CR

CR Classification Society

FOUNDED 1951

RULES FOR THE CONSTRUCTION AND CLASSIFICATION OF HIGH-SPEED CRAFT 2021

PART I — CLASSIFICATION AND SURVEY

August 2020

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Chapter 1

Classification of High-Speed Craft

1.1 General

1.1.1 High-Speed Craft (HSC) built and surveyed in accordance with the Rules for the Construction and Classification of High-Speed Craft (hereinafter referred to as the Rules) published by the CR Classification Society (hereinafter referred to as the Society) or alternatives found to represent an overall safety standard equivalent to that of the Rules (See 1.1.6 of this Part) will be assigned a class in the Register of Ships (hereinafter referred to as the Register) and will continue to be classed so long as they are found, upon examination at the prescribed surveys, to be maintained in a fit and efficient condition and in accordance with the requirements of the Rules.

The Rules is applicable to high-speed craft constructed of steel, aluminum, or FRP and having $V/\sqrt{L}$ not less than 2.36 where L is as defined in 1.1.2 of Part III and V is as defined in 1.1.18 of Part III. Applicable craft type and length are as follows:

Application Limits	
Craft Type	Applicable Length
Mono-hull	< 130 m
Multi-hull	< 100 m
Surface Effects Ship (SES)	< 90 m
Hydrofoil	< 60 m

Craft which have lengths that are in excess of the above table may be classed using the requirements in the Rules, as applicable, providing that requirements in 2.1 and 2.2 of Part III of the Rules are verified by theoretical prediction, first principles analysis, and model testing.

The craft will at all times be in reasonable proximity to a place of refuge, having due regard to the following:

(a) Passenger craft which do not proceed in the course of their voyage more than 4 hours at 90% of maximum speed from a place of refuge; and

(b) Cargo craft of 500 gross tonnage and upwards which do not proceed in the course of their voyage more than 8 hours at 90% of maximum speed from a place of refuge when fully laden.

1.1.2 Classification will be conditional upon compliance with the Rules in respect of both hull and machinery (i.e., main and auxiliary engines, boilers, essential appliances, pumping arrangements and electrical equipment). The products including the equipment, components, systems and materials intended for classed craft or craft to be classed are to comply with the requirments in "Guidelines for Survey of Product for Marine Use".

1.1.3 The Rules are framed on the understanding that craft will be properly loaded and handled; they do not, unless stated in the class notation, provide for special distributions or concentrations of loading. The Society may also require additional strengthening to be fitted in any craft which, in their opinion, may be subjected to severe stresses due to particular features in her design, or when it is desired to make provisions for exceptionally loaded or ballasted conditions. In these cases particulars are to be submitted for consideration.

1.1.4 The stability of the craft is to be sufficient and in compliance with the requirements of governmental authority or International Conventions and Codes and Part II Chapter 30 and 30A of the Rules for Steel Ships, as applicable.

1.1.5 The Rules do not cover certain technical characteristics, such as trim, hull vibration, etc., but the Society is willing to advise on such matters although it cannot assume responsibility for them.

1.1.6 Alternatives are to be accepted, provided that they are considered by the Society to be equivalent to the Rules.

1.1.7 The construction of craft which involves novel features of design in respect of hull, machinery or equipment and to which the provisions of the Rules are not directly applicable may be classed, when approved by the Society on the basis that the Rules insofar as applicable have been complied with and that special consideration based on the best information available at the time has been given to the novel features. The Rules are framed on the understanding that crafts are not to be operated in environmental conditions more than those agreed for the design basis and approval, without the prior agreement of the Society.

1.1.8 Register

Craft with their class approved by the Society are to be recorded in the Register. The Register is to be published on the CR website and is to contain the names of craft and other useful items of information such as flag, port of registry, gross tonnage, class notations, owners, shipbuilders, dimensions, machinery particulars, the date of build, etc.

1.1.9 Date of build

(a) The date of build is normally to be the date of completion of the classification initial survey during construction of craft built under the inspection.

(b) If the period between launching and completion or putting a craft to use is unduly made longer than usual, the date of launching may be additionally indicated in the Register.

(c) If a craft is not immediately put into service after completion, but is laid up for a period, the craft is to be drydocked for examination by the Surveyor of the Society (hereinafter referred to as the Surveyor) before proceeding to sea, and the subsequent Special Survey is based on the date of such an examination provided that the result of such survey is satisfactory in all respects.

1.1.10 Loading conditions and any other preparations required to permit a craft with a notation specifying some service limitation to undertake a sea-going-voyage, either from port of loading to service area or from one service area to another, are to be in accordance with arrangement agreed by the Society prior to the voyage.

1.1.11 Damage, repairs and alternations

Any damage, defect, breakdown or grounding, which could invalidate the conditions for which a class has been assigned, is to be reported to the Society without delay.

1.1.12 For craft, the arrangements and equipment of which are required to comply with the requirements of the International Convention and applicable Protocols and Amendments relating thereto, such compliance is to be demonstrated by possession of applicable Convention Certificates issued by the Government of the State whose flag the craft is flying (hereinafter refer to as the Administration) or by any organization authorized by the Administration.

1.1.13 For craft not engaged in international voyages are to comply with the relevant regulations of the Administration.

1.1.14 Where an on-board computer system having either a longitudinal strength or a stability computation capability or both, is provided on new craft, or newly installed on existing craft, then the system is to be certified for such use in accordance with the Society's procedure for approval of on-board computer systems for stability calculation (Refer to Appendix 1).

1.1.15 When longitudinal strength calculations have been required, loading guidance information is supplied to the Master by means of a Loading Manual and in addition, when required, by means of loading instrument.

1.1.16 For all craft, new installation of materials which contain asbestos is to be prohibited.

1.1.17 Craft of length less than 24 meters may be designed and constructed in accordance with other recognized standards, e.g. ISO standards provided the agreement is issued by the Society.

1.1.18 In general, while references are made to IACS URs (Unified Requirements), the latest version of the documents are to be used.

1.1.19 Direct analyses

(a) Required analyses

Direct analyses are required in particular cases to demonstrate the adequacy of the structural design, as indicated in the Table I 1-1 and Table I 1-2.

The methods and requirements for direct analysis are in 1.3 of Part III, as applicable.

Similarly for craft designs having the length or speed values exceeding the mentioned ones, a suitable direct analysis is to be performed to demonstrate the adequacy of the hull girder strength. (See also 2.1.1(a)(i) and 2.1.2(a) of Part III.)

Considerations will be given for craft which have been previously approved, or offer slight variations on the Length/Speed based requirements above. All novel concepts will be subject to special consideration, and the requirements may differ from the above.

The direct analyses are to be performed using an acceptable finite element method computer program. The extent of, and boundary conditions applied to the analytical model(s) are to be appropriate to reflect adequately the behavior of the structure. The loads to be applied to the structural model are to be based on consideration of the design values, deck cargo and similar internal loads in the hull (accounting for dynamic effects as appropriate), the external pressure loads (see 2.2 of Part III, as applicable) and distribution specified in the Rules, as applicable, and appropriate wave induced hull girder bending moment and shear force effects. The requirements for this analysis are in 1.3 of Part III, as applicable.

(b) Supplementary analyses

In addition to the direct analyses required in 1.1.19(a) above, the Society may require the performance of additional direct analyses to demonstrate and document the adequacy of other features of the hull structural design, which are considered to be within the scope of classification. The need to provide such analyses can arise: in the case of trimarans, stabilized slender monohulls and other unique hull forms; where structural displacement is expected to influence (more than usually) structural response; where hull propulsion or steering system load transmission in the hull needs to be specially addressed; to demonstrate the efficiency of novel connection details on hull strength, etc.

For types of behavior or loading effects which are not within the scope of classification of the craft to be classed, the Society will upon request provide advice on what it feels constitutes an appropriate analysis. Such analyses include those for vibration and docking arrangements.

(c) Analysis scope and documentation

The scope, details and manner of documenting the analyses are to be agreed with the Society before the analyses are done.

Table I 1-1
Criteria for Steel and Aluminum High-Speed Craft

Craft Type	Length (L)	Speed (V)	Required calculations to be submitted
High-Speed Craft	91 m ≤ L	All	First principles loads(1) applied to a global finite element model
	61 m ≤ L < 91 m	V < 40 knots	Rules loads(2) applied to a global finite element model
	61 m ≤ L < 91 m	40 knots < V	First principles loads(1) applied to a global finite element model
	L < 61 m	40 knots < V	First principles slam loads(1) and accelerations applied to a global finite element model
Coastal Craft	91 m ≤ L	All	First principles loads(1) applied to a global finite element model
	L < 91 m	50 knots ≤ V	First principles slam loads(1) and accelerations applied to a global finite element model
	L < 91 m	V < 50 knots	None
Riverine Craft	None	None	None

Notes:
(1) Refer to 1.3 of Part III.
(2) All loads and pressures as defined by Chapter 2 of Part III, as applicable.

Table I 1-2
Criteria for FRP High-Speed Craft

Craft Type	Length (L)	Speed (V)	Required calculations to be submitted
All	50 m ≤ L	All	First principles slam loads(1) and accelerations applied to a global finite element model
	All	40 knots ≤ V	First principles slam loads(1) and accelerations applied to a global finite element model
	L < 50 m	V < 40 knots	None

Notes:
(1) Refer to 1.3 of Part III.

1.2 Application

The Society has the right to adopt, and publish as deemed necessary, Rules relating to classification and has (in relation thereto) provided the following:

1.2.1 Except in the case of a special directive by the Society, no new Regulation or alteration to any existing Regulation relating to classification character or to class notation is to be applied to existing craft.

1.2.2 Except in the case of a special directive by the Society, or where changes necessitated by mandatory implementation of International Conventions and Codes are concerned, no new Rule or alteration in any existing Rules is to be applied compulsorily after the date on which the contract between the ship builder and shipowner for construction of the craft has been signed, nor within 6 months of its adoption, nor after the approval of the original midship section or equivalent structural plans. The date of "contract for construction" of a craft is the date on which the contract to build the craft is signed between the prospective shipowner and the shipbuilder. This date and the construction number (i.e. hull numbers) of all the craft included in the contract are to be declared by the party applying for the assignment of class to a newbuilding. The date of "contract for construction" of a series of sister ship, including specified optional craft for which the option is ultimately exercised, is the date on which the contract to build the series is signed between the prospective shipowner and the shipbuilder. In this section a "series of sister ship" is a series of craft built to the same approved plans for classification purposes, under a single contract for construction. The optional craft will be considered part of the same series of sister ship if the option is exercised not later than 1 year after the contract to build the series was signed. If a contract for construction is later amended to include additional craft or additional options, the date of "contract for construction" for such craft is the date on which the amendment to the contract is signed between the prospective shipowner and the shipbuilder. The amendment to the contract is to be considered as a "new contract". If a contract for construction is amended to change the craft type, the date of "contract for construction" of this modified

craft, is the date on which the revised contract or new contract is signed between the Owner, or Owners, and the shipbuilder. Where it is desired to use existing approved craft or machinery plans for a new contract, written application is to be made to the Society. Sister ship may have minor design alterations provided that such alterations do not affect matters related to classification, or if the alterations are subject to classification requirements, these alterations are to comply with the classification requirements in effect on the date on which the alterations are contracted between the prospective owner and the shipbuilder or, in the absence of the alteration contract, comply with the classification requirements in effect on the date on which the alterations are submitted to the Society for approval. Recognising the long time period that may occur between the initial design contract and the contract for construction for offshore units for fixed locations, the date determining effective classification requirements will be specially considered by the Society in such cases.

1.2.3 Information contained in the reports of classification and statutory surveys will be made available to the relevant owner, National Administration, Port State Administration and, if authorised in writing by that owner, to any other person or organisation.

1.2.4 Information relating to the status of classification and statutory surveys and suspensions/withdrawals of class together with any associated conditions of class will be made available as required by applicable legislation or court order.

1.3 Classification Characters

1.3.1 All craft, when classed, will be assigned following classification characters as applicable.

1.3.2 Classification symbols

(a) **CR100** —This class is to be assigned to the craft's hull which in all their parts complies with the Rules for the draught required.

(b) **CMS** —This class is to be assigned to the machinery including propelling and essential auxiliary machinery and all other equipment covered by the classification which complies with the Rules.

(c) The symbol **CMS** will be added concurrently to a craft assigned with **CR100**.

1.3.3 Surveying symbols

(a) ✠ This symbol when affixed to classification symbols means the plans of craft have been approved by the Society in accordance with the Rules, and craft has been built to the satisfaction of the Surveyor to the Society.

(b) ✠ This symbol is to be assigned to the craft has not been built under the survey of the Society but has been constructed under the survey of a recognized society. In addition, the whole of hull and machinery will be required to have been installed and tested to the satisfaction of the Surveyor to the Society in accordance with the Rules of the Society.

(c) No surveying symbol are to be assigned to the hull and machinery of any craft not having been surveyed during construction by either the Society or any other recognized party but the existing installation and arrangement has been examined and tested and found to be acceptable to the Society.

1.3.4 Equipment symbols

The letter **E** which is affixed to surveying symbols of hull means the equipment including anchors, chain cables and hawsers of new or existing craft is supplied and maintained in accordance with the full requirements of the Rules, or partial requirements under special approval. In the case of a craft classed for a special or restricted service, if approved by the Society that requirements of the Rules are not necessary to apply, no equipment symbol is to be affixed.

1.3.5 Automation symbols

A symbol, which is to be round-bracketed and be affixed next to the classification symbol **CMS**, indicating that an automatic or remote control and monitoring system for propulsion machinery, propulsion machinery spaces, etc. is provided and relevant requirements of the Rules are complied with. See Table I 1-3.

1.4 Class Notations

1.4.1 General

(a) When considered necessary by the Committee, or when requested by an Owner and agreed by the Committee, a class notation will be appended to classification character assigned to the craft. This class notation will consist of one of, or a combination of, the notations listed in 1.4.2 to 1.4.5. The classification characters and class notations assigned to a craft are indicated on the Certificate of Classification as well as in the Register of Ship published by the Society.

(b) The notations for type of craft, service restriction, feature, cargo, equipment, additional survey, etc. are added after the classification symbol **CR100**. The automation symbol and notations for navigation safety system, special equipment of machinery, machinery survey, etc. are added after the classification symbol **CMS**.

(c) Where a class notation assigned to a specific craft together with classification characters is required by the Rules to which the craft is subject, such notation is a necessary one for this craft, otherwise an optional one.

(d) Every 2 sets of class notations are to be separated by a comma ",", e.g.:

CR100 ✠ E Passener Ship, Aluminum Alloy Hull, ……

CMS(CAU)✠ PCM,…

Unless specially stated otherwise, class notations are generally given in the following sequence.

(e) The notations not covered by the Rules are to comply with the applicable requirements of Part I of the Rules for Steel Ships.

1.4.2 Hull structural material notation

A notation indicating that the craft uses materials other than steel as the structural materials for the main hull, e.g. **FRP Hull, Aluminum Alloy Hull** etc.

1.4.3 Craft type notation, special duty or purpose notation, additional service notation and hull construction notation

(a) Craft type notation

A notation indicating that the craft has been arranged and constructed in compliance with particular usage intended to apply to that type of craft. See Table I 1-4.

(b) Special duties or purpose notation

(i) A notation indicating that the craft has been designed, modified or arranged for special duties other than those implied by the type and cargo notation, e.g. **Research Vessel**. Craft with special duties notations are not thereby prevented from performing any other duties for which they may be suitable.

(ii) A notation indicating that the craft has been designed, modified or arranged for special service other than those implied by the type and cargo notation, e.g. **Special Government Services**, etc. Craft with special purpose notations are not thereby prevented from performing any other duties for which they may be suitable.

(c) Additional service notation

A type notation and/or a special duty or purpose notation may be completed by one or more additional service notations. The specific rule requirements applicable to each service notation are to be complied with. See Table I 1-5.

(d) Hull construction notation

For craft with hull construction other than monohull, such as catamaran, trimaran, small waterplane area twin hull (SWATH) and etc., the hull construction of craft is in compliance with relevant requirements of the Rules or the requirements agreed by the Society, the hull construction notation of **Catamaran**, **Trimaran**, or **SWATH** will be affixed after the craft type notation.

1.4.4 Service restriction notation

A notation indicating that the craft has been classed on the understanding that it will be operated only in suitable areas or conditions which have been agreed by the Committee. See Table I 1-6.

1.4.5 Additional Class Notation

A notation expressing the classification of equipment or specific arrangement, which has been requested by the Owner.

(a) Special features notation

A notation indicating that the craft incorporates special features which significantly affect the design, e.g. **Hydrofoil Craft.**

(b) Cargo notation

A notation indicating that the craft has been designed, modified or arranged to carry one or more particular cargoes, e.g. **Sulphuric Acid**. Ship with one or more cargo notation are not thereby prevented from carrying other cargoes for which they are suitable.

(c) Additional survey notation.

A notation indicating that one or more Special Surveys are adopted and relevant requirements of the Rules are complied with. See Table I 1-7.

(d) Special equipment notation

A notation indicating that one or more special equipments are provided and relevant requirements of the Rules are complied with. See Table I 1-8.

(e) Navigation safety notation

A notation indicating that a navigational safety system is provided and relevant requirements of the Rules are complied with. See Table I 1-9.

(f) Environmental protection notation

A notation indicating that one or more environmental protection features are adopted and relevant requirements of the Rules are complied with. See Table I 1-10.

1.5 Application for Classification and Surveys

1.5.1 An application for the classification of craft is to be submitted in writing or by e-mail or fax by the builder for a craft to be built under the Society's survey or by the owner for a craft not built under the Society's survey.

1.5.2 An application for surveys for maintenance of class is to be submitted in writing or by e-mail or fax by the owner or owner's representative.

1.6 Surveys of Craft

1.6.1 General

(a) All craft classed with the Society are subjected to the following periodical surveys:

(i) Annual Surveys.

(ii) Bottom Surveys.

(iii) Intermediate Surveys.

(iv) Special Surveys.

(v) Boiler Surveys and thermal oil heater surveys.

(vi) Propeller shaft and tube shaft surveys.

(b) The contents of surveys by the Society are detailed in the "Survey Requirements of Craft" in Chapter 2 of this Part.

(c) Special consideration may be given to any unusual circumstances justifying a modification of either survey requirements or the interval of surveys. The Society may make special requirements including intervals of periodical surveys to coincide with the regulations of the flag state of craft if owner requests.

(d) Statutory survey will be acted by the Society, when authorized on behalf of Governments, in respect of National and International statutory safety and other requirements for passenger and cargo craft.

(e) Survey planning meeting (kick-off meeting) is to be held prior to the commencement of the Intermediate Survey and Special Survey.

1.6.2 Classification initial survey during construction

(a) New craft are to be built in accordance with the Rules. The constructional plans and particulars of the hull, equipment and machinery, together with their drawing list, are to be submitted for approval of the Society before the work is commenced. In case these plans need to be modified or altered, a re-approval is indispensable.

(b) The new machinery including boilers, pressure vessels and electrical equipment for craft classed or intended to be classed is to be manufactured under and surveyed according to the Rules.

(c) From the commencement of the work until the completion of the craft and final test of the machinery under working condition, the Surveyors are to be satisfied that the materials, workmanship and arrangements are satisfactory and in accordance with the Rules or the approved plans, or any material, workmanship or arrangement found to be unsatisfactory, it is to be rectified.

(d) The materials used in the construction of hulls and machinery intended for classification are to be of good quality and free defects and are to be tested in accordance with the requirements of Part II of the Rules and Part XI of the Rules for Steel Ships. The steel is to be manufactured by an approved process at works recognized by the Society. Alternatively, tests to the satisfaction of the Society will be required to demonstrate the suitability of the steel.

(e) Copies of finish plans (showing the craft as built), essential Certificates and records, required loading and other instruction manuals are to be readily available for use when required by the Surveyor, and may be required to be kept on board.

(f) Hull Survey for New Construction

(i) Qualification and Monitoring of Personnel

Exclusive Surveyors of the Society are to confirm through patrol, review and witness that the craft are built using approved plans in accordance with the relevant rules and statutory requirements. The Surveyors are to be qualified to be able to carry out the tasks and procedures are to be in place to ensure that their activities are monitored through the QM of the Society.

(ii) Survey of the hull structure

IACS UR Z23 Table 1 provides a list of surveyable items for the hull structure and coating and is applicable to the Society including:

(1) Description of the shipbuilding functions;

(2) Classification and statutory survey requirements;

(3) Survey method required for classification;

(4) Relevant IACS and statutory requirement references;

(5) Documentation to be available for the Surveyor during construction.

a) The shipbuilder is to provide the Surveyors access to documentation required by classification, this includes documentation retained by the shipbuilder or other third parties.

b) The list of documents approved or reviewed by the Society for the specific new construction are as follows:

- plans and supporting documents
- examination and testing plans
- NDE plans
- welding consumable details
- welding procedure specifications
- welding plan or details
- welder's qualification records
- NDE operator's qualification records

(6) Documents to be inserted into the craft construction file.

(7) A list of specific activities which are relevant to the shipbuilding functions. This list is not exhaustive and can be modified to reflect the construction facilities or specific craft type.

(8) Evidence is also to be made available, as required, by the shipbuilder, to the Surveyor whilst the construction process proceeds to prove that the material and equipment supplied to the craft has been built or manufactured under survey relevant to the classification rules and statutory requirements.

(iii) Newbuilding survey planning

Prior to commencement of surveys for any newbuilding project, a kick-off meeting shall be carried out.

A record of the meeting is to be made. The records are to take note of specific published Administration requirements and interpretations of statutory requirements. The shipyard shall be requested to advise of any changes to the activities agreed at the kick-off meeting and these are to be documented. Shipbuilding quality standards for the hull structure during new construction are to be reviewed and agreed during the kick-off meeting. Structural fabrication is to be carried out in accordance with IACS Recommendation 47, "Shipbuilding and Repair Quality Standard", or a recognized fabrication standard which has been accepted by the Society prior to the commencement of fabrication/construction. The work is to be carried out in accordance with the Rules and under survey of the Society. In the event of series craft production consideration may be given to waiving the requirement for a kick-off meeting for the second and subsequent craft.

(iv) Examination and test plan for newbuilding activities. The shipbuilder is to provide plans of the items which are intended to be examined and tested. These plans need not be submitted for approval and examination at the time of the kick-off meeting, but the plans and any modifications to them are to be submitted to the Surveyors in sufficient time to allow review before the relevant survey activity commences. They are to include:

(1) Proposals for the examination of completed steelwork - generally referred to as the block plan and are to include details of joining blocks together at the pre-erection and erection stages or at other relevant stages;

(2) Proposals for fit up examinations where necessary;

(3) Proposals for testing of the structure (leak and hydrostatic) as well as for all watertight and weathertight closing appliances;

(4) Proposals for non-destructive examination;

(5) Any other proposals specific to the craft type or to the statutory requirements.

(v) Craft Construction File

(1) The shipbuilder is to deliver documents for the Craft Construction File. In the event that items have been provided by another party such as the shipowner and where separate arrangements have been made for document delivery which excludes the shipbuilder, that party has the responsibility. The Craft Construction File shall be reviewed for content.

