{eff}}{A}} + \frac{m\sigma_{b\_max}}{\varphi_c \sigma_{sw\_s}} \leq 1$$

where: ϕ_c — coefficient, 0.7 for flat bars, 0.80 for bulb flats and 0.75 for angles and T sections;

σ_{cr_a}— critical buckling stress of longitudinal or stiffener, in N/mm^2, to be calculated by the following formula:

$$\sigma_{cr\_a} = \begin{cases} \sigma_{aE} & \text{when } \sigma_{aE} \leq \frac{\sigma_{sw\_s}}{2} \\ \sigma_{sw\_s}\left(1 - \frac{\sigma_{sw\_s}}{4\sigma_{aE}}\right) & \text{when } \sigma_{aE} > \frac{\sigma_{sw\_s}}{2} \end{cases}$$

σ_{aE} — ideal elastic buckling stress of longitudinal or stiffener, in N/mm^2, $\sigma_{aE} = \frac{\pi^2 E}{(l/r_{eff})^2}$

where: r_{eff} — radius of inertia of effective area A_{eff}, in mm;

A_{eff} — effective area of beam-column model, in mm^2, $A_{eff} = A_s + B_{eff\_x}t_p$;

A_s — section area of longitudinal or stiffener not including attached plating, inmm^2;

A — total area of beam-column model, in mm^2, $A = A_s + st_p$;

m — amplification coefficient, $m = \frac{1}{\left(1 - \sigma_{a\_\max} / \sigma_{aE}\right)}$ and not to be less than 1.0;

σ_{b_max}— bending stress of longitudinal or stiffener in ultimate limit state, in N/mm^2, $\sigma_{b\_\max} = \frac{M_{\max}}{W_{eff}}$;

M_{max}— maximum bending moment of longitudinal or stiffener due to lateral load in ultimate limit state, to be calculated by the following formula:

$$M_{\max} = \frac{c_m p_{\max} s l^2}{24} \times 10^{-3} \quad N \cdot mm$$

c_m — bending moment adjusting coefficient, which may be taken as 0.75;

W_{eff} — section modulus of longitudinal or stiffener at flange, taking into account of effective breadth b_{eff} of attached plating, in mm^3;

7.3.3.3 In the condition of ultimate strength, the torsional buckling mode of longitudinal or stiffener is to satisfy the following formula:

$$\frac{\sigma_{a\_\max}}{\varphi \sigma_{cr\_t} \frac{A_{eff}}{A}} \leq 1$$

where: ϕ — coefficient, 0.55 for flat bars, 0.80 for bulb flats, 0.85 for angles and 1.0 for T sections;

A_{eff}, A — the same as in 7.3.3.2;

σ_{cr_t}— critical torsional buckling stress of longitudinal or stiffener, in N/mm^2, to be calculated by the following formula:

$$\sigma_{cr\_t} = \begin{cases} \sigma_{ET} & \text{when} \quad \sigma_{ET} \leq \frac{\sigma_{sw\_s}}{2} \\ \sigma_{sw\_s}\left(1 - \frac{\sigma_{sw\_s}}{4\sigma_{ET}}\right) & \text{when} \quad \sigma_{ET} > \frac{\sigma_{sw\_s}}{2} \end{cases};$$

σ_{ET} — ideal elastic torsional buckling stress of longitudinal or stiffener including attached plating, in N/mm^2, to be calculated by the following formula:

$$\sigma_{ET} = \frac{\frac{K}{2.6} + \left(\frac{n\pi}{l}\right)^2 \Gamma + \frac{C_0}{E}\left(\frac{l}{n\pi}\right)^2}{I_0 + \frac{C_0}{\sigma_{cL}}\left(\frac{l}{n\pi}\right)^2} E;$$

where: K — St Venant's torsion constant of profile (not including attached plating), in mm^4,

$$K = \frac{b_f t_f^{\,3} + h_w t_w^{\,3}}{3};$$

I_0 — polar moment of inertia of profile about connection of longitudinal or stiffener to plate (not including attached plating), in mm^4;

$$I_0 = I_y + \gamma I_z + A_s\left(y_0^{\,2} + z_0^{\,2}\right)$$

I_y, I_z— moment of inertia of longitudinal or stiffener about y and z axe respectively (not including attached plating), see Figure 7.3.3.3;

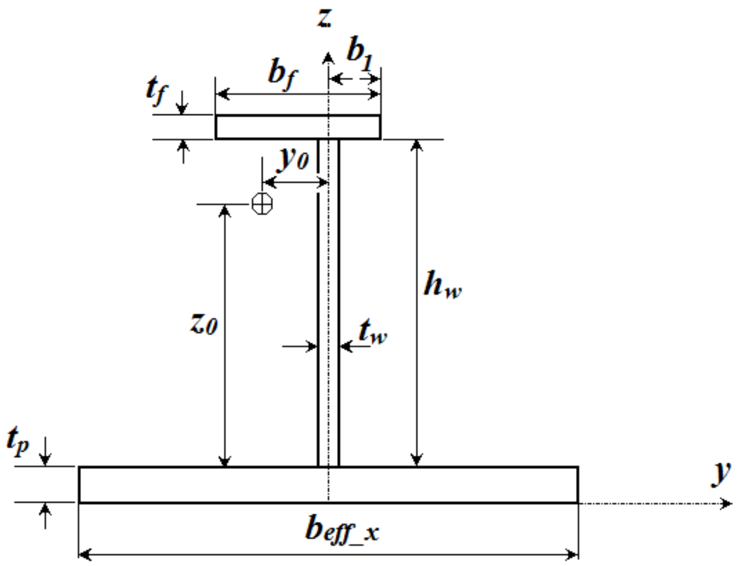


Figure 7.3.3.3 Characteristics of Stiffened Panel Combined Section

$\gamma = 1.0 - u\left(0.7 - 0.1\dfrac{h_w}{b_f}\right)$;

u — asymmetrical coefficient, $u = 1.0 - 2\dfrac{b_1}{b_f}$;

y_0 — horizontal distance between the center of longitudinal or stiffener and web centerline, in mm;

z_0 — vertical distance between the center of longitudinal or stiffener and web toe, in mm;

b_1 — outstand dimension of flange/face plate with respect to web's centerline (taking the size of shorter side), in mm;