(2) Ship Construction File on board the craft, is to facilitate inspection (survey) and repair and maintenance, shall include in addition to documents listed in IACS Z23 Table 1, but not be limited to:

- As-built structural drawings including scantling details, material details, and, as applicable, wastage allowances, location of butts and seams, cross section details and locations of all partial and full penetration welds, areas identified for close attention and rudders;
- Manuals required for classification and statutory requirements, e.g. loading and stability, bow doors and inner doors and side shell doors and stern doors – operations and maintenance manuals (IACS S8 and S9);
- Craft structure access manual, as applicable;
- Copies of certificates of forgings and castings welded into the hull (IACS W7 and W8);
- Details of equipment forming part of the watertight and weathertight integrity of the craft;
- Tank testing plan including details of the test requirements (IACS S14);
- Corrosion protection specifications (IACS Z8);
- Details for the In-Water Survey, if applicable, information for divers, clearances measurements instructions etc., tank and compartment boundaries;
- Docking plan and details of all penetrations normally examined at drydocking;

(vi) Review of the construction facility

The Society is to familiarize themselves with the yard's production facilities, management processes, and safety for consideration in complying with the requirements of Table 1 of IACS UR Z23 prior to any steelwork or construction taking place in the following circumstances:

(1) where the Society has none or no recent experience of the construction facilities – typically after a 1 year lapse - or when significant new infrastructure has been added;

(2) where there has been a significant management or personnel re-structuring having an impact on the craft construction process;

(3) or where the shipbuilder contracts to construct a craft of a different type or substantially different in design.

1.6.3 Classification survey of craft not built under survey

Craft which have not been built under survey to the Society, but which are submitted for classification, are to be subjected to a classification survey of craft not built under survey (See 2.8 of this Part). Survey planning meeting (kick-off meeting) is to be held prior to the commencement of the survey.

1.6.4 Special Survey

(a) Survey intervals

The Special Survey is to be subjected to surveys at the fixed intervals not exceeding 5 years. Special Surveys are normally to be effected in the sequences of :

No.1 - for craft up to 5 years old.

No.2 - for craft between 5-10 years old.

No.3 - for craft between 10-15 years old.

No.4 & subsequent - for craft age > 15 years old.

(b) Commencement of Special Survey

(i) The Special Survey may be commenced at the 4th annual survey and be progressed with a view to completion by the 5th anniversary date.

(ii) As part of the preparation for the Special Survey, the thickness measurement held and survey plan are to be dealt with in advance of the Special Survey. However, the thickness measurement held before the 4th annual survey cannot be credited as a part of Special Survey.

(c) Premature of Special Survey

(i) If a Special Survey is completed prematurely but within 3 months prior to the due date, the due date of the next Special Survey is based upon a date not exceeding 5 years from the due date of the existing Special Survey. If a Special Survey is completed more than 3 months prior to the due date, the due

date of the next Special Survey is based upon a date not exceeding 5 years from the date of completing of the Special Survey.

(ii) Where a Special Survey is commenced more than 15 months prior to the due date, the entire survey is normally to be completed within 15 months, if such work is to be credited to the Special Survey. Survey is based upon a date not exceeding 5 years from the date of completion of the Special Survey.

(d) Extension of Special Surveys

(i) If a craft at the time when the Special Survey is due but not in a port in which it is to be surveyed, the Society may upon the Owner's written request in advance in each case extend a period not exceeding 3 months. Such extension is, however, only to be granted for allowing the craft to complete its voyage to the port in which it is to be surveyed, and only in cases where it is considered proper and reasonable to do so.

(ii) If a Special Survey is completed after the due date, the due date of the next Special Survey is based upon a date not exceeding 5 years from the due date of the existing Special Survey.

(iii) A maximum 3 months extension of Special Survey beyond the due date may be granted provided an occasional survey has been carried out satisfactorily based on a scope of Annual Survey and the additional items considered by the Head Office of the Society.

(e) If a Special Survey has been completed and a new final certificate can't be issued or placed on board the craft before the expiry date of the existing certificate, the attending Surveyor authorized by the Society may endorse the existing certificate and such a certificate is to be accepted as valid for a further period which is not to exceed 6 months from the expiry date.

(f) Continuous survey

(i) At the request of the owner, and upon approval of the proposed arrangement, a system of continuous surveys for hull, machinery and cargo refrigerating machinery appliances, may be undertaken, except for hull surveys of tankers, bulk carriers and similar types of craft, where-by the Special Survey requirements are carried out in regular cycle to complete all the requirements of the particular Special Survey within a 5-year period. If the continuous survey is completed beyond the 5-year period, the completion date is to be recorded to agree with the original due date of the cycle. If the continuous survey is completed prematurely but within 3 months prior to the due date, the Special Survey is to be credited to agree with the effective due date. The continuous survey can, also be adopted respectively for the hull, the machinery including the electrical equipment and the refrigerated cargo installations.

(ii) Where some items of the machinery are opened up and examined by the recognized chief engineer as normal routine for maintenance at ports where the Surveyor is not available or at sea, the open-up inspection of the items, at the request of Owner, under certain conditions, may be dispensed with at the discretion of the Surveyor subject to a confirmatory survey at the convenient port of call where the Surveyor is available. The confirmatory survey is to be carried out within 5 months from the date of the item of the machinery which was opened up and inspected by the recognized chief engineer. If deemed necessary by the Surveyor, the individual item may be inspected again.

(iii) All items stipulated in 2.7.1 except thickness measurement are covered by a system of continuous survey for hull. The thickness measurement for the craft which adopts a system of continuous survey for hull conducted before the 4th Annual Survey cannot be credited for the Special Survey.

(g) Planned Maintenance Scheme (PMS) for machinery

(i) Application

(1) These requirements apply to an approved Planned Maintenance Scheme for Machinery (PMS) as an alternative to the Machinery Continuous Survey (MCS). (see 1.6.4(f) above)

(2) It considers surveys to be carried out on the basis of intervals between overhauls recommended by manufacturers, documented operator's experience and a condition monitoring system, where fitted.

(3) This scheme is limited to components and systems covered by MCS.

(4) Any items not covered by PMS shall be surveyed and credited in the usual way.

(ii) Maintenance intervals

In general, the intervals for PMS shall not exceed those specified for MCS. However, for components where the maintenance is based on running hours longer intervals may be accepted as long as the intervals are based on the manufacturer's recommendations.

(iii) Onboard responsibility

(1) The chief engineer shall be the responsible person on board in charge of the PMS.

(2) Documentation on overhauls of items covered by the PMS shall be reported and signed by the chief engineer.

(3) Access to computerized systems for updating of the maintenance documentation and maintenance program shall only be permitted by the chief engineer or other authorized person.

(iv) Procedures and conditions for approval of a PMS

(1) System Requirements

a) The PMS shall be programmed and maintained by a computerized system. However, this may not be applied to the current already approved schemes.

b) The system shall be approved in accordance with a procedure of the Society.

c) Computerized systems shall include back-up devices, such as disks, tapes, or CDs, which are to be updated at regular intervals.

(2) Documentation and information

The following documentation shall be submitted for the approval of the scheme:

a) organization chart identifying areas of responsibility.

b) documentation filling procedures.

c) listing of equipment to be considered by classification in PMS.

d) machinery identification procedure.

e) preventive maintenance sheet(s) for each machine to be considered.

f) listing and schedule of preventive maintenance procedures.

(3) In addition to the above documentation the following information shall be available on board:

a) all clauses in (2) above, in an up-to-date fashion.

b) maintenance instructions (manufacturer's and shipyard's).

c) reference documentation (trend investigation procedures etc.).

d) records of maintenance including repairs and renewals carried out.

(v) Approval validity

(1) When the PMS is approved, the notation **PMS** will be assigned to the craft.

(2) An implementation survey shall be carried out to confirm the validity of the notation **PMS** (see 1.6.4(g)(vi)).

(3) An annual report covering the year's service, including the information as required under the clauses 1.6.4(g)(iv)(2)c) and e) as well as the information on changes to other clauses in 1.6.4(g)(iv)(2), shall be reviewed by the Society.

(4) An Annual Audit shall be carried out to maintain the validity of the PMS (see 1.6.4(g)(vii)).

(5) The survey arrangement for machinery under PMS can be cancelled by the Society if PMS is not being satisfactorily carried out either from the maintenance records or the general condition of the machinery, or when the agreed intervals between overhauls are exceeded.

(6) The case of sale or change of management of the craft or transfer of class shall cause the approval to be reconsidered.

(7) The shipowner may, at any time, cancel the survey arrangement for machinery under PMS by informing the Society in writing and for this case the items which have been inspected under the PMS since the last annual survey can be credited for class at the discretion of the attending Surveyor.

(vi) Implementation Survey

(1) The Implementation Survey shall be carried out by the Surveyor within one year from the date of approval of the PMS.

(2) During the Implementation Survey the following shall be verified by the Surveyor to ensure:

a) the PMS is implemented according to the approval documentation and is adapted to the type and complexity of the components/system on board.

b) the PMS is producing the documentation required for the Annual Audit and the requirements of surveys and testing for retention of class are complied with.

c) the onboard personnel is familiar with the PMS.

(3) When this survey is carried out and the implementation is found in order, a report describing the PMS shall be submitted to the Society and the approved PMS may replace the MCS.

(vii) Annual Audit*

(1) An Annual Audit of the PMS shall be carried out by the Surveyor and preferably concurrently with the Annual Survey of machinery.

(2) The Surveyor shall review the annual report or verify that it has been reviewed by the Society.

(3) The purpose of this survey shall be to verify that the scheme is being correctly operated and that the machinery has been functioning satisfactorily since the previous survey. A general examination of the items concerned shall be carried out.

(4) The performance and maintenance records shall be examined to verify that the machinery has functioned satisfactorily since the previous survey or action has been taken in response to machinery operating parameters exceeding acceptable tolerances and the overhaul intervals have been maintained.

(5) Written details of break-down or malfunction shall be made available.

(6) Description of repairs carried out shall be examined. Any machinery part, which has been replaced by a spare one, due to damage, is to be retained on board, where possible, until examined by the Surveyor.

(7) Upon satisfactory completion of the above requirements, the Society shall retain the PMS.

Note: * The term audit, in this context, is not related to ISM audit.

(viii) Damage and repairs

(1) The damage of components/machinery shall be reported to the Society. The repairs of such damaged components/machinery shall be carried out to the satisfaction of the Surveyor.

(2) Any repair and corrective action regarding machinery under PMS system shall be recorded in the PMS logbook and repair verified by the Surveyor at the Annual Audit.

(3) In the case of overdue outstanding recommendations or a record of unrepaired damage which would affect the PMS the relevant items shall be kept out of the PMS until the recommendation is fulfilled or the repair is carried out.

(ix) Planned Maintenance (PM)

Owners may conduct Planned Maintenance on any item(s) of equipment. However, the following equipment cannot be enrolled into the PMS and credit will not be given towards periodic surveys.

(1) System piping (All).

(2) Valves (All).

(3) Sea chests.

(4) All operational tests.

(5) Fire pumps.

(6) Fire fighting equipment.

(7) All safety devices, trips and relief valves.

(8) Air receivers with associated relief valves and safety devices.

(9) Heat exchangers and unfired pressure vessels with design pressures over 6.9 bar and associated relief valves.

(10) Steering gear piping, pumps and control/relief valves.

(11) Steam turbines.

(x) Open-up survey

The following machinery is, in principle, to be opened and examined in the attendance of the Surveyor in accordance with the survey schedule table.

(1) Crankpins and bearings, crank-journals and bearings, and crosshead bearings for main diesel engines.

(2) Rotors, blades, casings, main bearings, couplings between turbine and reduction gear, nozzle valves and maneuvering valves for main steam turbine.

(3) Aux. steam turbine for main generator.

(4) Thrust shaft and bearings for main propulsion.

(5) Reduction gear for main propulsion.

(6) Flexible coupling for main propulsion.

(7) Other items deemed necessary by the Society.

(xi) For engine with bore 300 mm or under of the non-ocean going vessels, special consideration may be given to modify the above PMS requirements based on the manufacturer's recommendation of maintenance manual.

(h) Condition Monitoring and Condition Based Maintenance Schemes

(i) Application

(1) These requirements apply to the approved Condition Monitoring (CM) and Condition Based Maintenance (CBM) schemes where the condition monitoring results are used to influence the scope and/or frequency of Class survey.

(2) This scheme may be applied to components and systems covered by Machinery Continuous Survey (MCS), and other components and systems as requested by the owner. The extent of Condition Based Maintenance and associated monitoring equipment to be included in the maintenance scheme is decided by the Owner.

(3) These requirements can be applied only to craft operating on approved PMS survey scheme.

(4) The scheme may be applied to any individual items and systems. Any items not covered by the scheme shall be surveyed and credited in accordance with the requirements of 2.7.2 and/or 1.6.4(g) of this Part.

(ii) Definitions

The following standard terms are defined in ISO 13372:2012:

(1) Condition monitoring: acquisition and processing of information and data that indicate the state of a machine over time. The machine state deteriorates if faults or failures occur.

(2) Diagnostic: examination of symptoms and syndromes to determine the nature of faults or failures.

(3) Condition Based Maintenance: maintenance performed as governed by condition monitoring programmes.

(iii) Condition Monitoring (CM)

(1) Where an approved condition monitoring system is fitted, credit for survey may be based on acceptable condition monitoring results. The condition monitoring results are to be reviewed during the Annual Audit.

(2) Limiting parameters are to be based on the Original Equipment Manufacturers guidelines (OEM), or a recognized international standard.

(3) The condition monitoring system is to provide an equivalent or greater degree of confidence in the condition of the machinery to traditional survey techniques.

(4) The condition monitoring system shall be approved in accordance with the Society's procedures.

(5) A condition monitoring system may be used to provide a greater understanding of equipment condition, and a condition based maintenance scheme may be used to obtain maintenance efficiency. Class approval is required where owners wish to change the survey cycle based on CM/CBM.

(6) Software systems can use complex algorithms, machine learning and knowledge of global equipment populations/defect data in order to identify acceptability for continued service or the requirement for maintenance. These systems may be independent of the OEM recommended maintenance and condition monitoring suggested limits. Approval of this type of software is to be based on OEM recommendations, industry standards and experience of the Society.

(7) The Society retains the right to test or open-up the machinery, irrespective of the CM results, if deemed necessary.

(iv) Condition Based Maintenance (CBM)

(1) Where an owner wishes to base their equipment maintenance on a CBM approach, this is to meet the requirements of the ISM Code.

(2) Where an agreed planned maintenance and CBM scheme is in operation, the MCS and other survey intervals may be extended based on OEM maintenance recommendations and acceptable condition monitoring results.

(3) Limiting parameters (alarms and warnings) are to be based on the OEM guidelines, or a recognized international standard.

(4) The CBM scheme is to provide an equivalent or greater degree of confidence in the condition of the machinery to traditional maintenance techniques.

(5) The scheme shall be approved in accordance with the Society's procedures.

(6) Software systems can use complex algorithms, machine learning and knowledge of global equipment populations/defect data in order to identify acceptability for continued service or the requirement for maintenance. These systems may be independent of the OEM recommended maintenance and condition monitoring suggested limits. Approval of this type of software is to be based on OEM recommendations, industry standards and experience of the Society.

(v) Procedures and Conditions for approval of CM and CBM

(1) Onboard Responsibility

a) The chief engineer shall be the responsible person on board in charge of the CM and CBM.

b) Documentation on the overhaul of items covered by CM and CBM schemes shall be reported by the chief engineer.

c) Access to computerized systems for updating of the maintenance documentation and maintenance program shall only be permitted by the chief engineer or other authorized person.

d) All personnel involved in CM and CBM shall be appropriately qualified.

Note: CM does not replace routine surveillance or the chief engineer's responsibility for taking decisions in accordance with his judgement.

(2) Equipment and System Requirements

a) CM equipment and systems shall be approved in accordance with a procedure of the Society.

b) The CM/CBM scheme and its extent, are to be approved by the Society.

c) The CBM scheme is to be capable of producing a condition report, and maintenance recommendations.

d) A system is to be provided to identify where limiting parameters (alarms and warnings) are modified during the operation of the scheme.

e) Where CM and CBM schemes use remote monitoring and diagnosis (i.e. data is transferred from the craft and analysed remotely), the system is to meet the applicable standards for Cyber Safety and Security. The system shall be capable of continued onboard operation in the event of loss of the communication function.

f) CBM schemes are to identify defects and unexpected failures that were not prevented by the CM system.

g) Systems shall include a method of backing up data at regular intervals.

(3) Documentation and Information

a) The following documentation shall be made available to the Society for the approval of the scheme:

i) Procedure for changes to software system and CM parameters

ii) Listing of equipment to be included in the scheme

iii) Listing of acceptable condition monitoring parameters

iv) Description of CBM scheme

v) Listing, specifications and maintenance procedures for condition monitoring equipment

vi) Baseline data for equipment with condition monitoring

vii) Qualification of personnel and company responsible for analysing CM results

b) In addition to the above documentation the following information shall be available on board:

i) All clauses in a) above in an up-to-date fashion

ii) Maintenance instructions (manufacturer's and shipyard's)

iii) Condition monitoring data including all data since last opening of the machine and the original base line data

iv) Reference documentation (trend investigation procedures etc.)

v) Records of maintenance including repairs and renewals carried out

vi) Records of changes to software systems and parameters

vii) Sensors calibration records / certification / status

(4) Approval validity

a) An Annual Audit shall be carried out to maintain the validity of the CM/CBM scheme.

b) The survey arrangement for machinery under CM/CBM can be cancelled by the Society if the scheme is not being satisfactorily carried out either from the maintenance records or the general condition of the machinery.

c) The case of sale or change of management of the craft or transfer of class shall cause the approval to be reconsidered.

d) The shipowner may, at any time, cancel the survey arrangement for machinery under the scheme by informing the Society in writing and for this case the items which have been inspected under the scheme since the last Annual Audit can be credited for class at the discretion of the attending Surveyor.

(vi) Surveys

(1) Installation Survey

a) Condition monitoring equipment is to be installed and surveyed in accordance with the Rules of the Society, and a set of base line readings is to be taken.

(2) Implementation Survey

a) The Implementation Survey shall be carried out by the Society's surveyor no earlier than 6 months after installation survey and no later than the first Class Annual Survey.

b) During the Implementation Survey the following shall be verified by the Surveyor:

i) the CM/CBM scheme is implemented according to the approval documentation, including a comparison with baseline data;

ii) the scheme is producing the documentation required for the Annual Audit and the requirements of surveys and testing for the maintenance of class are complied with;

iii) the onboard personnel are familiar with operating the scheme.

iv) records of any limiting parameters (alarms and warnings) that have been modified during the operation of the scheme.

v) Records of any failures of monitored equipment are to be reviewed to ensure that the condition monitoring scheme is effective / sufficient.

c) When this survey is carried out and the implementation is found in order, a report describing the scheme shall be submitted to the Society and the scheme may be put into service.

(3) Annual Audit

a) An Annual Audit of the CM and CBM scheme shall be carried out by the Surveyor concurrently with the Class Annual Survey.

b) The purpose of this audit shall be to verify that the scheme is being correctly operated and that the machinery has been functioning satisfactorily since the previous audit. This is to include any limiting parameters (alarms and warnings) that have been modified since the last audit. A general examination of the items concerned shall be carried out.

c) The performance, condition monitoring and maintenance records shall be examined to verify that the machinery has functioned satisfactorily since the previous survey, or action has been taken in response to machinery operating parameters exceeding acceptable tolerances.

d) Written details of break-down or malfunction shall be made available.

e) At the discretion of the Surveyor, function tests, confirmatory surveys and random check readings, where Condition Monitoring / Condition Based Maintenance equipment is in use, shall be carried out as far as practicable and reasonable.

f) The familiarity of the chief engineer and other personnel involved with the CM system shall be verified.

g) Calibration status of sensors and equipment shall be verified.

h) Verification that the suitability of the CM/CBM scheme has been reviewed following defects and failures shall be carried out.

(4) Damage and repairs

a) Damage to components or items of machinery is to be reported to the Society. The repairs of such damaged components or items of machinery are to be carried out to the satisfaction of the Surveyor.

b) Details of repairs and maintenance carried out shall be examined. Any machinery part, which has been replaced by a spare one, due to damage, is to be retained on board where possible until examined by the Surveyor.

c) Defect and failure data is to be reviewed in order to ensure the system output is appropriate. Where necessary, following review of the failure data, there is to be a method of amending the CM and CBM scheme.

1.6.5 Annual Survey

(a) Annual Surveys are to be carried out within 3 months before or after each anniversary date of the date of the initial classification survey or the completion of the last Special Survey

(b) The anniversary date is to be changed if the Annual Survey is completed before the period specified in (a) of this subparagraph.

(i) The new anniversary date is to be amended by endorsement to a date which is not 3 months later than the date on which the survey was completed.

(ii) The subsequent Annual Survey is to be completed at the intervals prescribed as above using the new anniversary date.

(iii) The expiry date for a Special Survey may remain unchanged provided one or more Annual Surveys, as appropriate, are carried out so that the maximum intervals between the surveys prescribed are not exceed.

1.6.6 Intermediate Surveys

(a) Intermediate Surveys are to be carried out either at or between the 2nd or 3rd Annual Survey.

(b) Those items which are additional to the requirements of the Annual Survey may be surveyed either at or between the 2nd or 3rd Annual Survey.

1.6.7 Bottom Survey

(a) Survey intervals

(i) There is to be a minimum of 2 examinations of the outside of the craft's bottom and related items during each 5-year Special Survey period. One such examination is to be carried out in conjunction with the Special Survey. In all cases the interval between any 2 such examinations is not to exceed 36 months.

For craft operating solely in fresh water, the maximum interval is not to exceed 5 years.

(ii) An extension of examination of the craft's bottom up to 3 months beyond the due date may be granted in exceptional circumstances provided an occasional survey has been carried out satisfactorily with the survey items required by the Head Office of the Society.

(b) In-Water Survey in lieu of Bottom Survey in dry dock

(i) An approved In-Water Survey equivalent to a docking survey may be considered as an alternative to a docking survey, subject to the provisions of 2.2.2 of this Part.

(ii) An In-Water Survey not credited as a Bottom Survey of the Special Survey may be carried out with the craft afloat.

(iii) Special consideration is to be given to craft of 15 years or over before being permitted to have such inspection.

(c) Bottom Survey at Special Survey

A Bottom Survey in dry dock is to be a part of the Special Survey.

(d) For passenger craft, the bottom surveys are to be carried out at each Annual Survey and Special Survey, at least 2 Bottom Surveys to be carried out in dry dock within each 5 years period of the classification Special Survey and the maximum interval between the 2 bottom survey in dry dock is not to exceed 36 months. The In-Water Surveys may be carried out and credited as the other Bottom Survey.

1.6.8 Survey of propeller shaft and tube shaft

(a) Survey intervals

(i) Oil lubricated shafts or closed loop system fresh water lubricated shafts (closed system)

Normal survey interval is 5 years. Detailed requirements are in accordance with 2.3.2 of this Part.

(ii) Water lubricated shafts (open systems)

The survey interval of water lubricated shafts (open systems) is in accordance with 2.3.3 of this Part.

(iii) Controllable pitch propellers for main propulsion purposes are to be surveyed at the same intervals as the propeller shaft.