$C_0 = \dfrac{Et_p^{\,3}}{3s}$;

Γ — warping constant, in mm^6, $\Gamma = \gamma I_{yf} h_w^{\,2} + \dfrac{h_w^{\,3} t_w^{\,3}}{36}$,

where: $I_{yf} = \dfrac{t_f b_f^{\,3}}{12}\left(1.0 + 3.0\dfrac{u^2 h_w t_w}{A_s}\right)$, in mm^4;

σ_{cL} — critical buckling stress corresponding to n-half waves (including attached plating), in N/mm^2, to be calculated by the following formula:

$$\sigma_{cL} = \frac{\pi^2 E\left(\dfrac{n}{\alpha} + \dfrac{\alpha}{n}\right)^2\left(\dfrac{t_p}{s}\right)^2}{12\left(1-\nu^2\right)},$$

where: $\alpha = \dfrac{l}{s}$;

n — number of half waves corresponding to the smallest σ_{ET}, to be determined by tentative calculation.

Appendix 3 Guidelines for Direct Calculations of Hull Structure Strength of High Speed Craft Made of Composite Material

1 General requirements

1.1 Unless provided otherwise, the direct calculation methods for high speed craft made of composite material are to be checked for strength in accordance with Appendix 2 of the Rules.

2 Direct strength calculation

2.1 Model extent

2.1.1 Model extent of overall strength check

A global three-dimensional model is to be adopted for overall structural analysis, and hull shell, bulkheads, decks and platforms, primary members as well as superstructures are all to be represented in the model.

2.1.2 Model extent of local strength check

(1) Local strength check is to be carried out to important local structures on which actual loads can not be applied in the global analysis, such as bottom, side, decks, superstructures, catamaran cross deck bottom and wave-piercer craft front hull where local high stress occurs.

(2) Local structures where scantlings of their primary member are to be checked by means of direct calculation.

(3) A model for local structural analysis is to have the target structure as its center, extending outward to the strength structures. In general, grillage models of bottom, side, deck and cross deck are at least to cover the length of one compartment, reaching in width and height the adjoining main structures of hull, such as bulkhead, side shell or deck.

2.2 Model elements

The real structure is to be simulated by plate elements. Quadrilateral elements with aspect ratio less than 3 are to be adopted as far as possible. Use of triangular elements is to be avoided at high stress area and high stress area which deviates from the actual stress distribution. The size of element is generally taken as 50 × 50 mm.

2.3 Material properties

When given material properties of finite element, the material parameters may be set as per each ply of laminate direction and laminate thickness in accordance with the laminate design. Material properties may also be given directly by means of the integral characteristics of laminate panels. Where material properties are given for each ply of laminate, the mechanical property parameters of a single laminate may be determined by test methods. Table 2.3 below may be used for design values.

Generic constituent material properties **Table 2.3**

			Fibers				Matrices
			E-Glass	Aramid	HS Carbon	HM Carbon	Polyester / Epoxy
Specific gravity		[g/cm^3]	2.54	1.44	1.74	1.81	1.2
Young's Modulus	parallel to fibers	[MPa]	73000	124000	230000	392000	3600
	Perpendicular to fibers	[MPa]	5500	6900	28000	15000	
Shear Modulus		[MPa]	30000	2800	50000	28600	1330
Poisson's ratio		--	0.18	0.36	0.23	0.20	0.35

2.4 Boundary conditions, load and condition combinations

The boundary conditions, load and condition combinations for direct calculation of hull girder strength and local strength are to be determined in accordance with the requirements of Appendix 2 of the Rules.

2.5 Criteria

(1) Maximum strain for laminates in axial tension/compression is to be:

– 0.25 % for standard modulus, intermediate modulus or high strength carbon fiber laminates, built as wet, vacuum or in infusion technology;

– 0.275 % for standard modulus, intermediate modulus or high strength carbon fiber laminates, built using pre-preg technology;

– Smaller value of 0.25% or UCS/3 for laminates consisting of high modulus carbon fibers, built as wet, vacuum or in infusion technology;

– Smaller value of 0.275% or UCS/3 for laminates consisting of high modulus carbon fibers, built using pre-preg technology;

– 0.35 % for E-Glass laminates.

(2) Maximum allowable in-plane shear strain is to be:

– 0.45 % for standard modulus, intermediate modulus or high strength carbon fibers laminates, built as wet, vacuum or in infusion technology;

– 0.49 % for standard modulus, intermediate modulus or high strength carbon fibers laminates, built using pre-preg technology;

– Smaller value of 0.25% or UCS-0.6 for laminates consisting of high modulus carbon fibers, built as wet, vacuum or in infusion technology;

– Smaller value of 0.275% or UCS-0.6 for laminates consisting of high modulus carbon fibers, built using pre-preg technology;

– 0.7 % for E-Glass laminates.

where: “UCS” — ultimate compressive strain, test method is given in ASTM D694.