(iv) Directional propellers for main propulsion purposes are to be surveyed at intervals not exceeding 5 years.

(v) Waterjet units for main propulsion purposes are to be surveyed at intervals not exceeding 5 years provided the impeller shafts are made of approved corrosion resistant material or have approved equivalent arrangements.

(vi) Dynamic positioning and/or thruster-assisted mooring and athwartship thrust propellers and shaftings are to be surveyed at intervals not exceeding 5 years.

(vii) All other shafts not covered above, their normal survey interval is 3 years.

(b) Survey extensions for propeller shaft and tube shaft

An extension with specified period may be granted by the Society, when requested by the Owner, provided the extension survey is carried out to the satisfaction of the Surveyor.

(i) For oil lubricated shafts, the survey extensions are in accordance with 2.3.2(c)(ii) of this Part.

(ii) For closed loop system fresh water lubricated shafts, the survey extensions are in accordance with 2.3.2(d)(ii) of this Parts.

(iii) For water lubricated shafts (open systems), the survey extensions are in accordance with 2.3.3(c)(ii) of this Part.

If the extension survey is carried out within 1 month of the shaft survey due date then the extension will take effect from the Shaft Survey due date.

If the extension survey is carried out more than 1 month prior to the Shaft Survey due date, then the period of extension will take effect from the date on which the extension survey was completed.

1.6.9 Auxiliary Boiler Surveys and thermal oil heater surveys

(a) Survey intervals

(i) Auxiliary boilers or thermal oil heaters, waste heat steam generators/economizers having a working pressure exceeding 0.35 MPa and heating surface exceeding 4.5 m^2, a minimum of 2 surveys are to be carried out during each 5-year Special Survey period. One such survey is to be carried out in conjunction with the Special Survey. In all cases, the interval between any 2 such surveys is not to exceed 36 months. An extension of the survey up to 3 months may be granted by the Surveyor in exceptional circumstances(1), provided a survey is carried out in accordance with 2.4.1(i) of this Part.

In addition, Annual Examinations are to be carried out in accordance with 2.4.1(h) of this Part.

Note: (1) "Exceptional circumstances" means, e.g., unavailability of repair facilities, unavailability of essential materials, equipment or spare parts, or delays incurred by action taken to avoid severe weather conditions.

1.6.10 Occasional surveys

Occasional surveys are to be carried out when craft have sustained damage, undergone major repairs or alternations, or lay-up and re-commissioning.

(a) Damage, major repair or alternations

(i) The Society is to be immediately informed about any deficiencies and damages to hull and machinery or other equipment classed, where these may be of relevance to the craft's class. An occasional survey is to be arranged for a date not later than that craft's arrival at the next port. A craft may be temporarily repaired and retained her class if the Surveyor deems so and reports to the Society that the craft has been repaired to such a degree as being considered in a technical fitness condition for the intended voyage. In such cases a permanent repair and survey are to be duly carried out. If the survey reveals that a craft's class has been affected, the class is to be maintained only on condition that the repairs or modifications demanded by the Society are to be carried out within the period specified by the Surveyor. Until full settlement of recommendations the class is to be restricted.

(ii) In the case of alterations, plans are to be approved before the work is commenced.

(iii) If any part of the main or auxiliary machinery including boilers, or insulation or fittings, is removed for repair or alteration, the exposed part of the structure normally not accessible is to be specially examined.

(iv) In exceptional cases, the inspection of hull and machinery, and the performance of the repairs required for maintenance of the original class may be dispensed with, if the Owner agree to the class and/or the range of service being restricted, or possibly a higher freeboard being assigned.

(b) Lay-up and re-commissioning

(i) The Society is to be notified by the Owner that a craft has been laid up. Craft intended to be laid up are to comply with the requirements of "Guidelines for Lay-up of Ship" of the Society. This status is to be noted in the Register, and surveys falling due during lay-up may then be held in abeyance until the craft re-commissions. Lay-up procedures and arrangements for maintenance of conditions during lay-up may be submitted to the Society for review and verified on board by the Surveyor.

(ii) In the case of craft which have been laid up for an extended period (i.e. six months or more) the requirements for surveys on re-commissioning are to be specially considered in each case, due regard being given to the status of surveys at the time of the commencement of the lay-up period, the length of the period and the conditions under which the craft has been maintained during that period.

(iii) Where the lay-up preparations and procedures have been submitted to the Society for review and verified by annual lay-up surveys, consideration may be given to deducting part of or all of the time in lay-up from the progression of survey intervals.

(iv) For craft returning to active service regardless of whether the Society has been informed previously that the craft has been laid up, a re-commissioning survey is required.

1.6.11 Miscellaneous items

(a) If the recommendations of the Surveyor are considered in any case to be unnecessary or unreasonable, appeal may be made to the Society, who may direct a special examination to be held.

(b) It is the responsibility of the Owner to ensure that all surveys necessary for the maintenance of class are carried out at the proper time under the supervision of the Surveyor. It is, however, the normal practice of the Society to give timely notice to Owners when surveys become due, but the non-receipt of such notice, or of notice regarding other surveys, does not absolve Owners from their responsibility.

(c) Period of class

The craft's hull and machinery are always assigned the same period of validity of class (duration of one class period). The class continues to be valid, provided that the hull and machinery are subjected to all surveys stipulated and that any repairs required are carried out to the satisfaction of the Society.

(d) If the hull and/or the machinery are not subjected to the prescribed surveys on their due dates, a craft's class is to be suspended for both hull and machinery. If special shipboard equipment classed is not subject to the prescribed surveys on their due dates, the class of the special equipment only is to be suspended (i.e. Aux. boiler, CAS, CAB or CAU, or RMS).

1.7 Approval

1.7.1 Survey reports

Upon completion of a survey of a classed craft, the Surveyor is to send one original and one copy of his reports with his recommendations, if set up, to the applicant, and at the same time, one copy to the Society. The Society reserves the right for final decision on the Surveyor's recommendations.

1.7.2 Decision of classification

Any member of the Committee or the staff of the Society having either direct or indirect interest in a craft to be classed, is not permitted to be present at or to participate in the meeting for the decision of the classification.

1.8 Certificates of Classification

1.8.1 Final Certificate of Classification

When the required reports and Interim Certificates on completion of the classification initial survey during construction of new craft, or the classification survey of craft not built under survey have been submitted for classification and approved by the Classification Committee, final Certificates of Classification signed by the Chairman, the President and the Chief Surveyor will be issued to the builders or owners.

1.8.2 Interim Certificates of Classification

(a) Upon completion of a classification entry survey, when the craft in the Surveyor's opinion, is considered to be in a fit and efficient condition and eligible to be classed, the Surveyor is permitted to issued an Interim Certificate of Classification stating that he has recommended to the Classification Committee that the craft is in a fit and efficient condition and eligible to be classed.

(b) The validity of Interim Certificates is limited to 6 months.

1.9 Notice of Surveys

1.9.1 It is the responsibility of the Owners to ensure that all surveys necessary for the maintenance of class are carried out at the proper time and in accordance with the instruction of the Society.

1.9.2 The Society will give timely notice to an Owner about forthcoming surveys by means of a letter or e-mail. The omission of such notice, however, does not absolve the Owner from his responsibility to comply with CR's survey requirements for maintenance of class.

1.10 Suspension and Withdrawal of Class

1.10.1 In any of the following cases, the class of a craft is liable to be withheld or if already granted, may be withdrawn or expunged from the Register:

(a) The wording, symbols or marks on the certificate is altered, defaced or obliterated.

(b) Any damage or casualty is done to the hull or machinery to such an extent as affecting her class in the Register and the damage so sustained has been un-repaired or not been repaired to the satisfaction of the Society.

(c) The structure or arrangement of the hull, equipment and machinery have been altered without approval of the Society.

(d) The loading of the craft exceeds the load line assigned by the Society or the freeboard marks have been placed higher on the craft's sides than the positions assigned by the Society.

(e) The applicant fails to pay any survey fees or expenses.

(f) The applicant fails to fulfill the Society's requirements.

(g) The Owner so request.

(h) If the Annual Survey or Intermediate Survey is not complete within 3 months of the due date of the survey.

1.10.2 Class suspension and cancellation

(a) Class will be suspended automatically in the following condition.

(i) If a class periodical survey, MCS survey or HCS survey is over-due.

(ii) If any outstanding recommendation is over-due.

(iii) If other required survey in the Rules is over-due. However, over-due of required survey of environmental protection notation as listed in Table I 1-10 will not cause the suspension of class.

Class will be reinstated automatically from the date of satisfactory completion of the over-due surveys or the over-due recommendations.

(b) If the Owners failed to apply for a survey on any casualty, damage, operational failure or any repair upon the first opportunity, class may be suspended until the date before the repair survey is completed satisfactorily.

(c) Class Maintenance Certificate is not to be issued during the period of class suspension and before the required survey is completed satisfactorily.

(d) Class suspended for over 3 months may result in cancellation of class.

1.10.3 Change of periodicity, postponement or advance of surveys.

(a) This Society reserves the right, after due consideration, to change the periodicity, postponement or advance of surveys, taking into account particular circumstances.

(b) When a survey becomes overdue during a voyage, the following applies:

(i) In the case of a class Special Survey becomes overdue during a voyage, the Society may grant an extension to allow for completion of the class Special Survey, provided there is documented agreement to such an extension prior to the expiry date of the Certificate of Classification, adequate arrangements have been made for attendance of the Surveyor at the first port of call and the Society is satisfied that there is technical justification for such an extension. Such an extension will be granted only until arrival at the first port of call after the expiry date of the Certificate of Classification.

However if owing to "exceptional circumstances" as defined below, the class Special Survey cannot be completed at the first port of call, the Society may grant an extension according to 1.6.4(d), but the total period of extension shall in no case be longer than 3 months after the original due date of the class Special Survey.

"Exceptional circumstances" means:

(1) unavailability of dry-docking facilities, or

(2) unavailability of repair facilities, or

(3) unavailability of essential materials, equipment or spare parts, or

(4) delays incurred by action taken to avoid severe weather conditions.

(ii) In the case of Annual and Intermediate Surveys, no postponement is granted. Such surveys are to be completed within their prescribed windows;

(iii) In the case of all other periodical surveys and recommendations, extension of class may be granted until the arrival of the craft at the first port of call.

1.10.4 Alternative Procedures for Certain Types of Craft

Alternatives to procedures specified in 1.10.2(a) above for automatic suspension of class and procedures specified in 1.10.2(d) above for cancellation of class may be applied to governmental craft, commercial craft owned or chartered by governments which are utilized in support of governmental operations or service, and laid-up craft.

1.11 Reclassification

1.11.1 When reclassification is desired for a craft for which the class previously assigned has been withdrawn, the Society is to direct a reclassification survey, appropriate to the age of the craft and the circumstances of the case, to be carried out by the Surveyor. If at such a survey, the craft is found or placed in a good and efficient condition in accordance with the requirements of the Rules, the Society is prepared to reinstate her original class as may be deemed necessary. The date of reclassification is to be recorded in the Register.

1.12 Survey Fees and Expenses

1.12.1 Survey fees are to be chargeable and expenses to be reimbursed if incurred according to the "Scale of Survey Fees" of the Society. All fees and expenses are to be promptly paid by the Owner or the applicant or their representatives after completion of each survey. In default of such payment, the Society may withhold the issuance of the certificates or reports. If the class is already granted, the same may be withdrawn or expunged from the Register.

1.13 International Conventions and Codes

Where authorized by the Administration of a country signatory thereto and upon request of the Owners of a classed craft or one intended to be classed, the Society will survey a new or existing craft of the applicable size for compliance with the provisions of applicable International Conventions or Codes and certify thereto in the manner prescribed in the Convention and Code.

1.14 Governmental Regulations

Where authorized by a government agency and/or upon request of the Owners of a classed craft or one intended to be classed, the Society will survey and certify a new or existing craft for compliance with particular regulations of that government on their behalf.

All work performed on behalf of governments shall be governed by the terms and conditions of the Rules, unless the government specifies otherwise.

Owners of a classed craft are required to notify the Society when a craft changes flag so that appropriate action can be determined with respect to the scope of CR's authorization by the new flag Administration.

1.15 Sea Trials

1.15.1 In the classification survey of all craft, sea trials specified in following (a) to (j) are to be carried out in full load condition, in the calmest possible sea and weather condition and at the deep unrestricted water. However, where sea trials cannot be carried out in full load condition, sea trials may be carried out in an appropriate loaded condition. The noise measurements specified in (k) are to be carried out at either the full load condition or the ballast condition.

(a) Speed test.

(b) Astern test.

(c) Steering test and the change-over test from the main to auxiliary steering gear.

(d) Turning test.

(e) Confirmation of no abnormality for the operating condition of machinery and behaviors of the craft during the trials.

(f) Performance test of windlass.

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

(h) The accumulation test of boilers.

(i) Measurement of the torsional vibration for the shafting systems. (refer to Part IV Chapter 6 of the Rules of Steel Ships)

Where it is to be deemed as appropriate by the Society, the measurement of the torsional vibration for the shafting systems during the sea trials may be dispensed with, provided that sufficient analysis data (eg. torsional vibration analysis), that ensure there is no critical vibration within the service speed range.

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

(k) Noise measurements. (If applicable, refer to Part II Chapter 34 of the Rules of Steel Ships)

(l) Other tests where deemed necessary by the Society.

Some sea trial tests of an individual craft may be dispensed with provided that the available data can be obtained from those of a sister ship or other adequate means and a special approval in given by the Society.

1.15.2 The results of the tests are to be submitted to the Society as sea trial record.

1.15.3 In the case of classification survey of the craft not built under the Society's survey, the above tests may be dispensed with, provided that sufficient data on the previous tests are available and no alteration affecting the tests specified above have been made after the previous tests.

1.16 Stability Experiment

1.16.1 In the classification survey, Stability Experiments by inclining test of a craft are to be carried out upon completion of the craft (See Appendix 2). A stability information booklet, which is to be prepared on the basis of the particulars of stability determined by the results of stability experimental and to be approved by the Society, is to be provided on board. The intact stability criteria specified in Part III Chapter 3 of the Rules shall be as a minimum requirement.

1.16.2 Inclining test may be dispensed with, provided that:

(a) The craft's basic stability data is available from inclining test of a sister ship, if a weight survey is carried out upon completion, and in comparison with the data derived from the sister ship, the deviation from the lightship displacement is not exceeding 1% for craft of 160 m or more in length, and 2% for craft of 50 m or less in length and as determined by linear interpolation for intermediate lengths, and a deviation from lightship LCG not exceeding 0.5 % of subdivision length (Ls); or

(b) The craft is especially designed for the carriage of liquid or ore in bulk, when reference to existing data for similar craft clearly indicates that due to the craft's proportions and arrangements, more sufficient GM will be available in all probable loading cases.

1.16.3 Where any alteration are made to a craft so as to materially affect the stability information, amended and approved stability information shall be provided. The craft shall be re-inclined if anticipated deviations exceed one of the values specified in next paragraph.

1.16.4 At periodical intervals not exceeding 5 years, a lightweight survey shall be carried out on all passenger ships to verify any changes in lightweight displacement and LCG. The craft shall be re-inclined whenever, in comparison with the approved stability information, a deviation from the lightship displacement exceeding 2% or a deviation of LCG exceeding 1% of Ls is found or anticipated.

1.17 Liability and Compensation

1.17.1 Article 1

(a) CR CLASSIFICATION SOCIETY is a Society (the "Society") whose purpose is the classification («Classification») of any craft or structure of any type or part of it or system therein collectively hereinafter referred to as a "Unit" whether linked to shore, river bed or sea bed or not, whether operated or located at sea or in inland waters or partly on land, including submarines, hovership, drilling rigs, offshore installations of any type and of any purpose, their related and ancillary equipment, subsea or not, such as well head and pipelines, mooring legs and mooring points or otherwise as decided by the Society.

The Society:

(i) prepares and publishes Rules for classification, Guidance Notes and other documents (« Rules »);

(ii) issues Certificates, Attestations and Reports following its interventions (« Certificates »);

(iii) publishes Registers on the CR Website.

(b) The Society also participates in the application of National and International Regulations or Standards, in particular by delegation from different Governments. Those activities are hereafter collectively referred to as « Certification ».

(c) The Society can also provide services related to Classification and Certification such as craft and company safety management certification; craft and port security certification, training activities; all activities and duties incidental thereto such as documentation on any supporting means, software, instrumentation, measurements, tests and trials on board.

(d) The Society can also provide services in independent surveys, such as independent survey of a craft, materials and equipment, or other equipment carried out according to the Purchase Agreement or specified rules; or appraisal before purchase of a non-CR class craft or verification of seaworthiness of a craft conducted at the request of the owner; or damage survey of a non-CR class craft as required by an insurance company.

(e) The interventions mentioned in (a), (b) and (c) are referred to as « Services ». The party and/or its representative requesting the services is hereinafter referred to as the « Client ». The Services are prepared and carried out on the assumption that the Clients are aware of the International Maritime and/or Offshore Industry (the "Industry") practices.

(f) The Society is neither and may not be considered as an Underwriter, Broker in ship's sale or chartering, Expert in Unit's valuation, Consulting Engineer, Controller, Naval Architect, Manufacturer, Shipbuilder, Repair yard, Charterer or Shipowner, who are not relieved of any of their expressed or implied obligations by the interventions of the Society.

1.17.2 Article 2

(a) Classification is the appraisement given by the Society for its Client, at a certain date, following surveys by its Surveyors along the lines specified in 1.17.3 and 1.17.4 hereafter on the level of compliance of a Unit to its Rules or part of them. This appraisement is represented by a class entered on the Certificates and periodically transcribed in the Society's Register.

(b) Certification is carried out by the Society along the same lines as set out in 1.17.3 and 1.17.4 hereafter and with reference to the applicable National and International Regulations or Standards.

(c) It is incumbent upon the Client to maintain the condition of the Unit after surveys, to present the Unit for surveys and to inform the Society without delay of circumstances which may affect the given appraisement or cause to modify its scope.

(d) The Client is to give to the Society all access and information necessary for the performance of the requested services.

1.17.3 Article 3

(a) The Rules, procedures and instructions of the Society take into account, at the date of their preparation, the state of currently available and proven technical knowledge of the Industry. They are not a code of construction neither a guide for maintenance or a safety handbook. Committees consisting of personalities from the Industry contribute to the development of those documents.

(b) The Society only is qualified to apply its Rules and to interpret them. Any reference to them has no effect unless it involves the Society's intervention.

(c) The Services of the Society are carried out by professional Surveyors according to the Code of Ethics of CR CLASSIFICATION SOCIETY.

(d) The operations of the Society in providing its Services are exclusively conducted by way of random inspections and do not in any circumstances involve monitoring or exhaustive verification.

1.17.4 Article 4

The Society, acting by reference to its Rules:

(a) Reviews the construction arrangements of the Units as shown on the documents presented by the Client;

(b) Conducts surveys at the place of their construction;

(c) Classes Units and enters their class in its Register;

(d) Surveys periodically the Units in service to note that the requirements for the maintenance of class are met. The Client is to inform the Society without delay of circumstances which may cause the date or the extent of the surveys to be changed.

1.17.5 Article 5

(a) The Society acts as a provider of services. This cannot be construed as an obligation bearing on the Society to obtain a result or as a warranty.

(b) The certificates issued by the Society pursuant to 1.17.5(a) here above are a statement on the level of compliance of the Unit to its Rules or to the documents of reference for the Services provided for. In particular, the Society does not engage in any work relating to the design, building, production or repair checks, neither in the operation of the Units or in their trade, neither in any advisory services, and cannot be held liable on those accounts. Its certificates cannot be construed as an implied or express warranty of safety, fitness for the purpose, seaworthiness of the Unit or of its value for sale, insurance or chartering.

(c) The Society does not declare the acceptance or commissioning of a Unit, nor of its construction in conformity with its design, that being the exclusive responsibility of its owner or builder, respectively.

(d) The Services of the Society cannot create any obligation bearing on the Society or constitute any warranty of proper operation, beyond any representation set forth in the Rules, of any Unit, equipment or machinery, computer software of any sort or other comparable concepts that has been subject to any survey by the Society.

1.17.6 Article 6

(a) The Society accepts no responsibility for the use of information related to its Services which was not provided for the purpose by the Society or with its assistance.

(b) If the Services of the Society cause the Client a damage which is proved to be the direct and reasonably foreseeable consequence of an error or omission of the Society, its liability towards the Client is limited to two times the amount of fee paid for the Service having caused the damage, but no greater than ten million (NT$10,000,000) New Taiwan dollars. The Society bears no liability for indirect or consequential loss such as e.g. loss of revenue, loss of profit, loss of production, loss relative to other contracts and indemnities for termination of other agreements.

(c) All claims are to be presented to the Society in writing within 3 months of the date when the Services were supplied or (if later) the date when the events which are relied on of were first known to the Client, and any claim which is not so presented shall be deemed waived and absolutely barred.

1.17.7 Article 7

(a) Requests for Services are to be in writing.

(b) Either the Client or the Society has rights to terminate the requested Services after giving the other party thirty days' written notice, for convenience, and without prejudice to the provisions in 1.17.8 hereunder.

(c) The class granted to the concerned Units and the previously issued certificates remain valid until the date of effect of the notice issued according to 1.17.7(b) hereabove subject to compliance with 1.17.2(c) hereabove and 1.17.8 hereunder.

1.17.8 Article 8

(a) The Services of the Society, whether completed or not, involve the payment of fee upon receipt of the invoice and the reimbursement of the expenses incurred.

(b) Overdue amounts are increased as of right by interest in accordance with the applicable legislation.

(c) The class of a Units may be suspended in the event of non-payment of fee after a first unfruitful notification to pay.

1.17.9 Article 9

The documents and data provided to or prepared by the Society for its Services, and the information available to the Society, are treated as confidential. However:

(a) Clients have access to the data they have provided to the Society and, during the period of classification of the Units for them, to the classification file consisting of survey reports and certificates which have been prepared at any time by the Society for the classification of the Units;

(b) Copy of the documents made available for the classification of the Units and of available survey reports can be handed over to another Classification Society in case of the Unit's transfer of class;

(c) The certificates, documents and information relative to the Units classed with the Society may be reviewed and disclosed upon order of the concerned governmental or inter-governmental authorities or of a Court having jurisdiction. The documents and data are subject to a file management plan.

1.17.10 Article 10

Any delay or shortcoming in the performance of its Services by the Society arising from an event not reasonably foreseeable by or beyond the control of the Society shall be deemed not to be a breach of contract.

1.17.11 Article 11

(a) In case of diverging opinions during surveys between the Client and the Society's Surveyor, the Society may designate another of its Surveyors at the request of the Client.

(b) Disagreements of a technical nature between the Client and the Society can be submitted by the Society to the advice of its Head Office.

1.17.12 Article 12

(a) Disputes over the Services carried out by delegation of Governments are assessed within the framework of the applicable agreements with the States, international Conventions and national rules.

(b) Disputes arising out of the payment of the Society's invoices by the Client are submitted to Taiwan Taipei District Court.

(c) Other disputes over the present Article 1.17 or over the Services of the Society are exclusively submitted to arbitration, by 3 arbitrators, in Taipei according to the Arbitration Act or any statutory modification or re-enactment thereof. The contract between the Society and the Client shall be governed by the Republic of China (Taiwan) law.

1.17.13 Article 13

(a) The Article 1.17 constitutes the sole contractual obligations binding together the Society and the Client, to the exclusion of all other representation, statements, terms, conditions whether express or implied. They may be varied in writing by mutual agreement.

(b) The invalidity of one or more stipulations of the present Article 1.17 does not affect the validity of the remaining provisions.

(c) The definitions herein take precedence over any definitions serving the same purpose which may appear in other documents issued by the Society.

Table I 1-3
List of Automation Symbol affixed to CMS

Symbol	Description	Reference
CAS	This symbol will be assigned when a craft's machinery installation complies with the requirements for automatic or remote control and monitoring system.	Part IV Chapter 5 of the Rules
CAU	This symbol will be assigned when a craft's machinery installation complies with the requirements for automatic or remote control and monitoring system with unattended machinery spaces.	Part IV Chapter 5 of the Rules
CAB	This symbol will be assigned when a craft is capable of operating as **CAU** but because of their compact propulsion machinery space design are not fitted with the means to control the propulsion and its associated machinery from a centralized location within the propulsion machinery space.	Part IV Chapter 5 of the Rules

Table I 1-4
List of Ship Type Notation

Notation	Description	Reference
Passenger Ship	For ship which carry more than 12 passengers.	The Rules

Note:

(1) For craft deemed necessary by the Society, an appropriate notation except specified above may be affixed to classification character.

Table I 1-5
List of Additional Service Notation

Notation	Description	Reference
HSC-PA or HSC-PB	This notation will be assigned to the craft meeting the Rules and the requirements of category A (up to 450 passengers) or B (over 450 passengers) of International Code of Safety for High-Speed Craft (hereinafter referred to as HSC Code).	The Rules and HSC Code
HSC-C	This notation will be assigned to the cargo craft meeting the Rules and the requirements of cargo craft category of HSC Code.	The Rules and HSC Code
LSC	This notation (**L**ight **S**tructure **C**raft) will be assigned to craft not engaged in international voyages which are capable of maximum speed $2.36 \leq V/\sqrt{L}$ and not to proceed in the course of their voyage more than the time as specified in 1.3.4 of HSC Code.	The Rules and HSC Code, as applicable.
PSPC	This notation (**P**erformance **S**tandard for **P**rotective **C**oating) will be assigned to any craft where the applicable requirements in 23.1.4 of Part II of the Rules for Steel Ships are complied with.	Part II 23.1.4 of the Rules for Steel Ships
NR	This notation (the comfort **R**ating of **N**oise) will be assigned to craft where the applicable requirements in Chapter 34 of Part II of the Rules for Steel Ships are complied with.	Part II Chapter 34 of the Rules for Steel Ships
VR	This notation will be assigned to craft which comply with the limits for vibration of ISO 20283-5:2016, as given in Table II 34-2 of the Rules for Steel Ships	Part II Chapter 34 of the Rules for Steel Ships

Table I 1-6
List of Service Restriction Notation

Notation	Description	Reference
Coastal Service	Service along a coast, the geographical limits of which will be indicated in the Register, and for a distance out to sea generally not exceeding 30 nautical miles, unless some other distance is specified for 'Coastal Service' by the Administration with which the craft is registered, or by the Administration of the coast off which it is operating, as applicable. The operation/service limitations, such as significant wave height, or maximum voyage etc., may be indicated in the bracket affixed after this notation.	
Greater Coastal Service	Service along a coast, the geographical limits of which will be indicated in the Register, and for a distance out to sea generally farther than the area of **Coastal Service** in domestic voyage. The operation/service limitations, such as significant wave height, or maximum voyage etc., may be indicated in the bracket affixed after this notation.	
Protected Waters Service	Service in sheltered water adjacent to sand banks, reefs, breakwaters or other coastal features, and in sheltered waters between islands.	
Specified Operating Area Service	Service within one or more geographical area(s) which will be indicated in the Register.	
Specified Route Service	Service between two or more ports or other geographical features which will be indicated in the Register.	

Table I 1-7
List of Additional Survey Notation

Notation	Description	Reference
IWS	This notation (**I**n **W**ater **S**urvey) will be assigned to craft which are suitable for In-Water Survey in lieu of bottom survey in dry dock.	Part I/1.6.7(b) & 2.2.2 of the Rules
PCM(1)	This notation (**P**ropeller shaft **C**ondition **M**onitoring) will be assigned when oil lubricated propeller shaft arrangements with approved oil glands are fitted and the requirements of 2.3.4 of Part I of the Rules are complied with.	Part I/2.3.4 of the Rules
PMS(1)	This notation (**P**lanned **M**aintenance **S**cheme for machinery) will be assigned to craft for which an approved planned maintenance scheme for machinery is adopted as an alternative to continuous survey for machinery.	Part I /1.6.4(g) of the Rules

Note:
(1) Means notation, when assigned, to be added after the classification symbol **CMS**.

Table I 1-8
List of Special Equipment Notation

Notation	Description	Reference
Helideck-N	This notation(**Heli**copter **deck**), with N being **I**, **II, III** or **IV**, will be assigned to craft provided with helicopter facilities in accordance with related requirements of the Rules for Steel Ships.	Part II Chapter 12A of the Rules for Steel Ships
HHA	This notation (**H**igh **H**olding **A**nchor) will be assigned to craft receiving the equipment symbol **E,** with a specially considered and approved anchor that have at least 2 times the holding power of ordinary stockless anchors of the same weight. The mass of each bower anchor can be reduced up to 25% of the mass specified in Part III 5.1.4(a), (see Table III 5-1.), of the Rules.	Part III/ 5.1.4(a) of the Rules and Part XI Chapter 12 of the Rules for Steel Ships
SHHA	This notation (**Super H**igh **H**olding **A**nchor) will be assigned to craft receiving the equipment symbol **E,** with a specially considered and approved anchor that have at least 4 times the holding power of ordinary stockless anchors of the same weight. The mass of each bower anchor can be reduced by up to 50% of the mass specified in Part III 5.1.4(a), (see Table III 5-1), of the Rules.	Part III/ 5.1.4(a) of the Rules and Part XI Chapter 12 of the Rules for Steel Ships

Table I 1-9
List of Navigation Safety Notation

Notation	Description	Reference
NAV(1)	This notation will be assigned to craft when the requirements of navigation safety system in Chapters 2 and 3 of Part XIII of the Rules for Steel Ships are complied with.	Part XIII of the Rules for Steel Ships
NAV0(1)	This notation will be assigned to craft when the requirements of navigation safety system in Chapters 2 ~ 9 and 10 of Part XIII of the Rules for Steel Ships are complied with.	Part XIII of the Rules for Steel Ships
NAV1(1)	This notation will be assigned to craft when the requirements of navigation safety system in Chapters 2 ~ 10 of Part XIII of the Rules for Steel Ships are complied with.	Part XIII of the Rules for Steel Ships

Note:
(1) It means notation, when assigned, to be added after the classification symbol **CMS**.

Table I 1-10
List of Environmental Protection Notation

Notation	Description	Reference
POT	This notation (**P**rotection of Fuel and Lubricating **O**il **T**anks) will be assigned to craft having an aggregate fuel oil capacity of 600 m^3 and above with fuel oil and lubricating oil tanks arranged in accordance with the requirement specified in 6.5.3 of Part VI of the Rules for Steel Ships.	Part VI/6.5.3 of the Rules for Steel Ships
PP	This notation (**P**ollution **P**revention) will be assigned to craft where the applicable requirements in Chapter 32 of Part II of the Rules for Steel Ships are complied with.	Part II Chapter 32 of the Rules for Steel Ships
BWM	This notation (**B**allast **W**ater **M**anagement) will be assigned to craft where the applicable requirements in Chapter 32 of Part II of the Rules for Steel Ships are complied with.	Part II Chapter 32 of the Rules for Steel Ships
EEDI	This notation (**E**nergy **E**fficiency **D**esign **I**ndex) will be assigned to craft where the applicable requirements in Chapter 32 of Part II of the Rules for Steel Ships are complied with.	Part II Chapter 32 of the Rules for Steel Ships
SEEMP	This notation (**Ship E**nergy **E**fficiency **M**anagement **P**lan) will be assigned to craft where the applicable requirements in Chapter 32 of Part II of the Rules for Steel Ships are complied with.	Part II Chapter 32 of the Rules for Steel Ships
SRE	This notation (**Ship Re**cycling) will be assigned to craft where the applicable requirements in Chapter 31 of Part II of the Rules for Steel Ships are complied with.	Part II Chapter 31 of the Rules for Steel Ships
SRE-EU	This notation **SRE-EU** will be assigned to craft where the applicable requirements in Chapter 31 of Part II of the Rules for Steel Ships are complied with.	Part II Chapter 31 of the Rules for Steel Ships
SCR(1)	This notation will be assigned to craft where the applicable requirements in the Guidelines for **S**elective **C**atalytic **R**eduction Systems are complied with.	Part IV/ 3.7.3(i) of the Rules for Steel Ships
SO_X Scrubber(1)	This notation will be assigned to craft where the applicable requirements in the Guidelines for **SOx Scrubber** Systems are complied with.	Part IV/ 3.7.3(i) of the Rules for Steel Ships
SO_X Scrubber Ready-N(1)	This notation, with **N** being **I**, **II** or **III**, will be assigned to craft where the applicable requirements in the Guidelines for SO_X Scrubber Systems are complied with.	Guidelines for SO_X Scrubber Systems
EGR(1)	This notation will be assigned to craft where the applicable requirements in the Guidelines for **E**xhaust **G**as **R**ecirculation Systems are complied with.	Part IV/ 3.7.3(i) of the Rules for Steel Ships

Note:
(1) It means notation, when assigned, to be added after the classification symbol **CMS**.

Chapter 2

Survey Requirements of Craft

2.1 General

2.1.1 General

(a) The Surveyor is to have free access at any time in order to examine a classed craft and to make sure of her good condition.

(b) When a survey becomes due or any damage or alterations which may affect the technical fitness or the class to the hull or machinery of the craft occurred, the owner or his representative is to apply in time for a survey to be made without waiting for notice from the Society. (See 1.6.10(a) and 1.6.11(b))

(c) In the case of any disagreement or dispute between the owner and the Surveyor or other officers regarding the inspection, examination and survey work, an appeal in writing for re-survey or explanation may be made to the Society.

(d) Though the survey of a certain part of the craft being surveyed is not included in this Chapter, the Surveyor may, if deemed necessary, make an additional survey of such a part. The Head Office of the Society also reserve the rights to perform an occasional survey whenever reasonable necessity exists.

(e) Modification of requirements

(i) At the periodical surveys, the Surveyor may modify the requirements for periodical surveys specified in this Chapter having regard to the size, service engaged, age, construction, results of last surveys and actual condition of the craft.

(ii) For spaces where effective coatings are found to be in a Good condition, the extent of internal examination or gauging requirements specified in this Chapter may be specially considered at the discretion of the Surveyor.

(f) The survey requirements to maintain a Class Notation for an additional system or service are as contained in Chapter 3 of the Rules for Steel Ships, if any.

2.1.2 Definitions

(a) Ballast Tank

(i) Ballast Tank - All Vessels

A Ballast Tank is a tank which is used primarily for the carriage of salt water ballast.

(b) Spaces

Spaces are separate compartments including holds, tanks, cofferdams and void spaces bounding cargo holds, decks and the outer hull.

(c) Overall Survey

An Overall Survey is a survey intended to report on the overall condition of the hull structure and determine the extent of additional close-up surveys.

(d) Transverse Section

A Transverse Section includes all longitudinal members such as plating, longitudinals and girders at the deck, sides, bottom, inner bottom, longitudinal bulkhead and wing tanks. For transversely framed vessels, a transverse section includes adjacent frames and their end connections in way of transverse sections.

(e) Representative Tanks/Spaces

Representative Tanks/Spaces are those which are expected to reflect the condition of other tanks/spaces of similar type and service and with similar corrosion prevention systems. When selecting Representative Tanks/Spaces account is to be taken of the service and repair history on board and identifiable Critical Structural Areas and/or Suspect Areas

(f) Suspect Areas

Suspect Areas are locations showing Substantial Corrosion and/or are considered by the Surveyor to be prone to rapid wastage.

(g) Critical Structural Area

Critical Structural Areas are locations which have been identified from calculations to require monitoring or from the service history of the subject craft or from similar or sister ship (if available) to be sensitive to cracking, buckling or corrosion which would impair the structural integrity of the craft.

(h) Renewal Thickness

Renewal thickness (t_{ren}) is the minimum allowable thickness, in mm, below which renewal of structural members is to be carried out.

(i) Substantial Corrosion

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

(j) Corrosion Prevention System

A Corrosion Prevention System is normally considered as a full hard coating.
Hard Protective Coating is usually to be epoxy coatings or equivalent.
Other coating systems, which are neither soft nor semi-hard coatings, may be considered acceptable as alternatives, provided that they are applied and matained in compliance with the manufacturers' specification.

(k) Coating Condition

Coating condition is defined as follows:

(i) GOOD is a condition with only minor spot rusting.

(ii) FAIR is a condition with local breakdown at edges of stiffeners and weld connections and/or light rusting over 20% or more of areas under consideration, but less than as defined for POOR condition.

(iii) POOR is a condition with general breakdown of coating over 20% or more of areas, or hard scale at 10% or more of areas under consideration.

(l) Prompt and Thorough Repair

A Prompt and Thorough repair is a permanent repair completed at the time of the survey to the satisfaction of the Surveyor, therein removing the need for the imposition of any associated condition of classification or recommendation.

(m) Special consideration

Special consideration or specially considered (in connection with close-up surveys and thickness measurements) means sufficient close-up inspection and thickness measurements are to be taken to confirm the actual average condition of the structure under the coating.

(n) Air pipe head

Air pipe heads installed on the exposed decks are those extending above the freeboard deck or superstructure decks.

(o) General Dry Cargo Ship

"General dry cargo ship" are ship carrying solid cargoes other than: (see Note:)

(i) bulk carriers (Double Skin or Non-Double Skin, subject to ESP);

(ii) dedicated container carriers;

(iii) dedicated forest product carriers (not timber or log carriers);

(iv) ro-ro cargo ship;

(v) refrigerated cargo ship;

(vi) dedicated wood chip carriers;

(vii) dedicated cement carriers;

(viii) livestock carriers;

(ix) deck cargo ship (A deck cargo ship is a ship that is designed to carry cargo exclusively above deck without any access for cargo below deck); and

(x) general dry cargo ship of double side-skin construction , with double side-skin extending for the entire length of the cargo area, and for the entire height of the cargo hold to the upper deck.

Note: At Annual Survey and Special Survey, an examination and a test to the water ingress detection system and their alarms also apply to those cargo ship, which, although belonging to the ship types listed herein that are excluded from the application of IACS UR, are fitted with a single cargo hold.

(p) Cargo Length Area (all craft)

Cargo Length Area is that part of the craft that contains cargo holds and adjacent areas including cofferdams, ballast tanks, fuel tanks and void spaces.

(q) Wind and Water Strakes

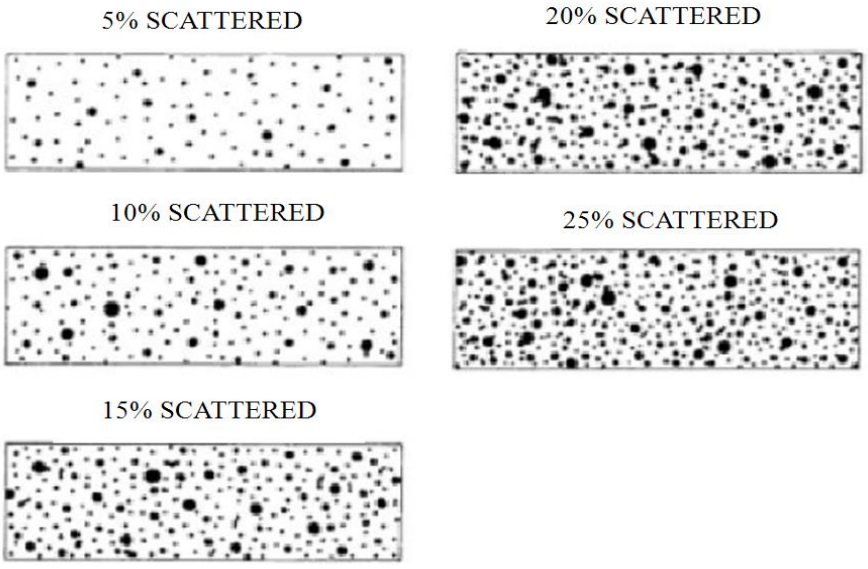
Wind and water strakes are the strakes of a craft's side shell plating between the ballast and deepest load waterline.

(r) Oil

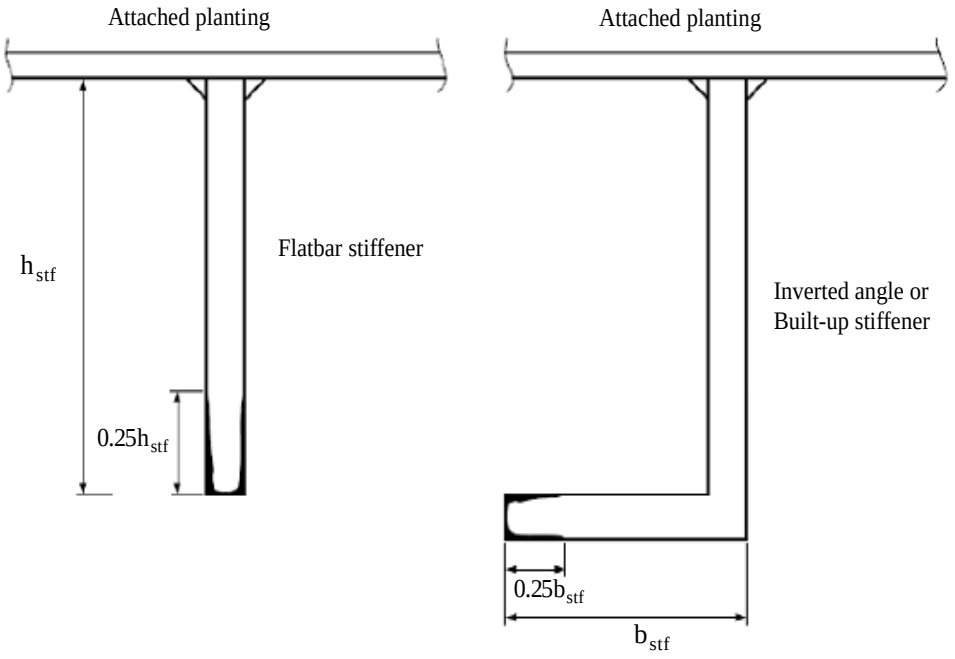
Oil is petroleum in any form including crude oil, fuel oil, sludge, oil refuse, and refined products others than petrochemicals which are subject to the provisions of Annex II of the MARPOL 73/78.

(s) Pitting Corrosion , Edge corrosion and Grooving corrosion

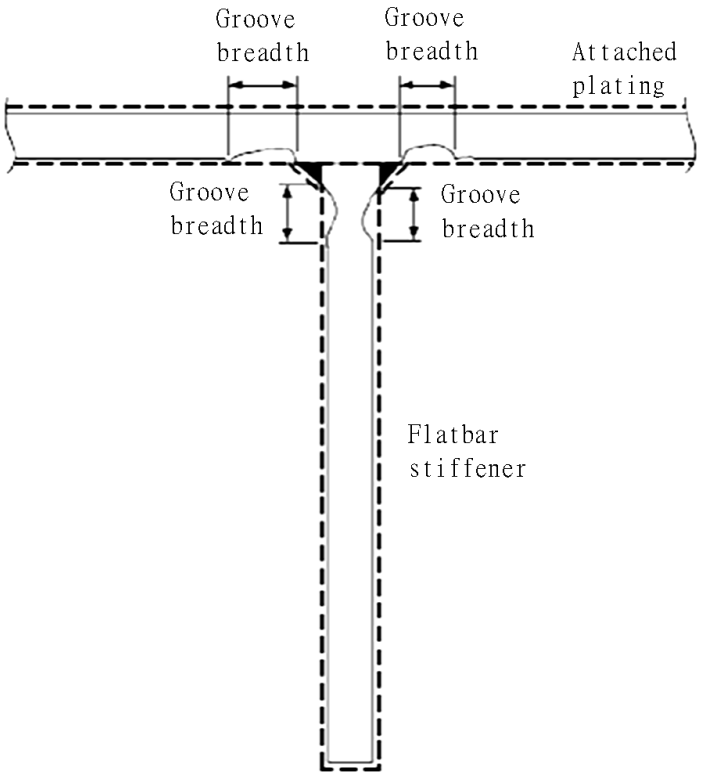
(i) Pitting corrosion is defined as scattered corrosion spots/areas with local material reductions which are greater than the general corrosion in the surrounding area. Pitting intensity is defined as shown below:



(ii) Edge corrosion is defined as local corrosion at the free edges of plates, stiffeners, primary support members and around openings. An example of edge corrosion is shown in below:



(iii) Grooving corrosion is typically local material loss adjacent to weld joints along abutting stiffeners and at stiffener or plate butts or seams. An example of groove corrosion is shown in below:



2.1.3 Repairs

(a) Any damage in association with wastage over the allowable limits (including buckling, grooving, detachment or fracture), or extensive areas of wastage over the allowable limits, which affects or, in the opinion of the Surveyor, will affect the craft's structural, watertight or weathertight integrity, is to be promptly and thoroughly (see 2.1.2 (k)) repaired. Area to be considered include:

(1) side shell frames, their end attachments and adjacent shell plating;
(2) deck structure and deck plating;
(3) bottom structure and bottom plating;
(4) watertight or oiltight bulkheads;
(5) hatch covers and hatch coamings;
(6) the weld connection between air pipes and deck plating;
(7) all air pipe heads installed on the exposed decks;
(8) ventilators, including closing devices, if any.

For locations where adquate repair facilities are not available, consideration may be given to allow the craft to proceed directly to a repair facility. This may require discharging the cargo and/or temporary repairs for the intended voyage.

(b) Additionally, when a survey results in the idetification of structural defects or corrosion, either of which, in the opinion of the Surveyor, will impair the craft's fitness for continued service, remedial measures are to be implemented before the craft continues in service.

(c) Where the damage found on structure mentioned in 2.1.3(b)(i) is isolated and of a localised nature which does not affect the craft's structural integrity, consideration may be given by the Surveyor to allow an appropriate temporary repair to restore watertight or weathertight integrity and impose a Recommendation/Condition of class in accordance with IACS PR 35, with a specific time limits.

2.1.4 Procedures for class related services

(a) Thickness measurements and close-up surveys – hull structures

(i) Thickness measurements are to be carried out by a firm approved by the Society in accordance with the procedures for certification of firms engaged in thickness measurement of hull structures as specified in “Guidelines for Approval of Service Suppliers” of the Society.

(ii) Thickness measurement is normally to be carried out under the supervision of the Surveyor. However, the Surveyor may accept thickness measurement not carried out under his supervision, in which case provisions is to be made for the Surveyor to recheck the measurements as deemed necessary to ensure acceptable accuracy.

(iii) A thickness measurement report is to be prepared by the approved firm carrying out the thickness measurement, the thickness measured as well as the corresponding original thickness. The report is to give the date when the measurement was carried out, the type of measuring equipment, names of personnel and their qualifications and is to be signed by the operator and the Surveyor.

(iv) The thickness measurement report is to be verified by the Surveyor.

(v) In any kind of survey, i.e. Special, Intermediate, Annual or other Surveys having the scope of foregoing ones, thickness measurements of structures in areas where close-up surveys are required, shall be carried out simultaneously with close-up surveys.

(vi) Consideration may be given by the attending Surveyor to allow use of Remote Inspection Techniques (RIT) as an alternative to close-up survey. Surveys conducted using a RIT are to completed to the satisfaction of the attending Surveyor. When RIT is used for a close-up survey, temporary means of access for the corresponding thickness measurements is to be provided unless such RIT also able to carry out the required thickness measurements.

(vii) For structure built with a material other than steel, alternative thickness measurement requirements may be developed and applied as deemed necessary by the Society.

(viii) Thickness measurements Acceptance Criteria.

The acceptance criteria for thickness measurements are according to Table I 2-5 to 2-7 and/or specific IACS URs depending on craft age and structural elements concernd.

(ix) Remote Inspection Techniques (RIT), where applicable

(1) The RIT is to provide the information normally obtained from a close-up survey. RIT surveys are to be carried out in accordance with the requirements given herein and the requirements of IACS Recommendation 42 “Guidelines for use of Remote Inspection Techniques for surveys”. These considerations are to be included in the proposals for use of a RIT which are to be submitted in advance of the survey so that satisfactory arrangements can be agreed with the Society.

(2) The equipment and procedure for observing and reporting the survey using a RIT are to be discussed and agreed with the parties involved prior to the RIT survry, and suitable time is to be allowed to set-up, calibrate and test all equipment beforehand.

(3) When using a RIT as an alternative to close-up survey, if it is not carried out by the Society itself, it is to be conducted by a firm approved as a service supplier according to “Guidelines for Approval of Service Suppliers” of the Society and is to be witnessed by the attending Surveyor of the Society.

(4) The structure to be examined using a RIT is to be sufficiently clean to permit meaningful examination. Visibility is to be sufficient to allow for a meaningful examination. The Society is to be satisfied with the methods of orientation on the structure.

(5) The Surveyor is to be satisfied with the method of data presentation including pictorial represetation, and a good two-way communication between the Surveyor and RIT operator is to be provided.

(6) If the RIT reveals damage or deteriotation that requires attention, the Surveyor may require traditional survey to be undertaken without use of a RIT.

(b) In-Water Surveys

(i) The In-Water Survey is to be carried out under the surveillance of the surveyor by an In-Water Survey firm approved by the Society according to CR “Guidelines for Approval of Service Suppliers”, by diver or Remotely Operated Vehicle (ROV).

(ii) The Society's approval is to be granted to the firms whose organization and management structure are satisfactorily established, which employ the divers using closed-circuit television with two-way communication or operators using Remotely Operated Vehicle (ROV) for the In-Water Survey work and which have sufficient equipment proved suitable for the work undertaken.

(iii) The continued approval of the firm is to depend on its original standards and ability being maintained. Any changes in the information originally supplied are to be reported to the Society; however, the approval is to be renewed after a period not exceeding 5 years.

2.1.5 Provision for surveys

(a) Conditions for survey

(i) The owner is to provide the necessary facilities for a safe execution of the survey.

(ii) Tanks and spaces are to be safe for access, i.e. gas freed, ventilated, and illuminated.

(iii) Tanks and spaces are to be sufficiently clean and free from water, scale, dirt, oil residues, etc. to reveal corrosion, deformation, fractures, damages or other structural deterioration. In particular, this applies to areas which are subject to thickness measurement.

(iv) Sufficient illumination is to be provided to reveal corrosion, deformation, fractures, damages or other structural deterioration.

(b) Access to structures

(i) For survey, means are to be provided to enable the Surveyor to examine the hull structure in a safe and practical way.

(ii) For survey in cargo holds and water ballast tanks, one or more of the following means for access, acceptable to the Surveyor, is to be provided.

(1) Permanent staging and passages through structures.

(2) Temporary staging and passages through structures.

(3) Hydraulic arm vehicles such as conventional cherry pickers, Lifts and moveable platforms.

(4) Other equivalent means.

(iii) For Surveys conducted by use of a Remote Inspection Technique (RIT), one or more of the following means for access, acceptable to the Surveyor, is to be provided:

(1) Unmanned robot arm

(2) Remotely Operated Vehicles (ROV)

(3) Unmanned Aerial Vehicles / Drones

(4) Other means acceptable to the Society.

(c) Equipment for survey

(i) Thickness measurement is normally to be carried out by means of ultrasonic test equipment. The accuracy of the equipment is to be proven to the Surveyor as required.

(ii) One or more of the following fracture detection procedures may be required if deemed necessary by the Surveyor:

(1) Radiographic equipment.

(2) Ultrasonic equipment.

(3) Magnetic particle equipment.

(4) Dye penetrate.

2.2 Bottom Surveys

2.2.1 Bottom Surveys in dry dock

At each Bottom Survey in dry dock the following requirements are to be complied with:

(a) Normally the craft is to be placed on blocks of sufficient height in a dry dock or on a slipway and cleaned, and proper staging is to be erected as may be necessary for examination. A docking survey covers an examination of elements such as shell plating including bottom and bow plating, stern frame and rudder, sea chests and vlaves, propellers, etc. The shell plating is to be examined for excessive corrosion, or deterioration due to chafing or contact with the ground and for any undue unfairness or buckling. Special attention is to be paid to the connection between the bilge strakes and the bilge keels. Important plate unfairness or other deterioration which do not necessitate immediate repairs are to be recorded.

(b) Sea chests and their gratings, sea connections and overboard discharge valves and cocks and their fastenings to the hull or sea chests are to be examined. Valves and cocks need not be opened up more than once in a Special Survey period unless considered necessary by the Surveyor.

(c) Visible parts of rudder, rudder pintles, rudder stocks and couplings, stern frame, gudgeons, etc. are to be examined. If considered necessary by the Surveyor, the rudder is to be lifted or the inspection plates removed for the examination of pintles. The clearance in the rudder bearing is to be ascertained and recorded. Where applicable, pressure test of the rudder may be required as deemed necessary by the Surveyor.

(d) Visible parts of propeller and stern bush, are to be examined. The clearance in the stern bush and the efficiency of the oil gland, if fitted, are to be ascertained and recorded. For controllable pitch propellers, the Surveyor is to be satisfied with the fastenings and tightness of hub and blade sealing. Dismantling need not to be carried out unless considered necessary by the Surveyor.

Survey in place for the propeller shaft and stern tube shaft is to be carried out as per requirement of 2.3.6.

(e) Visible parts of side thrusters are to be examined. Other propulsion systems which also have manoeuvring characteristics (such as directional propellers, vertical axis propellers, waterjet units) are to be examined externally with focus on the condition of gear housing, propeller blades, bolt locking and other fastening arrangements. Sealing arrangement of propeller blades, propeller shaft and steering column shall be verified. Dismantling may be required to the extent found necessary by the Surveyor.

(f) Anchor and anchor chains are to be arranged and examined. Chain lockers are to be internally examined. The diameter of anchor chain cables is to be measured at Special Survey No. 2 and subsequent Special Survey.

(g) Special consideration may be given in application of relevant requirements of this section to commercial ships owned or chartered by Governments, which are utilized in support of military operations or service.

2.2.2 In-Water Survey

(a) General requirements

(i) The underwater body is to be protected against corrosion by a full hard coating system and strongly recommended to be also protected by an impress current cathodic protection system.

(ii) The information obtained from the In-Water Survey is to be as reliable as that obtained from the docking survey.

(iii) The In-Water Survey is to provide the information normally obtained from a docking survey. Special consideration shall be given to ascertaining rudder bearing clearances and stern bush clearances of oil stern bearings based on a review of the operating history, on board testing and stern oil sample reports. These considerations are to be included in the proposals for In-Water Survey which are to be submitted in advance of the survey so that satisfactory arrangements can be agreed with the Society.

(iv) Application for the subsequent In-Water Survey is also to be submitted to the Society for acceptance.

(v) The In-Water Survey is to be carried out with the craft in sheltered water and preferably with weak tidal streams and currents. The in-water visibility and the cleanliness of the hull below the waterline is to be clear enough to permit a meaningful examination which allows the surveyor and the In-Water Survey firm to determine the condition of the plating, appendages and the welding.The Society is to be satisfied with the methods of orientation of the divers or Remotely Operated Vehicle (ROV) on the plating, which should make use where necessary of permanent markings on the plating at selected points.

(vi) The equipment, procedure for observing and reporting the survey are to be discussed with the parties involved prior to the In-Water Survey, and suitable time is to be allowed to permit the In-Water Survey firm to test all equipment beforehand.

(vii) The In-Water Survey is to be carried out under the surveillance of a surveyor by an In-Water Survey firm approved as a service supplier according to “Guidelines for Approval of Service Suppliers” of the Society.

(viii) The Surveyor is to be satisfied with the method of pictorial representation, and a good two-way communication between the Surveyor and divers is to be provided.

(ix) If the In-Water Survey reveals damage or deterioration that requires early attention, the Surveyor may require that the craft be drydocked in order that a detailed survey can be undertaken and the necessary repairs carried out.

(x) The In-Water Survey may not be applicable if there are outstanding recommendations for repairs to the propeller, rudder, stern frame, underwater hull structure, or sea valves.

(b) Plans and documents

When craft are intended to be subjected to an In-Water Survey, the following plans and documents are to be submitted to the Society:

(i) Plans of the shell plating below waterline showing the details of the location and sizes of shell opening, location of bottom plugs, location of water and oil tight bulkheads;

(ii) Detailed information or drawings of constructions and arrangement indicated in the item (c) below together with their colour photographs and detailed instruction for inspection of such constructions and arrangements; and

(iii) Other data, if deemed necessary.

(c) Constructions and arrangements

The constructions and arrangements of craft which are intended to be subjected to an In-Water Survey are to comply with the following:

(i) Anodes are to be attached in such a manner as to be easily replaced where necessary.

(ii) Rudder is to be provided with the means of facilitating the measurement of clearances in way of each pintle. Liners on rudder stock and pintles are to be marked in such a way so that any relative movements can be checked.

(iii) Rope guard ring plates are to be of such constructions as to facilitate the inspection of shafts between propeller hubs and stern frame boss.

(iv) In case of water lubricating type stern-tube bearings, the devices which may indicate the clearance of propeller shaft strut and stern bearings are to be provided.

(v) In case of oil lubricating type stern-tube bearings, suitable means of ascertaining the performances of stern-tube bearings including oil sealing devices are to be provided.

(vi) Suitable means of ascertaining the position and identifying each blade of propellers from inboard are to be provided.

(vii) Sea connections are to be provided with the means of blanking their openings to the sea from outboard so that the sea connections may be opened up from inboard for examination and repairs. Grating of sea suctions are to be of hinged type as far as practicable.

(viii) To the hull below load water line, provision is to be made for ready identification of the position of bulkheads and transverses (including indication of the number of transverses). To bottom shell plating, provision is to be made for ready identification of the flat bottom and of craft's lengthwise (fore and aft) and athwartship (port side or starboard side) direction.

(d) Performance of In-Water Survey

(i) The In-Water Survey is to be carried out in sufficiently clear and calm waters. The craft is to be as light as possible. The shell side below the waterline are to be sufficiently clean.

(ii) The underwater pictures on the surface monitor screen are to offer reliable technical information such as to enable the Surveyor to judge the parts surveyed.

(iii) The In-Water Survey is to provide the information normally obtained from a Bottom Survey in dry dock. It at least covers an examination of the bottom and side plates of the shell plating, including any attachments and the rudder, an external examination of propellers as well as propeller shafts, and the cleaning condition of sea chests.

2.3 Surveys of Propeller Shafts and Tube Shafts

2.3.1 General

(a) Application

(i) Unless alternative means are provided to assure the condition of the propeller shaft assembly, the requirements specified in 2.3.2 and 2.3.3 apply to all vessels with conventional shafting fitted with a propeller.

(ii) The surveys for miscellaneous propellers including controllable pitch propellers, directional propeller units and waterjet units are to be carried out in accordance with 2.3.4.

(iii) Propeller shaft condition monitoring, survey in place and wear-down limits are to in accordance with 2.3.5 to 2.3.7.

(b) Definitions (See also Fig. I 2-1(a)&(b))

(i) Shaft

For the purpose of this paragraph shaft is a general definition that includes:

(1) Propeller shaft

(2) Tube shaft

The definition does not include the intermediate shaft(s) which is(are) considered part of the propulsion shafting inside the vessel.

(ii) Propeller Shaft

Propeller shaft is the part of the propulsion shaft to which the propeller is fitted. It may also be called screwshaft or tailshaft.

(iii) Tube Shaft

Tube shaft is a shaft placed between the intermediate shaft and propeller shaft, normally arranged within a stern tube or running in open water. It may also be called Stern Tube Shaft.

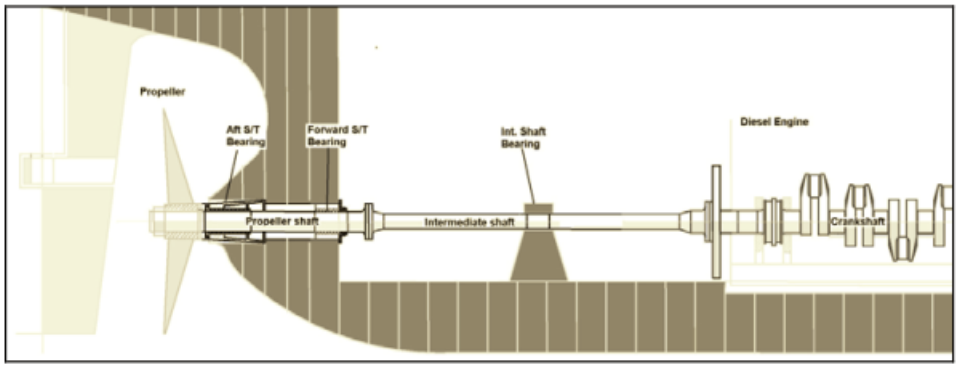


Fig. I 2-1(a)
Typical Shafting Arrangement

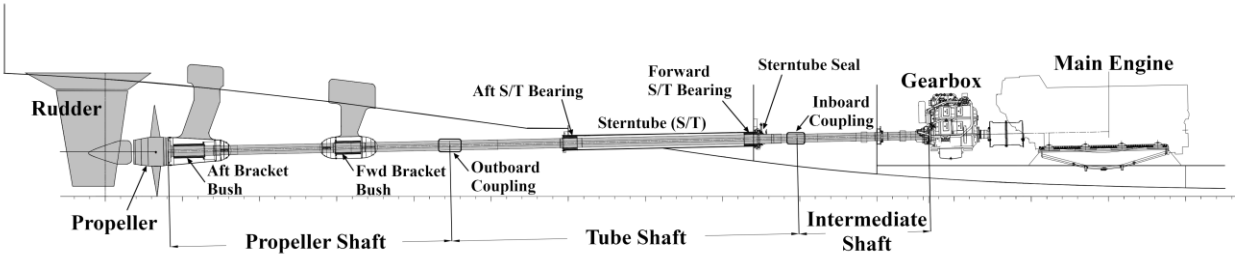


Fig. I 2-1(b)
Typical Water Lubricated Shaft Systems

(iv) Sterntube

Tube or pipe fitted in the shell of a craft at the stern (or rear part of the craft), below the water-line, through which passes the tube shaft or aftermost section of the propeller-shaft.

Sterntube is the housing of the shaft bearings, generally two (one aft and one fore), that sustain the shaft and allows its rotation with less frictional resistance. The stern tube also accommodates the shaft sealing arrangement.

(v) Closed loop (system) oil lubricated bearing

Closed loop oil lubricating systems use oil to lubricate the bearings and are sealed against the environment (seawater) by adequate sealing / gland devices.

(vi) Water Lubricated Bearing

Water lubricated bearings are bearings cooled / lubricated by water (fresh or salt).

(vii) Closed Loop System Fresh Water Lubricated Bearing

Closed loop water lubricating systems use fresh water to lubricate the bearings and are sealed against the environment (such as seawater) by adequate sealing / gland devices.

(viii) Open Systems (water)

Open water lubricating systems use water to lubricate the bearings and are exposed to the environment.

(ix) Adequate means for protection against corrosion

An adequate means for protection against corrosion is an approved means for full protection of the core shaft against sea water intrusion and subsequent corrosion attack. Such means are used for the protection of common steel material against corrosion particularly in combination with water lubricated bearings.

Typical means are for example:

(1) continuous metallic, corrosion resistant liners,

(2) continuous cladding,

(3) multiple layer synthetic coating,

(4) multiple layer of fiberglass,

(5) combinations of above mentioned,

(6) rubber / elastomer covering coating.

The means for protection against corrosion are installed / applied according to the Society approved procedures.

(x) Corrosion Resistant Shaft

Corrosion resistant shaft is made in approved corrosion resistant steel as core material for the shaft.

(xi) Sterntube Sealing System

Sterntube Sealing System is the equipment installed on the inboard extremity and, for closed systems, at outboard extremity of the sterntube. Inboard Seal is the device fitted on the fore part of the sterntube that achieve the sealing against the possible leakage of the lubricant media in to the craft internal.

Outboard seal is the device fitted on the aft part of the sterntube that achieve the sealing against the possible sea water ingress and the leakage of the lubricant media.

(xii) Service records

Service records are regularly recorded data showing in-service conditions of the shaft(s) and may include, as applicable: lubricating oil temperature, bearing temperature and oil consumption records (for oil lubricated bearings) or water flow, water temperature, salinity, pH, make-up water and water pressure (for closed loop fresh water lubricated bearings depending on design).

(xiii) Oil sample examination

An oil sample examination is a visual examination of the stern tube lubricating oil taken in presence of the Surveyor with a focus on water contamination.

(xiv) Lubricating oil analysis

Lubricating oil analysis is to be carried out at regular intervals not exceeding 6 months taking into account IACS Rec. 36.

The documentation on lubricating oil analysis is to be available on board.

Oil samples, to be submitted for the analysis, should be taken under service conditions.

(xv) Fresh Water sample test

Fresh water sample test should be carried out at regular intervals not exceeding 6 months.

Samples are to be taken under service conditions and are to be representative of the water circulating within the sterntube.

Analysis results are to be retained on board and made available to the Surveyor.

At time of survey the sample for the test has to be taken at the presence of the Surveyor.

Fresh water sample test shall include the following parameters:

(1) chlorides content,

(2) pH value,

(3) presence of bearing particles or other particles (only for laboratory analysis, not required for tests carried out in presence of the Surveyor).

(xvi) Keyless connection

Keyless connection is the forced coupling Methodology between the shaft and the propeller without a key achieved through interference fit of the propeller boss on the shaft tapered end.

(xvii) Keyed connection

Keyed connection is the forced coupling Methodology between the shaft and the propeller with a key and keyway achieved through the interference fit of the propeller boss on the shaft tapered end.

(xviii) Flanged connection

Flanged connection is the coupling Methodology, between the shaft and the propeller, achieved by a flange, built in at the shaft aft end, bolted to propeller boss.

(xix) Alternative means

Shafting arrangements such as, but not limited to, an approved Condition Monitoring Scheme and / or other reliable approved means for assessing and monitoring the condition of the tail shaft, bearings, sealing devices and the stern tube lubricant system capable to assure the condition of the propeller shaft assembly with an equivalent level of safety as obtained by survey methods as applicable herein.

2.3.2 Oil lubricated shafts or closed loop system fresh water lubricated shafts (closed system)

(a) Shaft survey methods

(i) METHOD 1 (IACS UR Z21)

The survey is to consist of:

- Drawing the shaft and examining the entire shaft, seals system and bearings
- For keyed and keyless connections:
  - Removing the propeller to expose the forward end of the taper,
  - Performing a non-destructive examination (NDE) by an approved surface crack-detection method all around the shaft in way of the forward portion of the taper section, including the keyway (if fitted). For shaft provided with liners the NDE shall extended to the after edge of the liner.
- For flanged connection:
  - Whenever the coupling bolts of any type of flange-connected shaft are removed or the flange radius is made accessible in connection with overhaul, repairs or when deemed necessary by the Surveyor, the coupling bolts and flange radius are to be examined by means of an approved surface crack detection method.
- Checking and recording the bearing clearances.
- Verification that the propeller is free of damages which may cause the propeller to be out of balance.
- Verification of the satisfactory conditions of inboard and outboard seals during the re-installation of the shaft and propeller.
- Recording the bearing weardown measurements (after re-installation)

(ii) METHOD 2 (IACS UR Z21)

The survey is to consist of:

- For keyed and keyless connections:
  - Removing the propeller to expose the forward end of the taper,
  - Performing a non-destructive examination (NDE) by an approved surface crack-detection Method all around the shaft in way of the forward portion of the taper section, including the keyway (if fitted).
- For flanged connection:
  - Whenever the coupling bolts of any type of flange-connected shaft are removed or the flange radius is made accessible in connection with overhaul, repairs or when deemed necessary by the Surveyor, the coupling bolts and flange radius are to be examined by means of a an approved surface crack detection Method.
- Checking and recording the bearing weardown measurements.
- Visual Inspection of all accessible parts of the shafting system.
- Verification that the propeller is free of damages which may cause the propeller to be out of balance.
- Seal liner found to be or placed in a satisfactory condition.

- Verification of the satisfactory re-installation of the propeller including verification of satisfactory conditions of inboard and outboard seals.

Pre-requisites to satisfactorily verify in order to apply METHOD 2:

- Review of service records.
- Review of test records of:
  - Lubricating Oil analysis (for oil lubricated shafts), or
  - Fresh Water Sample test (for closed system fresh water lubricated shafts).
- Oil sample Examination (for oil lubricated shafts), or Fresh Water Sample test (for closed system fresh water lubricated).
- Verification of no reported repairs by grinding or welding of shaft and/or propeller.

(iii) METHOD 3 (IACS UR Z21)

The survey is to consist of:

- Checking and recording the bearing weardown measurements.
- Visual Inspection of all accessible parts of the shafting system.
- Verification that the propeller is free of damages which may cause the propeller to be out of balance.
- Seal liner found to be or placed in a satisfactory condition.
- Verification of the satisfactory conditions of inboard and outboard seals.

Pre-requisites to satisfactorily verify in order to apply METHOD 3:

- Review of service records.
- Review of test records of
  - Lubricating Oil analysis (for oil lubricated shafts), or
  - Fresh Water Sample test (for closed system fresh water lubricated shafts).
- Oil sample Examination (for oil lubricated shafts), or Fresh Water Sample test (for closed system fresh water lubricated).
- Verification of no reported repairs by grinding or welding of shaft and/or propeller.

(b) Shaft extension surveys - Extension types

(i) Extension up to 2.5 years

The survey is to consist of:

- Checking and recording the bearing weardown measurements, as far as practicable.
- Visual Inspection of all accessible parts of the shafting system.
- Verification that the propeller is free of damages which may cause the propeller to be out of balance.
- Verification of the effectiveness of the inboard seal and outboard seals.

Pre-requisites to satisfactorily verify in order to apply EXTENSION UP TO 2.5 YEARS:

- Review of service records.
- Review of test records of
  - Lubricating Oil analysis (for oil lubricated shafts), or
  - Fresh Water Sample test (for closed system fresh water lubricated shafts).
- Oil sample Examination (for oil lubricated shafts), or Fresh Water Sample test (for closed system fresh water lubricated).
- Verification of no reported repairs by grinding or welding of shaft and/or propeller.
- Confirmation from the Chief Engineer that the shafting arrangement is in good working condition.

(ii) Extension up to 1 year

The survey is to consist of:

- Visual Inspection of all accessible parts of the shafting system.
- Verification that the propeller is free of damages which may cause the propeller to be out of balance.
- Verification of the effectiveness of the inboard seal and outboard seals.

Pre-requisites to satisfactorily verify in order to apply EXTENSION UP TO 1YEAR:

- Review of the previous weardown and/or clearance recordings.
- Review of service records.
- Review of test records of
  - Lubricating Oil analysis (for oil lubricated shafts), or
  - Fresh Water Sample test (for closed system fresh water lubricated shafts).
- Oil sample Examination (for oil lubricated shafts), or Fresh Water Sample test (for closed system resh water lubricated).
- Verification of no reported repairs by grinding or welding of shaft and/or propeller.
- Confirmation from the Chief Engineer that the shafting arrangement is in good working condition.

(iii) Extension up to 3 months

The survey is to consist of:

- Visual Inspection of all accessible parts of the shafting system.
- Verification of the effectiveness of the inboard seal.

Pre-requisites to satisfactorily verify in order to apply EXTENSION UP TO 3 MONTHS:

- Review of the previous weardown and/or clearance recordings.
- Review of service records.
- Review of test records of.
  - Lubricating Oil analysis (for oil lubricated shafts), or
  - resh Water Sample test (for closed system fresh water lubricated shafts).
- Oil sample Examination (for oil lubricated shafts), or Fresh Water Sample test (for closed system fresh water lubricated).
- Verification of no reported repairs by grinding or welding of shaft and/or propeller.
- Confirmation from the Chief Engineer that the shafting arrangement is in good working condition.

(c) Oil lubricated shafts

(i) Survey intervals

For surveys completed within 3 months before the shaft survey due date, the next period will start from the shaft survey due date.

(1) Flanged propeller connection
The following Methods are applicable:

a) Method 1 every 5 years, or

b) Method 2 every 5 years (pre-requisites have to be fulfilled), or

c) Method 3 every 5 years (pre-requisites have to be fulfilled).

(2) Keyless propeller connection
The following Methods are applicable:

a) Method 1 every 5 years, or

b) Method 2 every 5 years (pre-requisites have to be fulfilled), or

c) Method 3 every 5 years (pre-requisites have to be fulfilled). The maximum interval between 2 surveys carried out according to Method 1 or Method 2 shall not exceed 15 years, except in the case when one extension for no more than 3 months is granted.

(3) Keyed propeller connection
The following Methods are applicable:
a) Method 1 every 5 years, or
b) Method 2 every 5 years (pre-requisites have to be fulfilled).

(ii) Survey extensions

For all types of propeller connections, the interval between two consecutive surveys may be extended after the execution of extension survey as follows:

(1) Extension up to a maximum of 2.5 years: no more than one extension can be granted. No further extension, of other type, can be granted.

(2) Extension up to a maximum of 1 year: no more than two consecutive “one year extensions” can be granted. In the event an additional extension is requested the requirements of the “2.5 year extension” are to be carried out and the shaft survey due date, prior to the previous extension(s), is extended for a maximum of 2.5 years.

(3) Extension up to a maximum of 3 months: no more than one “3 months extension” can be granted. In the event an additional extension is requested the requirements of the “one year extension” or “2.5 years extension” are to be carried out and the shaft survey due date, prior to the previous extension, is extended for a maximum of one year or 2.5 years.

The extension survey should normally be carried out within 1 month of the shaft survey due date and the extension counts from the shaft survey due date.

If the extension survey is carried out more than 1 month prior to the shaft survey due date, then the period of extension counts from the date of the extension survey was completed.

(d) Survey intervals of closed loop system fresh water lubricated shafts

The maximum interval between two surveys carried out according to Method 1 shall not exceed 15 years. An extension for no more than 3 months can be granted.

(i) For surveys completed within 3 months before the shaft survey due date, the next period will start from the shaft survey due date.

(1) Flanged propeller connection
The following Methods are applicable:
a) Method 1 every 5 years, or
b) Method 2 every 5 years (pre-requisites have to be fulfilled), or
c) Method 3 every 5 years (pre-requisites have to be fulfilled).

(2) Keyless propeller connection
The following Methods are applicable:
a) Method 1 every 5 years, or
b) Method 2 every 5 years (pre-requisites have to be fulfilled), or
c) Method 3 every 5 years (pre-requisites have to be fulfilled).

(3) Keyed propeller connection
The following Methods are applicable:
a) Method 1 every 5 years, or
b) Method 2 every 5 years (pre-requisites have to be fulfilled).

(ii) Survey extensions

For all types of propeller connections, the interval between two consecutive surveys may be extended after the execution of extension survey as follows:

(1) Extension up to a maximum of 2.5 years, no more than one extension can be granted.
No further extension, of other type, can be granted.

(2) Extension up to a maximum of 1 year, no more than two consecutive extensions can be granted. In the event an additional extension is requested the requirements of the "2.5 year extension" are to be carried out and the shaft survey due date, prior to the previous extension(s), is extended for a maximum of 2.5 years.

(3) Extension up to a maximum of 3 months, no more than one "3 months extension" can be granted. In the event an additional extension is requested the requirements of the "one year extension" or "2.5 years extension" are to be carried out and the shaft survey due date, prior to the previous extension, is extended for a maximum of one year or 2.5 years.

The extension survey should normally be carried out within 1 month of the shaft survey due date and the extension counts from the shaft survey due date.

If the extension survey is carried out more than 1 month prior to the shaft survey due date, then the period of extension counts from the date of the extension survey was completed.

The maximum interval between two surveys carried out according to Method 1 shall not exceed 15 years, except in the case when one extension for no more than 3 months is granted.

(e) Survey Intervals for closed systems see the following Table.

Survey Intervals for Closed Systems

Survey Intervals (closed systems)			
Oil Lubricated			
	Flanged Propeller Coupling	Keyless Propeller Coupling	Keyed Propeller Coupling(2)
Every 5 years(1)	Method 1 or Method 2 or Method 3	Method 1 or Method 2 or Method 3(3)	Method 1 or Method 2
Extension 2.5 years	Yes(4)	Yes(4)	Yes(4)
Extension 1 year	Yes(5)	Yes(5)	Yes(5)
Extension 3 months	Yes(6)	Yes(6)	Yes(6)
Closed Loop System Fresh Water Lubricated			
	Flanged Propeller Coupling	Keyless Propeller Coupling	Keyed Propeller Coupling(2)
Every 5 years(1)	Method 1(7) or Method 2 or Method 3	Method 1(7) or Method 2 or Method 3	Method 1(7) or Method 2
Extension 2.5 years	Yes(4)	Yes(4)	Yes(4)
Extension 1 year	Yes(5)	Yes(5)	Yes(5)
Extension 3 months	Yes(6)	Yes(6)	Yes(6)
Footnotes: For surveys (Method 1, or Method 2, or Method 3) completed within 3 months before the shaft survey due date, the next period will start from the shaft survey due date. The extension survey should normally be carried out within 1 month of the shaft survey due date and the extension counts from the shaft survey due date. If the extension survey is carried out more than 1 month prior to the shaft survey due date, then the period of extension counts from the date of the extension survey was completed.			

Notes:

(1) Unless an Extension type (Extension 2.5 years, Extension 1 year, Extension 3 months) is applied in between.

(2) Method 3 not allowed.

(3) The maximum interval between two surveys carried out according to Method 1 or Method 2 shall not exceed 15 years, except in the case when one extension for no more than 3 months is granted.

(4) No more than one extension can be granted. No further extension of other type can be granted.

(5) No more than two consecutive extensions can be granted. In the event an additional extension is requested the requirements of the "2.5 years extension" are to be carried out and the shaft survey due date, prior to the previous extension(s), is extended for a maximum of 2.5 years.

(6) No more than one 3 months extension can be granted. In the event an additional extension is requested the requirements of the "1 year extension" or "2.5 years extension" are to be carried out and the shaft survey due date, prior to the previous extension, is extended for a maximum of one year or 2.5 years.

(7) The maximum interval between two surveys carried out according to Method 1 shall not be more than 15 years.

2.3.3 Water Lubricated shafts (open systems)

(a) Shaft Survey Methods

(i) METHOD 4 (IACS UR Z21)

The survey is to consist of:

- Drawing the shaft and examining the entire shaft (including liners, corrosion protection system and stress reducing features, where provided), inboard seal system and bearings.
- For keyed and keyless connections:
  - removing the propeller to expose the forward end of the taper,
  - performing a non-destructive examination (NDE) by an approved surface crack-detection Method all around the shaft in way of the forward portion of the taper section, including the keyway (if fitted). For shaft provided with liners the NDE shall be extended to the after edge of the liner.
- For flanged connection:
  - Whenever the coupling bolts of any type of flange-connected shaft are removed or the flange radius is made accessible in connection with overhaul, repairs or when deemed necessary by the surveyor, the coupling bolts and flange radius are to be examined by means of an approved surface crack detection method.
- Checking and recording the bearing clearances.
- Verification that the propeller is free of damages which may cause the propeller to be out of balance.
- Verification of the satisfactory conditions of inboard seal during re-installation of the shaft and propeller.

(b) Shaft extension surveys - Extension types

(i) Extension up to 1 year

The survey is to consist of:

- Visual Inspection of all accessible parts of the shafting system.
- Verification that the propeller is free of damages which may cause the propeller to be out of balance.
- Checking and recording the clearances of bearing.
- Verification of the effectiveness of the inboard seal.

Pre-requisites to satisfactorily verify in order to apply EXTENSION UP TO 1 YEAR:

- Review of the previous clearance recordings.
- Service records.
- Verification of no reported repairs by grinding or welding of shaft and/or propeller.
- Confirmation from the Chief Engineer that the shafting arrangement is in good working condition.

(ii) Extension up to 3 months

The survey is to consist of:

- Visual Inspection of all accessible parts of the shafting system.
- Verification that the propeller is free of damages which may cause the propeller to be out of balance.
- Verification of the effectiveness of the inboard seal.

Pre-requisites to satisfactorily verify in order to apply extension up to 3 months:

- Review of the previous clearance recordings.
- Service records.

- Verification of no reported repairs by grinding or welding of shaft and/or propeller.
- Confirmation from the Chief Engineer that the shafting arrangement is in good working condition.

(c) Shaft Survey Intervals

(i) The following survey intervals between surveys according to Method 4 are applicable to all types of propeller connections.

- For keyless propeller connections the maximum interval between two consecutive dismantling and verifications of the shaft cone by means of non-destructive examination (NDE) shall not exceed 15 years.
- For surveys completed within 3 months before the shaft survey due date, the next period will start from the shaft survey due date.

(1) Configurations allowing 5 year intervals

- Single shaft operating exclusively in fresh water.
- Single shaft provided with adequate means of corrosion protection, or single corrosion resistant shaft.
- All kinds of multiple shafts arrangements.

(2) Other systems
Shaft not belonging in one of the configurations listed in (1) above has to be surveyed according to Method 4 every 3 years.

(ii) Survey extensions

For all types of propeller connections, the interval between two consecutive surveys may be extended after the execution of extension survey as follows:

(1) Extension up to a maximum of 1 year: no more than 1 extension can be granted.
No further extension, of other type, can be granted.

(2) Extension up to a maximum of 3 months: no more than 1 "3 months extension" can be granted. In the event an additional extension is requested the requirements of the "1 year extension" are to be carried out and the shaft survey due date prior to the previous extension is extended for a maximum of 1 year.

The extension survey should normally be carried out within 1 month of the shaft survey due date and the extension counts from the shaft survey due date.

If the extension survey is carried out more than 1 month prior to the shaft survey due date, then the period of extension counts from the date of the extension survey was completed.

(d) Survey intervals for open systems see the following table.

Survey Intervals (Open Systems)

<table>
<tr><td colspan="4">Survey Intervals (Open Systems)</td></tr>
<tr><td colspan="2">– Single shaft operating exclusively in fresh water.
– Single shaft provided with adequate means of corrosion protection, single corrosion resistant shafts
– All kinds of multiple shafts arrangements</td><td colspan="2">Other shaft configuration</td></tr>
<tr><td colspan="2">All kinds of propeller coupling(4)</td><td colspan="2">All kinds of propeller coupling(4)</td></tr>
<tr><td>Every 5 years(1)</td><td>Method 4</td><td>Every 3 years(1)</td><td>Method 4</td></tr>
<tr><td>Extension 1 year</td><td>Yes(2)</td><td>Extension 1 year</td><td>Yes(2)</td></tr>
<tr><td>Extension 3 months</td><td>Yes(3)</td><td>Extension 3 months</td><td>Yes(3)</td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="4">Footnotes:
For surveys (Method 4) completed within 3 months before the shaft survey due date, the next period will start from the shaft survey due date.
The extension survey should normally be carried out within 1 month of the shaft survey due date and the extension counts from the shaft survey due date. If the extension survey is carried out more than 1 month prior to the shaft survey due date, then the period of extension counts from the date of the extension survey was completed.</td></tr>
</table>

Notes:

(1) Unless an Extension type (Extension 1 Y, Extension 3 M) is applied in between.

(2) No more than one extension can be granted. No further extension, of other type, can be granted.

(3) No more than one extension can be granted. In the event an additional extension is requested the requirements of the one year extension are to be carried out and the shaft survey due date prior to the previous extension is extended for a maximum of 1 year.

(4) For keyless propeller connections the maximum interval between two consecutive dismantling and verifications of the shaft cone by means of non-destructive examination (NDE) shall not exceed 15 years.

2.3.4 Miscellaneous propellers

(a) Controllable pitch propellers where fitted are to be opened up and the working parts examined, together with the control gear.

(b) Directional propeller units are to be examined as the following requirements.

(i) Lubrication oil samples are to be taken and sent to a recognised laboratory for analysis at regular intervals, not exceeding 3 months. Records of lubrication oil analysis are to include trends of previous analysis, and be available onboard at all times. A representative oil sample is to be taken before the filters and with the unit in its normal running condition. Oil analysis is to detect iron (Fe) and other solid contamination in addition to possible water content. Acceptance criteria for wear particles and water content are set by the relevant thruster maker (in case thruster maker criteria are not available due to e.g. bankruptcy of gear thruster maker, the water content due to condensation is normally not to exceed 0.5%). The oil analysis is to cover all of the following areas, if applicable:

(1) lubrication oil for gears, bearings;

(2) sealing boxes;

(3) steering gear; and

(4) propeller.

If the propeller shafts seal oil systems do not allow for sampling unless the vessel is in dry dock, a representative oil analysis is to be taken in connection with the bottom survey in dry-dock.

(ii) The thrusters are to be subjected to complete survey every 5 years. The complete survey is to include:

(1) evaluation of oil analysis of gear lubrication oil, propeller hydraulic system oil and sealing system oil as specified in 2.3.3(b)(i) above.

(2) opening up of protection covers.

(3) inspection of power transmission gear, bearings, visible parts of shafts and general condition of housing internally. Gear clearance and axial play of bearings shall be measured.

(4) examination of controllable pitch mechanism oil transmission system and feedback system.

(5) full stroke ahead and astern are to be verified and correct blade position feed-back and indication verified.

(6) examination of steering column and related sealing and bearing.

(7) running test at MCR (max continuous rating).

(iii) Inboard parts of the thruster accessible from the inside, such as drive motors, shafting system, gear transmissions, pumps and piping systems, alarm, safety and control systems are covered by the class surveys of machinery. This will be applicable for e.g. Voith-Schneider and pump type thrusters.

(iv) Outboard parts of the thruster, accessible from the outside, are to be externally examined during by the bottom surveys.

(v) If the thruster is overhauled at the time of the complete survey, NDT for TIFF (tooth interior fatigue fracture) shall be carried out according to maker's requirements and acceptance criteria. If the thruster is overhauled during the interval between two scheduled surveys, satisfactory documentation for NDT (TIFF) performed according to maker's requirements and acceptance criteria is to be submitted to the attending Surveyor at the next survey. Mounting of the thruster on board is to be verified and function tested.

(c) Waterjet units

Waterjet units for main propulsion purposes, including the impeller, casing, shaft, shaft seal, shaft bearing, inlet and outlet channels, steering nozzle, reversing arrangements, and control gear are to be surveyed at intervals not exceeding 5 years, provided the impeller shafts are made of approved corrosion-resistant material or have approved equivalent arrangements. They are to be generally examined so far as practicable. Dismantling may be required to the extent found necessary by the Surveyor.

(d) Dynamic positioning and/or thruster-assisted mooring and athwartship thrust propellers and shaftings are to be surveyed at intervals not exceeding 5 years. They are to be generally examined so far as possible in dry dock and tested under working conditions afloat for satisfactory operation. All accessible parts, including sealing, locking and bearing faces, and any other moving parts are to be examined. Non-destructive examination is to be carried out as considered necessary by the Surveyor on blade/fin roots. Consideration may be given to condition monitoring schemes for determining the condition of the unit.

2.3.5 Propeller shaft condition monitoring **(PCM)**

(a) Where oil lubricated shaft with approved oil glands are fitted, a class notation **PCM** may be assigned, if its monitoring manuals or maintenance manuals of preventive maintenance system together with relative diagrams, are submitted and approved by the Society. The management systems are to comply with the following:

(i) Lubricating oil analysis is to be carried out regularly at intervals not exceeding 6 months. The lubricating oil analysis documentation is to be available on board. Each analysis is to include the following minimum parameters:

(1) Water content;

(2) Chloride content;

(3) Bearing material and metal particles content; and

(4) Oil ageing (resistance to oxidation).

Oil samples are to be taken under service conditions and representative of the oil within the stern-tube.

(ii) Oil consumption is to be recorded monthly.

(iii) Bearing temperatures are to be recorded daily, (two temperature sensors with alarm or other approved arrangements are to be provided).

(iv) Facilities are to be provided for measurement of bearing wear down.

(v) Oil glands are to be capable of being replaced without withdrawal of the propeller shaft or removal of the propeller.

(b) For maintenance of the **PCM** notation, Annual Survey is to be carried out as follows:

(i) Satisfactory operating conditions of the propeller shaft are to be confirmed, including the verification of the records of lubricating oil analysis, lubricating oil consumption, bearing temperatures and wear down readings.

(c) Where the notation **PCM** has been assigned, the propeller shaft need not be withdrawn at surveys as required by 1.6.8 provided all condition monitoring data is found to be within permissible limits and all exposed areas of the shaft are examined by a magnetic particle crack detection method. Where the Surveyor considers that the data presented is not entirely to his satisfaction the shaft will be required to be withdrawn in accordance with 1.6.8.

(d) For craft with **PCM** notation, the propeller shaft survey interval required by 2.3.2(c) or (d) of this Part will be extended up to 15 years provided:

(i) Annual Surveys are carried out to the satisfaction of the attending Surveyors, and

(ii) The followings are carried out at each propeller shaft survey due date required by 2.3.2(c) or (d).

(1) Bearing weardown measurement.

(2) Verification that the propeller is free of damage which may cause the propeller to be out of balance.

(3) Verification of effective inboard seal.

(4) Renewal of outboard seal in accordance with manufacturer's recommendation.

(5) For keyed propellers, the fore part of the shaft taper and shaft keyway are to be examined by an appropriate surface crack detection method (such as magnetic particle or dye-penetration), for which dismantling of the propeller and removal of the key will be required.

(e) Initial Survey for existing craft obtaining **PCM** notation

(i) All systems required by 2.3.5(a) of this Part are to be examined and tested in accordance with the approval plans, and

(ii) Propeller shaft survey as per 2.3 of this Part will be required if the last propeller shaft survey was carried out more than 5 years prior to the initial survey, or

(iii) The propeller shaft survey may be waived subject to satisfactory review of the following records:

(1) Six-monthly records of stern bearing oil analysis for water and metal contents, covering the last 5 years.

(2) Monthly records of stern bearing oil consumption, covering the last 5 years.

(3) Monthly records of stern bearing temperature monitoring, covering the last 5 years.

(4) Propeller shaft, stern bearing assembly and propeller operation and repair records, if available.

(5) Records of stern bearing clearance and weardown measurement from new building and last dry docking.

2.3.6 Survey in place

The scope of a surveys of propeller shafts and tube shafts in place consists of:

(a) Checking of the clearances of the stern tube shafts,

(b) Checking of the tightness of the oil sealing glands,

(c) Examination of propeller,

(d) Where a controllable pitch propeller is fitted, it is to be ascertained that the pitch control device is in good working order, and if considered necessary, the device is to be opened up for further examination.

2.3.7 Wear-down Limits

(a) The after water-lubricated bearing other than rubber is to be rebushed when clearance has reached the maximum allowable wear-down limit as follows:

	Machinery amidship: C	Machinery after: C
D ≤ 230	6.4 mm	4.8 mm
230 < D ≤ 305	8.0 mm	6.4 mm
305 < D	9.5 mm	8.0 mm
D = Diameter of propeller shaft, in mm. C = Max. allowable wear-down limit, in mm.		

(b) Water lubricated rubber bearing are to be rebushed when any water groove is 50% of the original depth, or whenever the clearance exceeds the limits as given in (a) above for water-lubricated bearings other than rubber, whichever occurs first.

(c) Oil-lubricated bearings are to be rebushed when the wear down exceeds manufacturer's recommendations.

2.4 Boiler Survey and Thermal Oil Heater Surveys

2.4.1 Boiler Surveys

(a) At each survey, boilers, superheaters, and economizers are to be examined internally and externally in cleaned condition, including seat buffers and stays, if provided.

(b) Boiler mountings including safety valves are to be examined and opened up for further examination if deemed necessary by the Surveyor. Safety valves are to be set as the requirements in Part V of the Rules for Steel Ships. All studs fastening directly to boiler shells or heads, if provided, are to be examined.

(c) In case the dimensions of boiler plates, tubes and stays are required to be ascertained, an efficient non-destructive examination is to be carried out. The allowable working pressure may be required to reduce from its designed working pressure if the dimension is found to be undersized due to corrosion or waste.

Boiler safety valve relieving gear (easing gear) is to be examined and tested to verify satisfactory operation. This test is to be carried out prior to any safety valve operation or setting test under steam.

For waste heat boilers, if steam cannot be raised at port, the safety valves may be tested and set by the Chief Engineer at sea, and the results recorded in the log book for review by the Surveyor.

(d) The oil fuel burning system together with its safety appliances, valves, control gears, oil discharge pipes between pumps and burners are to be examined under working condition.

(e) Automatic combustion control devices, if provided, are to be tested under working condition.

(f) In case an important repair carried out or if deemed necessary by the Surveyor, the hydraulic test may be required.

Note: Hydraulic test pressures are as follows:

Boiler's age	Test pressure	Remarks
Age < 12 years	$P = 1.25\ P_o$	$P_o \le 4$ MPa
	$P = 1.2\ P_o + 0.2$	$P_o > 4$ MPa
Age ≥ 12 years	$P = 1.15\ P_o$	

P_o is the working pressure.

(g) In fired boilers employing forced circulation, the pumps used for this service are to be opened and examined at each Boiler Survey.

(h) Annual Examination

External examination of boilers including test of safety and protective devices, and test of safety valve using its relieving gear, is to be carried out within the window of the Annual Survey of the craft.

(i) Survey extensions

An extension may be granted by the Surveyor after the following is satisfactorily carried out:

(i) External examination of the boiler

(ii) Boiler safety valve relieving gear (easing gear) is to be examined and operationally tested

(iii) Boiler protective devices (alarms and shutdowns) operationally tested

(iv) Review of the following records since the last Boiler Survey:

Operation record, maintenance record, repair history record, and feedwater chemistry record.

(j) Auxiliary Boiler Alternative Survey Program

Craft with an approved program of Preventative Maintenance will be given special consideration for an alternative survey program of auxiliary boilers at the first Boiler Survey carried out during each 5-year Special Survey period. The Boiler Survey carried out in conjunction with the Special Survey is not eligible for the alternative survey program.

2.4.2 Thermal Oil Heater Surveys

(a) Thermal oil plants are to be subjected to functional tests, while in operation.

(b) The following items are to be examined:

(i) The entire thermal oil plant for leakage.

(ii) The condition of the insulation.

(iii) The functioning of the indication, control and safety equipment.

(iv) Remote controls for the shut-off and discharge valves.

(v) Leakage monitors for heaters (for exhausting gas heating).

(vi) The testing of safety devices.

(c) Heating surfaces and, where appropriate, the combustion chamber, are to be examined for contamination, corrosion, deformations and leakage.

(d) As a rule, tightness tests are to be carried out to the admissible working pressure.

2.5 Annual Surveys

2.5.1 Annual Surveys - hull

At each Annual Survey, the general condition of hull and equipment is to be examined so far as can be seen and placed in satisfactory condition as necessary, attention being paid to the following items:

(a) Examination of weather decks, ship side plating above water line, hatch covers and coamings and watertight penetrations.

(i) Confirmation is to be obtained that no unapproved changes have been made to the hatch covers, hatch coamings and their securing and sealing devices since the last survey.

(ii) Where mechanically operated steel covers are fitted, checking the satisfactory condition, as applicable, of:

(1) Hatch covers;

(2) Tightness devices of longitudinal, transverse and intermediate cross junctions (gaskets, gasket lips, compression bars, drainage channels);

(3) Clamping devices, retaining bars, cleating;

(4) Chain or rope pulleys;

(5) Guides;

(6) Guide rails and track wheels;

(7) Stoppers, etc;

(8) Wires, chains, gypsies, tensioning devices;

(9) Hydraulic system essential to close and securing;

(10) Safety locks and retaining devices.

(iii) Where portable covers, wooden or steel pontoons are fitted, checking the satisfactory condition, where applicable, of:

(1) Wooden covers and portable beams, and their securing devices;

(2) Steel pontoons;

(3) Tarpaulins;

(4) Cleats, battens, wedges;

(5) Hatch securing bars and their securing devices;

(6) Loading pads/bars and the side plate edge;

(7) Guide plates and chocks;

(8) Compression bars, drainage channels and drain pipes (if any).

(iv) Checking the satisfactory condition of hatch coaming plating and their stiffeners,where applicable.

(v) Random checking of the satisfactory operating of mechanically operated hatch covers is to be made including:

(1) Stowage and securing in open condition;

(2) Proper fit and efficiency of sealing in closed condition; and

(3) Operational testing of hydraulic and power components, wires, chains and link drives.

(vi) Examination of the weld connection between air pipes and deck plating.

(vii) External examination of all air pipe heads installed on the exposed decks.

(viii) Examination of flame screens on vents to all bunker tanks.

(ix) Examination of ventilators, including closing devices, if any.

(b) Suspect Areas and Examination of Ballast Tanks

(i) Suspect Areas identified at previous surveys are to be examined. Thickness measurements are to be taken of the areas of substantial corrosion and the extent of thickness measurements is to be increased to determine areas of substantial corrosion. Table I 2-3 may be used as guidance for these additional thickness measurements. These extended thickness measurements are to be carried out before the Annual Survey is credited as completed.

(ii) Examination of ballast tanks when required as a consequence of the results of the Special Survey and Intermediate Survey is to be carried out. When considered necessary by the Surveyor, or where extensive corrosion exists, thickness measurement is to be carried out. If the results of these thickness measurements indicate that Substantial Corrosion is found, then the extent of thickness measurements is to be increased to determine areas of substantial corrosion. Table I 2-3 may be used as guidance for these additional measurements. These extended thickness measurements are to be carried out before the Annual Survey is credited as completed.

(c) Protection of other openings

(i) Hatchways, manholes, and scuttles in freeboard and superstructure decks.

(ii) Machinery casings, fiddley covers, companion-ways and deckhouses protecting openings in freeboard or enclosed superstructure decks.

(iii) Portlights together with dead covers, cargo ports, bow or stern access, chutes and similar openings in craft's sides or ends below the freeboard deck or in way of enclosed superstructures.

(iv) Ventilators, air pipes together with flame screens, scuppers and discharges serving spaces on or below the freeboard deck.

(v) Watertight bulkheads, bulkhead penetrations and wall of enclosed superstructure.

(vi) Weather-tight and watertight doors and closing appliances for all of the above including proper operation of such doors.

(d) Freeing ports together with bars, shutters and hinges.

(e) Protection of the crew

Guard rails, lifelines, gangways, accommodation ladders with accessory wires, winches and gears and deck houses accommodating crew.

(f) Verification of loading guidance and stability data

(i) For craft provided with the loading manual continuous such means in ready use.

(ii) For craft provided with the loading computer, if any, confirmed that a loading computer installed on board has the performance and functions as deemed appropriate by the Society.

(iii) Confirmed that an approved stability booklet is kept on board for ready use.

(g) Verification that no alterations have been made to the hull or superstructures which would affect the calculation determining the position of load lines. The load line marks (see Appendix 3) are to be sighted, found plainly visible, and recut and/or painted as required. Surveys carried out by the National Authorities of the countries in which the craft are registered may be accepted as meeting these requirements.

(h) Anchoring and mooring equipment including the working test of windlass.

(i) Bow doors, inner doors, side shell doors and stern doors are to be surveyed as per Annual Survey, if any, see IACS UR Z24-4.

(j) Fire protection and fire fighting arrangements including operation tests as far as practicable

Confirmation as far as practicable, that no significant changes have been made to the arrangement of structural fire protection is also to be carried out. Surveys carried out by the National Authorities of the countries in which the craft are registered may be accepted as meeting these requirements.

(k) Additional requirements for navigational arrangements for periodical one man watch, and where applicable integrated bridge system. Annual Surveys are to be carried out to ascertain that the equipment and arrangements required for the applicable class notation are being maintained in good working order. At the time of the survey relevant statutory certificates may be accepted as evidence of satisfactory operation.

(l) Helicopter deck

Where areas of the craft are designated for helicopter operations, the helicopter deck, deck supporting structure, deck surface, deck drainage, tie downs, markings, lighting, wind indicator, securing arrangements where fitted and safety netting or equivalent are to be examined.

(m) Craft constructed of Fiber Reinforced Plastics (FRP)

In addition to the applicable requirements of the annual survey - hull is also to include the following:

(i) All accessible parts particularly liable to rapid deterioration.

(ii) The deck to hull connection, and superstructure and deckhouse connections to the deck.

2.5.2 Annual Survey – machinery

At each Annual Survey, the following requirements are to be complied with:

(a) At each Annual Survey, a general examination of the propelling machinery and essential auxiliaries, is to be made. The Surveyor may in addition, require such further items to be opened up as considered necessary to ascertain that they are in good working condition.

(b) Machinery and boiler spaces with particular attention to the fire and explosion hazards, and also emergency escape routes are to be generally examined.

(c) All main and auxiliary steering gears including their associated and control systems are to be examined and tested in operation.

(d) All the means of communication between the navigation bridge and the machinery control position, as well as the bridge and the alternative steering position, if fitted, are to be tested.

(e) Bilge pumping systems and bilge wells including operation of pumps, remote reach-rods and level alarms, where fitted, are to be examined as far as practical.

(f) Boilers, thermal oil heaters heated by flame or combustion gas, pressure vessels and their mountings including safety devices, foundations, controls, releasing gear, high pressure and steam escape piping, insulation and gauges are to be externally examined. Confirmation of the safety devices of the boilers and the thermal oil heaters may be required as considered necessary by the Surveyor.

In addition, boilers are to be examined in accordance with 2.4.1(h) of this Chapter.

(g) Electrical machinery, emergency sources of electrical power switchgear and other electrical equipment are to be generally examined and also to be tested in operation as far as practicable.

(h) Confirmation as far as practicable of the operation of all emergency sources of power is to be made. If they are automatic, also in the automatic mode.

(i) Where automatic and/or remote controls are fitted for essential machinery, they are to be tested to demonstrate that they are in good working condition.

(j) Parts which are opened up for maintenance at Owner's option are to be examined as necessary.

(k) For hydraulic power units, hoses, piping for any damage, corrosion or leakages, and hydraulic oil cooling system condition and operation are to be checked. Operational test of all emergency stops, controls and remote controls are also to be checked.

2.5.3 Annual Survey – **CAS**, **CAU** and **CAB**

The following performances are to be made and placed in order. Where appropriate records of daily checks and periodical maintenance have been kept, some of the tests may be dispensed with at the Surveyor's discretion.

(a) Safety devices for main propulsion machinery or controllable pitch propellers, and emergency stopping devices for main propulsion machinery fitted in the remote control station for the main propulsion machinery or controllable pitch propellers.

(b) Safety devices for boilers.

(c) Safety devices for electric generating sets.

(d) Communication system specified in 2.5.9 in Part VII of the Rules for Steel Ships.

2.5.4 Annual Survey - marine oil pollution prevention installations

Marine oil pollution prevention installations including operation tests as far as practicable are to be surveyed according to the IMO Resolution A.1053(27) - Guidelines for Surveys under Annex I of MARPOL 73/78 with its amendments. Surveys carried out by the National Authorities of the countries in which the craft are registered may be accepted as meeting these requirements.

2.6 Intermediate Surveys

2.6.1 A survey planning meeting is to be held prior to the commencement of the survey.

2.6.2 Concurrent crediting to both Intermediate Survey (IS) and Special Survey (SS) for surveys and thickness measurements of spaces are not acceptable.

2.6.3 At each Intermediate Survey for hull, in addition to all the requirements for Annual Survey in 2.5, the following additional applicable requirements are also to be complied with:

(a) For craft between 5 and 10 years of age, a general, internal examination of representative ballast tanks is to be carried out. If there is no hard protective coating, soft or semi-hard coating, or POOR coating condition without dealing with is found, the examination is to be extended to other ballast spaces of the same type.

(b) For craft over 10 years of age, a general, internal examination of all spaces used for water ballast is to be carried out.

(c) If such examinations, in 2.6.3(a) and (b) above, reveals no visible structural defects, the examination may be limited to a verification that the coatings remain efficient.

(d) For ballast tanks, excluding double bottom tanks, if there is no hard protective coating, soft or semi-hard coating or Poor coating condition without dealing with is found, the spaces in question are to be internally examined at annual intervals.

(e) When such conditions, in 2.6.3(d) above, are found in water ballast double bottom tanks, the spaces in question may be internally examined at annual intervals.

(f) In the case of dry cargo craft over 15 years old, an internal examination of selected cargo holds is to be carried out.

(g) In the case of craft over 10 years of age, other than craft engaged in the carriage of dry cargoes only, an internal examination of selected cargo spaces is to be carried out.

2.6.4 Intermediate Survey – machinery

(a) At each Intermediate Survey, all the requirements for Annual Survey are to be complied with.

2.6.5 Intermediate Survey – marine oil pollution prevention installations

Marine oil pollution prevention installations including operation tests as far as practicable are to be surveyed according to the IMO Resolution A.1053(27) – Guidelines for Surveys under Annex 1 of MARPOL 73/78 with its amendments. Surveys carried out by the National Authorities of the countries in which the ship are registered may be accepted as meeting these requirements.

2.7 Special Surveys

Procedures for class related services, see 2.1.4 of this Chapter.

Provision for surveys, see 2.1.5 of this Chapter.

A Survey planning meeting is to be held prior to the commencement of the survey.

Concurrent crediting to both Intermediate Survey (IS) and Special Survey (SS) for surveys and thickness measurements of spaces are not acceptable.

2.7.1 Special Survey - hull

All Annual Survey requirements together with the following are to be complied with:

(a) The examinations of the hull are to be supplemented by thickness measurements and testing as required in 2.7.1(j) and 2.7.1(k), to ensure that the structural integrity remains effective. The aim of the examination is to discover Substantial Corrosion, significant deformation, fractures, damages or other structural deterioration, that may be present.

(b) A Bottom Survey in dry dock in accordance with the requirements of 2.2.1 of this Chapter is to be carried out as part of the Special Survey.

(c) The anchors and chain cables are to be ranged, examined and the required complement and condition verified. The chain locker, holdfasts, hawse pipes and chain stoppers are to be examined and pumping arrangements of the chain locker tested.

At Special Survey No. 2 and subsequent Special Surveys, chain cables are to gauged and renewed in cases where their mean diameter is 12% worn below the requirement limits allowed by the Society.

(d) All spaces including holds and their 'tween decks where fitted; double bottom, deep, ballast, peak tanks; pipe tunnels, duct keels, machinery spaces, dry spaces, cofferdams and voids are to be internally examined including the plating and framing, bilges and drain wells, sounding, venting, pumping and drainage arrangements.

Internal examination of fuel oil, lube oil and fresh water tanks is to be carried out in accordance with Table I 2-1.

At Special Survey No.3 and subsequent Special Surveys, structural downflooding ducts and structural ventilation ducts, where applicable, are to be internally examined.

(e) Engine room structure is to be examined. Particular attention is to be given to tank tops, shell plating in way of tank tops, brackets connecting side shell frames and tank tops, and engine room bulkheads in way of tank top and bilge wells. Particular attention is to be given to the sea suctions, sea water cooling pipes and overboard discharge valves and their connections to the shell plating. Where wastage is evident or suspect, thickness measurements are to be carried out, and renewals or repairs made when wastage exceeds allowable limits.

(f) Where provided, the condition of corrosion prevention system of ballast tanks is to be examined. For ballast tanks, excluding double bottom tanks, where a hard protective coating is found in POOR condition without dealing with is found, where soft or semi-hard coating has been applied, or where a hard protective coating was not applied from time of construction, the tanks in question are to be examined at annual intervals. Thickness measurements are to be carried out as deemed necessary by the Surveyor.

(g) When such breakdown of hard protective coating is found in double bottom ballast tanks and it is not renewed, where a soft or semi-hard coating has been applied, or where a hard protective coating was not applied from the time of construction, the tanks in question may be examined at annual intervals. When considered necessary by the Surveyor, or where extensive corrosion exists, thickness measurements are to be carried out.

(h) Extent of Tank Testing

(i) Boundaries of double-bottom, deep, ballast, peak, and other tanks, including holds adapted for the carriage of salt water ballast, are to be tested with a head of liquid to the top of air pipes. or to near the top of hatches for ballast/cargo holds.

(ii) Boundaries of fuel oil, lube oil and fresh water tanks are to be tested with a head of liquid to the highest point that liquid will rise under service conditions.

(iii) Tank testing of fuel oil, lube oil and fresh water tanks may be specially considered based on a satisfactory external examination of the tank boundaries, and a confirmation from the Master stating that the pressure testing has been carried out according to the requirements with satisfactory results. The Surveyor may extend the testing as deemed necessary.

(i) Hatch covers and coamings are to be surveyed as follows:

(i) A thorough inspection of the items listed in 2.5.1(a), including close-up survey of hatch cover plating and hatch coaming plating, is to be carried out.

Subject to cargo hold hatch covers of approved design which structurally have no access to the internals, close-up survey shall be done of accessible parts of hatch covers structures.

(ii) Checking of the satisfactory operation of all mechanically operated hatch covers is to be made, including:

(1) Storage and securing in open condition;

(2) Proper fit and efficiency of sealing in closed condition;

(3) Operational testing of hydraulic and power components, wires, chains, and link drives;

(iii) Checking the effectiveness of sealing arrangements of all hatch covers by hose testing or equivalent is to be carried out.

(j) Thickness measurements are to be carried out in accordance with Table I 2-2. The Surveyor may extend the thickness measurements as deemed necessary. When thickness measurements indicate substantial corrosion, the extent of thickness measurements is to be increased to determine areas of substantial corrosion. Table I 2-3 may be used as guidance for these additional thickness measurements. These extent of thickness measurements are to be carried out before the survey is credited as completed. The wastage allowances are as given in Table I 2-5 to Table I 2-7.

(k) All bilge and ballast piping systems are to be examined and operationally tested to working pressure to the attending Surveyor's satisfaction to ensure that tightness and condition remain satisfactory.

(l) For all craft except for passenger craft, automatic air pipe heads are to be completely examined (both externally and internally) as indicated in Table I 2-4.
For designs where the inner parts cannot be properly inspected from outside, this is to include removal of the head from the air pipe. Particular attention is to be paid to the condition of the zinc coating in heads constructed from galvanized steel.

(m) When spaces are insulated in connection with refrigeration, hatches and limbers are to be removed and the condition of the structural members examined.

(n) Gangways, accommodation ladders with accessory wires, winches and gears are to be load tested and operationally tested with maximum operational load.

(o) Bow doors, inner doors, side shell doors and stern doors are to be surveyed as per Special Survey, see IACS UR Z24-3.

2.7.2 Special Survey–machinery

(a) Pumps and the pumping system including valves, cocks, pipes and strainers are to be examined. For hydraulic power units, records of hydraulic oil replacement are to be checked. Oil samples for analysis may be required at the discretion of the Society. Other systems are to be tested if considered necessary.

(b) All shafts (except propeller and stern tube shafts which are detailed in propeller shaft survey), thrust blocks, line shaft bearings are to be opened up for examination. The lower halves of bearings need not be exposed if alignment and wear are found acceptable.

(c) Steering machinery including auxiliary arrangement is to be examined and operation tested. The machinery may be opened up for examination if deemed necessary by the Surveyor.

(d) Holding down bolts and chocks of main and auxiliary engines and shafting bearing blocks are to be examined.

(e) All air vessels for essential services, together with their mountings, valves and safety devices, are to be cleaned internally, and examined internally and externally. If internal examination of the air vessels is not practicable, they are to be tested hydraulically to at 1.25 times the working pressure. Safety valves setting are to be checked.

(f) Fuel tanks which do not form part of craft's structure together with their fittings are to be examined and, if deemed necessary by the Surveyor, they are to be tested as specified for new tanks.

(g) The reduction gears are to be examined, and opened up if deemed necessary by the Surveyor, in order to confirm the condition of the gears, pinions, gear teeth, spiders, shafts, bearings and lubrication system. Alternative means of accertaining the condition of epicyclic gearing will be specially considered.

(h) The machinery and heat exchangers which are not included in the boiler survey requirements are to be examined and opened up for further examination if deemed necessary by the Surveyor.

(i) The windlass and mooring winches are to be examined including operation test. They are to be opened up for examination if deemed necessary by the Surveyor.

(j) The bilge system including valves, cocks, strainers and bilge injections are to be opened up for examination if deemed necessary by the Surveyor. The system is to be tested in working condition.

(k) Air compressor of essential services is to be examined. Safety valve setting is to be checked.

(l) Evaporators are to be opened up and examined. Safety valve settings are to be checked.

(m) Main and auxiliary engines are to be tested in working condition if deemed necessary by the Surveyor.

(n) Engine room remote control quick closing valves are to be opened up, examined and tested in working condition.

(o) Feed pumps, burning pumps and boiler water circulating pumps for boilers are to be opened up and examined.

(p) Steam turbines

In addition to the foregoing items (a) to (o) of 2.7.2 above, steam turbines used as main and auxiliary engines are to be examined as follows:

(i) Steam turbine blades, rotors, stop valves, shafts glands, thrust and adjusting bearings together with oil drains and sealing pipes are to be examined.

(ii) Exhaust steam turbines, gears, clutches, and electric motors are to be opened up and examined; coned ends of internal driving shafts are to be examined.

(iii) For main steam pipes, a selected section is to be removed and examined when they are 12 years old and thenceforth at each Special Survey. Sufficient lagging is to be removed for examination and hydraulically tested to twice the working pressure. When deemed necessary by the Surveyor the thickness of pipes is to be ascertained to determine the future working pressure.

(iv) Condensers are to be examined and tested if repaired.

(v) Safety devices are to be examined and tested.

(q) Diesel engine

(i) In addition to the foregoing items (a) to (o) of 2.7.2 above, diesel engines used as main and auxiliary engines are to be examined as follows:

Cylinders, covers, valves and valve gears, pistons, piston rod, crossheads, guides, connecting rods, crankshafts and all bearings, crankcases, bed-plates, entablatures, crankcase door fastenings and explosion relief devices, scavenge pumps, scavenge blowers, superchargers and their associated coolers, air compressors and their intercoolers, filters and/or separators and safety devices, fuel injection pumps and fittings, camshaft drives and balancer units, torsional vibration dampers or de-tuners, flexible couplings, clutches, reverse gears, attached pumps and cooling arrangements are to be examined.

Special consideration as to the requirements for Special Surveys may be given for diesel engines with bores 300 mm or under, provided the engine is maintained under a manufacturer's scheduled maintenance program.

(1) The records of the program, including lubrication servicing, are to be made available to the Surveyor. Periodical overhauls, required by the manufacturer's scheduled maintenance program, are to be witnessed by the Surveyor.

(2) For craft not engaged in international voyages, the survey may be carried out by reviewing the records of the program and other effective means, such as the verification runs specified in (s) of 2.7.2 below, to confirm that engines are in good order. Periodical overhauls, required by the manufacturer's scheduled maintenance program, are to be witnessed by the Surveyor.

(ii) Tie rods are to be re-tensioned, as necessary. Engine entablature bolting is to be checked for tightness, and crankshaft deflections of medium-speed and low-speed type engines are to be measured and placed in good order.

(r) Electrical installations.

(i) The survey is to comprise examination of the electrical installation with regard to fire and explosion hazards and injury from accidental touching. The survey is also to include testing of correct functioning of equipment covered by the requirements of the Rules.

(ii) As far as practicable, the following equipment is to be examined for satisfactory condition:

(1) Main and emergency switchboards.

(2) Generators.

(3) Distribution boards.

(4) Motor starters.

(5) Electrical motors.

(6) Converters (e.g. transformers, rectifiers, chargers).

(7) Cable installations.

(8) Enclosures for electrical equipment.

(9) Lighting equipment.

(10) Heating equipment.

(11) Battery installation.

(iii) The following are to be tested to the extent deemed necessary by the Surveyor to ascertain the proper functioning of the equipment:

(1) Generator load test.

(2) Generator parallel operation.

(3) Generator protection relays.

(4) Generator remote speed control.

(5) Generator synchronizing equipment.

(6) Power plant interlocking systems.

(7) Insulation resistance indicating device.

(8) Emergency generator including switchboard.

(9) Battery chargers.

(10) Mechanical ventilation of battery rooms /lockers.

(11) Navigation lights, with controllers including alarms.

(iv) Measurements of insulation resistance on main and emergency switchboards, generators, exciters, propulsion motors if the craft is of electrical propulsion and all electrical installations and their wiring are to be performed as follows:

Part to be tested	Insulation resistance	
Switchboard with all out-going circuit breakers and switches opened, and control and measuring instrument disconnected	Between each busbar, and busbar to hull	1 megohm
Generator and motor	Each generator or motor to hull	1,000 times the rated voltage of the machine in ohms
All wiring measured from switchboard with circuit breakers and protective devices closed, except those of the generator	Between each conductor and conductor to hull	100,000 ohms

(v) Tests of emergency stopping means of all oil transfer systems, and boiler and engine room ventilations are to be performed.

(vi) For the main electric propelling machinery, windings, commutators and slip-rings, all air ducts in stator coil and ventilating holes in rotors are to be examined.

(s) Machinery verification runs for craft not engaged in international voyages

As part of the Special Survey of machinery, a dock trial in the presence of the Surveyor is to be carried out in order to confirm satisfactory operation of main and auxiliary machinery. A sea trial may be carried out if deemed necessary by the Surveyor.

If significant repairs are carried out to main or auxiliary machinery or steering gear, consideration should be given to a sea trial to the satisfaction of the Surveyor.

2.7.3 Special Survey – **CAS**

The following are to be performance tested and placed in order:

(a) Main propulsion machinery and controllable pitch propellers
  (i) Change-over devices of control positions between main control station and local control station.
  (ii) Safety devices.

(b) Boilers
  (i) Automatic and remote control systems.
  (ii) Safety devices.

(c) Electric generating sets
  (i) Automatic and remote control systems.
  (ii) Safety devices.

(d) Automatic change-over devices (or remote start/stop devices) of essential pumps and automatic starting devices (or remote start/stop devices) of air compressors.

(e) Alarm systems
  (i) Function of alarm systems and indicator devices.
  (ii) Confirmations of setting points of alarms.

(f) Remote control and monitoring systems

2.7.4 Special Survey – **CAU**, **CAB**

The following are to be performance tested and placed in order:

(a) Main propulsion machinery and controllable pitch propellers
  (i) Change-over devices of control positions between navigation bridge and main control station and between main control station and local control station, or between main monitoring and control station on bridge and local station or sub-control station.
  (ii) Safety devices.

(b) Boilers
  (i) Automatic and remote control systems.
  (ii) Safety devices.

(c) Electric generating sets
  (i) Automatic and remote control systems.
  (ii) Safety devices.
  (iii) Automatic start of stand-by power supply unit after black-out, where applicable.

(d) Automatic change-over devices of essential pumps and automatic starting devices (or remote start/stop devices) of air compressors.

(e) Communication systems specified in 2.9 of Part VIII of the Rules for Steel Ships.

(f) Alarm systems
  (i) Function of alarm systems and indicator devices.
  (ii) Confirmations of setting points of alarms.

(g) Remote control and monitoring systems

Where considered necessary by the Surveyor, sea trials may be required upon completion of the above mentioned tests.

2.7.5 Special Survey – marine oil pollution prevention installations

Marine oil pollution prevention installations including operation tests as far as practicable are to be surveyed according to the IMO resolution A.1053(27) – Guidelines for Surveys under Annex I of MARPOL 73/78 with its amendments. Surveys carried out by the National Authorities of the countries in which the craft are registered may be accepted as meeting these requirements.

2.8 Classification Survey of Craft not Built under Survey

2.8.1 The following drawings and documents, necessary for classification purpose, are to be submitted as far as practicable together with the application for classification:

(a) Hull

(i) General arrangement.
(ii) Mid-ship section.
(iii) Scantling profile and deck plans.
(iv) Shell expansion.
(v) Capacity plan.
(vi) Piping and pumping diagrams.
(vii) Rudder and stern frames.
(viii) Data of chain cable and anchor.
(ix) Lines and hydrostatic curves (if freeboard assignment is required).
(x) Loading and stability information (i.e. loading manual).
(xi) Outfitting arrangement of craft's side fittings.

(b) Machinery

(i) Engine room arrangement.
(ii) Piping system in engine room.
(iii) Detail and arrangement of propulsion shafting.
(iv) Machinery particulars.
(v) General arrangement of electric equipment.
(vi) Electric wiring diagram of power, lighting and interior communication system.
(vii) Electric equipment particulars.
(viii) Main switchboard.

(c) **CAS/CAU/CAB**

(i) Machinery arrangement plans showing location of control stations in relation to controlled units.
(ii) Arrangements and details of control consoles including front view, installation arrangements together with schematic diagrams for all power, control and monitoring systems including their functions.
(iii) Kinds and sizes of all electrical cables and wiring associated with control systems including voltage rating, service voltage and currents together with overload and short circuit protection.
(iv) Schematic plans of hydraulic and pneumatic control systems together with all interconnections, piping sizes and materials including working pressures and relief valve settings.
(v) Description of all alarms and emergency tripping arrangements, functional sketches or description of all special valves, actuators, sensors and relays.
(vi) Schematic plans and supporting data of fire protection and extinguishing systems, including fire detection and alarm system, bilge high water level alarms.

2.8.2 Craft without classification

For the craft which have not been classed with any other Classification Society, all surveys to the extent as specified in the Rules, are to be carried out by the Surveyor who is to take into account the age, the standard of construction, the past maintenance, and the present status of the craft concerned.

2.8.3 Craft with classification

If the craft keeps the Class of another recognized Classification Society with sufficient status, in general, a survey to the extent of the Special Survey corresponding to the craft's age is to be conducted except the craft being within 3 months of the due date of Special Survey. Some Special Survey items may be omitted by the Surveyor in view of the craft's condition. In such case, the period of class is to remain as assigned by the previous Classification Society.

2.8.4 Subsequent surveys

Subsequent surveys are to be carried out as in the case of craft built under survey.

2.9 Hull Surveys of High-Speed Craft

2.9.1 Annual Survey

(a) For craft of fiber reinforced plastic (FRP) construction, in addition to the applicable requirements of 2.5 of this Part, the Annual Survey - Hull is to include the following:

(i) All accessible parts particularly liable to rapid deterioration.

(ii) The craft is to be placed in dry dock or slipway and all applicable items of the Annual Survey - Hull are to be examined.

(iii) The deck-to-hull connection, and superstructure and deckhouse connections are to be examined.

(iv) The craft is to be thoroughly checked and sounded for any apparent delaminations.

Where it is thought a delamination is found, a 50 mm diameter plug is to be removed from the area and examined for core to skin adhesion and water permeation.

(b) For craft of aluminum alloys construction, in addition to the applicable requirements of 2.5 of this Part, the Annual Survey - Hull is to include the following:

(i) All parts liable to rapid deterioration, particularly areas adjacent to dissimilar metals which are in close proximity.

(ii) In lieu of ballast tanks and combined cargo/ballast tanks, internal structure of a randomly selected cargo space, dry or liquid, together with any other space deemed necessary by the Surveyor, with particular attention to be given to bilges and drain wells.

(c) For craft subject to the HSC Code, in addition to the applicable requirements of.2.5 of this Part, Bottom Survey in dry dock is to be a part of the Annual Survey as required by 2.2.1 of this Part.

2.9.2 Special Survey

In addition to the Annual Survey in 2.9.1 above and the applicable requirements of Special Survey in 2.7 of this Part, the Special Survey is to include the following:

(a) Requirements for craft of fiber reinforced plastic (FRP) Construction

(i) Engine foundations and their attachments to the hull are to be examined.

(ii) A minimum of five plugs, each 50.8 mm in diameter, are to be removed from the hull bottom and topsides from locations deemed appropriate from the attending Surveyor and examined for core to skin adhesion and water permeation.

(iii) The framing and holds, hull laminate of the tween deck, deep tanks, peaks, bilges and drain wells, and machinery spaces are to be cleaned and examined. Linings, ceiling, tanks, and portable ballast are to be removed as considered necessary by the attending Surveyor.

(iv) Where there is evidence of cracking, distortion, wetness, or delamination, destructive or nondestructive testing and removal and repair of the defect is subject to the discretion of the attending Surveyor.

(v) The hull, fastenings, and backing reinforcements in way of hull fittings and attachments are to be examined. Fastenings are to be withdrawn as considered necessary by the attending Surveyor.

(vi) The efficiency of hand pumps or other drainage arrangements for end spaces is to be tested.

(vii) Additionally for Sailing and Unpowered craft, where applicable, ballast-keel fastenings and all openings to the sea, including sanitary and other overboard discharges, together with the cocks and valves connected therewith, are to be examined while the craft is in dry dock.Mast foundation and connection to the hull are to be examined.

(b) Requirements for craft of aluminum alloys construction

In addition to the applicable requirements of Special Survey in 2.7, particular attention is to be given to insulation material in joints of shell connections between dissimilar metals, which is to be found or made effective as necessary.

2.10 Surveys of Passenger Craft

2.10.1 General

These requirements apply to craft carrying more than 12 passengers. Passenger craft are subjected to the following periodical surveys:

(a) Annual Survey

(b) Intermediate Survey

(c) Bottom Survey

(d) Special Survey

(e) Boiler Survey

(f) Propeller Shaft Survey

2.10.2 Annual Survey:

In addition to the requirements of Annual Survey in 2.5, following items are also to be carried out:

(a) Hull:

(i) Bottom survey in dry dock or in water.

(ii) Inspection of the piping and valves of cross flooding system and operation tests of its remote control system. Main valves for the system are to be overhauled and inspected.

(iii) Inspection and operation test of door indicators and water leakage detectors of shell doors.

(iv) Inspection of discharge pipes and valves on shells below bulkhead deck. These valves are to be overhauled and inspected, but may be dispensed with when the bottom survey was carried out in water.

(v) Inspection and tightness test of the fixed parts of fin-stabilizers.

(vi) Inspection of all shell connections below bulkhead deck.

(vii) Inspection of gangways, all shell ports (cargo ports included), ash and rubbish chutes below the bulkhead deck.

(viii) Inspection of portlights including deadlights and securing arrangements below the bulkhead deck.

(ix) Inspection of all openings and their closures in watertight bulkheads below the bulkhead deck including watertight doors and operation of same.

(x) The escapes and any cross-flooding arrangement are to be checked.

(b) Machinery:

(i) Sea trials are to be carried out, if deemed necessary by the Surveyor.

(ii) The ability of the propulsion machinery to reverse the direction of the thrust of propellers and the ability to stop the craft are to be tested and verified.

(iii) Inspection of main and emergency electric power, and emergency lighting system.

(iv) Inspection of flooding detection system and/or water ingress alarm system for each watertight spaces below the bulkhead deck.

(c) Fire Protection and Fire Extinguishing System:

(i) Inspection of the general alarm system, fire alarm system, fire detection system, public addressing system, fire doors, fire dampers, draft stops and fire divisions.

(ii) Inspection and operation test of water sprinkler system including it's piping , valves, alarm system and automatic starting of fire pumps. Pressure tanks, if any, are to be pressure tested.

2.10.3 Intermediate and Special Survey

In addition to the requirements of Special Surveys in 2.7 and Annual Survey in 2.10.2 above, following items are also to be complied with.

(a) Hull:

(i) Check the light weight of the ship.

The light weight of the craft is to be checked during Special Survey. If the major conversion is found during Annual Survey or Intermediate Survey, the light weight of the craft is to be checked by the attending Surveyor.

Inclining experiments are to be carried out whenever the light weight is different from record by 2% or more or the longitudinal center of gravity is different from record by 1% of craft's length or more.

(b) Bottom Survey in dry dock is to be a part of Intermediate or Special Survey.

While the thickness measurements is carried out, if substantial corrosion is found, the extent of thickness measurements is to be increased in accordance with the requirements of Table I 2-3. Tanks or areas where coating was found to be in GOOD condition at the previous intermediate or periodical survey may be specially considered by the Society.

(c) For Intermediate Survey - machinery, the requirements of 2.7.2 may be dispensed with at the discretion of the Society or the attending Surveyor.

Table I 2-1
Minimum Requirements for Internal Examination
at Special Surveys of Fuel Oil, Lube Oil and Fresh Water Tanks

Spaces and Tanks [(1),(2),(3)]	SS No. 1 (Age ≤ 5)	SS No. 2 (5 < Age ≤ 10)	SS No. 3 (10 < Age ≤ 15)	SS No. 4 and Subsequent (15 < Age)
Fuel oil bunker tanks				
- Engine room	0	0	1	1
- Cargo length area	0	1	2[(4)]	Half, minimum 2[(4)]
- If no tanks in Cargo Length Area, additional fuel tank(s) outside of Engine Room (if fitted)	0	1	1	2
Lube oil	0	0	0	1
Fresh water	0	1	All	All

Notes:

(1) These requirements apply to tanks of integral (structural) type.

(2) If a selection of tanks is accepted to be examined, then different tanks are to be examined at each Special Survey, on a rotational basis.

(3) Peak tanks (all uses) are subject to internal examination at each Special Survey.

(4) At Special Surveys No. 3 and subsequent surveys, 1 deep tank for fuel oil in the cargo length area is to be included, if fitted.

Table I 2-2
Minimum Requirements for Thickness Measurements at Special Surveys

SS No. 1 (Age ≤ 5)	SS No. 2 (5<Age≤10)	SS No. 3 (10 < Age ≤ 15)	SS No. 4 and Subsequent (15 < Age)
1. Suspect Areas throughout the vessel	1. Suspect Areas throughout the vessel	1. Suspect Areas throughout the vessel	1. Suspect Areas throughout the vessel
	2. One transverse section of deck plating in way of a cargo space within the amidship 0.5L(5)	2. Two transverse sections within the amidship 0.5L in way of 2 different cargo spaces(5)	2. A minimum of 3 transverse sections in way of cargo spaces within the amidship 0.5L(5)
		3. Internals in forepeak and after peak ballast tanks	3. Internals in forepeak and after peak ballast tanks
		4. All cargo hold hatch covers and coamings (plating and stiffeners)	4. All cargo hold hatch covers and coamings (plating and stiffeners)
			5. All exposed main deck plating full length
			6. Representative exposed superstructure deck plating (poop, bridge, and forecastle deck)
			7. Lowest strake and strakes in way of 'tween decks of all transverse bulkheads in cargo spaces together with internals in way(5)
			8. All wind- and water strakes, port and starboard, full length
			9. All keel plates full length. Also, additional bottom plates in way of cofferdams, machinery space, and aft end of tanks
			10. Plating of sea chests. Shell plating in way of overboard discharges as considered necessary by the attending Surveyor

Notes:

(1) Thickness measurement locations are to be selected to provide the best representative sampling of areas likely to be most exposed to corrosion, considering cargo and ballast history and arrangement and condition of protective coatings.

(2) Thickness measurements of internals may be specially considered by the Surveyor if the protective coating is in Good condition.

(3) For craft less than 100 meters in length, the number of transverse sections required at Special Survey No. 3 may be reduced to 1, and the number of transverse sections required at Subsequent Special Surveys may be reduced to 2.

(4) For craft more than 100 meters in length, at Special Survey No. 3, thickness measurements of exposed deck plating within amidships 0.5 L may be required.

(5) For craft without defined cargo spaces, thickness measurements are to be taken at the appropriate, most onerous locations selected to provide the best representative sampling of areas likely to be exposed to corrosion the most.

(6) Subject to cargo hold hatch covers of approved design, which structurally have no access to the internals, thickness measurement shall be done of accessible parts of hatch covers structures.

Table I 2-3
Guidance for Additional Thickness Measurements in way of Substantial Corrosion

Structural Member	Extent of Measurement	Pattern of Measurement
Plating	Suspect area and adjacent plates	5 point pattern over 1 m^2
Stiffeners	Suspect area	3 measurements each in line across web and flange

Table I 2-4
Survey Requirements for Automatic Air Pipe Heads at Special Surveys

SS No. 1 (Age ≤ 5)	SS No. 2 (5 < Age ≤ 10)	SS No. 3 and subsequent (10 < Age)
- 2 air pipe heads, 1 port and 1 starboard, located on the exposed decks in the forward 0.25L, preferably air pipes serving ballast tanks. - 2 air pipe heads, 1 port and 1 starboard, on exposed decks, serving spaces aft of 0.25L, preferably air pipes serving ballast tanks. (1), (2)	- All air pipe heads located on the exposed decks in the forward 0.25L. - At least 20% of air pipe heads on the exposed decks serving spaces aft of 0.25L, preferably air pipes serving ballast tanks. (1), (2)	- All air pipe heads located on the exposed decks. (3)

Notes:

(1) The selection of air pipe heads to be examined is left to the attending Surveyor.

(2) According to the results of this examination, the Surveyor may require the examination of other heads located on the exposed decks.

(3) Exemption may be considered for air pipe heads where there is substantial evidence of replacement after the last Special Survey.

Table I 2-5
Individual Wastage Allowances for Steel Craft, 90 m ≤ L [(5), (6)]

Ordinary and High Strength Steel	Craft of all ages with Transv'ly framing	Craft of all ages with a combination of transverse and longitudinal framing.
Strength Deck Plating	25%	20%
Continuous Long'l Hatch Coamings & Above Deck Box-Girders	25%	20%
Deck Plates within Line of Hatches and at Ends.	30%	30%
Forecastle, Poop and Bridge Deck Plates; Superstructure End Bulkheads	30%	30%
Tween Deck Plates	30%	--
Sheer Strake Plates	25%	20%
Side Shell Plates	25%	25%
Bilge Strake Plates	25%	25%
Bottom Plates	25%	25%
Keel Plates[(4)]		
Outermost Strake of Inner Bottom	30%	30%
Other Plates of Inner Bottom	30%	30%
Top Strake of Longitudinal Bulkheads and Top Strake of Topside Tank Sloping Plating	25%	25%
Bottom Strake of Longitudinal Bulkheads	25%	25%
Other Plates of Longitudinal Bulkheads, Topside Tank Sloping Plating, Hopper Tank Sloping Plating and Transverse Bulkheads	25%	25%
Internals including Longitudinals, Girders, Transverses, Struts, Bulkhead Webs and Stringers, Brackets and Hatch Side Girders	25%	25%
Plates in way of Top of Tanks	30%	30%
Underdeck Box Girders (Long'l or Transverse)	20%	20%
Hatch Covers, Hatch coamings and brackets	30%	30%

Notes:

(1) Internals included in longitudinal strength must be continuous or be effectively developed at ends, throughout amidships 0.4L.

(2) Structure must meet individual member thickness and average wastage.

(3) If design was originally approved on basis of engineering analysis (such as car carriers and other specialized craft), or if owner specially request, the wastage may be assessed on engineering basis (i.e., acceptable stress levels and structural stability).

(4) Keel plates are to be renewed when they reach the minimum allowed thickness for adjacent bottom plating.

(5) The individual wastage allowances are acceptable, provided the hull girder Section Modulus is not less than 90% of the greater Section Modulus required: a) at the time of new construction or b) Z_{min} by 3.2.2 of Part II of the Rules for Steel Ships.

(6) For craft built to other society rules, that society carrying out the initial plan review is to be contacted for wastage allowances.

Table I 2-6
Individual Wastage Allowances for Steel Craft, L < 90 m

Main Deck Plating	25%
Bottom Plating	25%
Keel Plating	25%
Sheer Strake	25%
Bilge Strake	25%
Side Shell Plating	30%
Forecastle	30%
Internals and Bulkheads	30%

For craft built to other society rules, that society carrying out the initial plan review is to be contacted for wastage allowances.

Notes:

(1) Internals included in longitudinal strength must be continuous or be effectively developed at ends, throughout amidships 0.4L.

(2) The values shown in the table are the minimum requirements for individual members and plates.

(3) In addition to satisfying the individual member and plate requirements, it should be verified that the hull girder section modulus is not less than 90% of the greater Hull Girder Section Modulus required either:

a) At the time of new construction

b) Z_σ as specified in 3.2.1 of Part XV of the Rules for Steel Ships.

(4) For craft less than 60 m in ship's length only, maximum loss of deck or bottom area is 20% of Rule required area.

(5) For craft built to other Society rules, wastage allowance based on the previous Society requirements may apply.

Table I 2-7
Aluminum Wastage Allowances for Craft, L < 90 m

Main Deck Plating	15%
Bottom Plating	15%
Keel Plating	15%
Sheer Strake	15%
Bilge Strake	15%
Side Shell Plating	20%
Forecastle	20%
Internals and Bulkheads	20%

For craft built to other society rules, that society carrying out the initial plan review is to be contacted for wastage allowances.

Chapter 3

Survey Requirements for Additional Systems and Services

3.1 General

In order to maintain a Class Notation for an additional system or service, that system, equipment, or installation is to be surveyed in accordance with this chapter.

Survey Requirements for Additional Systems and Services as specified in Part I Chapter 3 of the Rules for Steel Ships, are to be applied, if any.

Appendix 1

Loading Computer System (LCS) for Stability and Longitudinal Strength

A1.1 General Requirements

A1.1.1 Application

(a) The requirements of this appendix apply to craft equipped with computer based systems for calculation and control of loading conditions for compliance with the applicable stability, longitudinal and local strength requirements.

A1.1.2 Class Notation

(a) Craft equipped with loading computer systems designed, manufactured and tested in compliance with the requirements of this appendix, for calculation and control of stability, longitudinal and local strength, may be assigned the additional class notation **LCS**.

A1.1.3 General requirements

(a) The Loading Computer System is regarded as supplementary to the Loading Manual and Stability Booklet and if relevant the Grain Loading Manual which are always to be provided on board.

(b) The user's manual is always to be provided for the loading computer.

(c) The user's manual and the computer software must be prepared in a language understood by the user. If this language is not English, a translation into English is to be included.

(d) If the software includes on-line interface, for instance remote tank sounding or draught reading, it is assumed that the remote system is maintained and calibrated as recommended by the manufacturers.

(e) On-line computers are to be connected through a gateway if connected to the craft's network serving main functions. The gateway shall have read only possibility unless the computer is approved for two-way communication.

(f) The software may be type approved or approved on a case by case basis for a specific craft.

(g) The software may be type approved, the validity and limitations of the type approval are to be carefully noted. If a type approval is found not to cover all parts of relevance for a specific craft, addition testing and documentation as for a case-by-case approval may be required.

A1.1.4 Documentation

(a) Hardware documentation

If the hardware is not type-approved, the concerned documentation is to be submitted.

(b) Documentation needed when software is type approved

In case of type-approved software, the following documentation is to be submitted:

(i) Preliminary test conditions (print of input and output data).

(ii) Stored characteristic data. (e.g. hydraustatics, cross curves, VCG or GM limit curves, lightweight definition, tank data and associated limits to still water shear force, bending moments and torque, as applicable, and with explanation as found necessary.)

(iii) Number, position and limits of read-out points. The shear force limits are to be specially considered for craft sides and longitudinal bulkheads. The loading computer is to take into account the local

correction of the shear forces for conditions with greater pressure differences on the craft's bottom structure.

(iv) Final test conditions (print of input and output data)

In case the user's manual is tailor made for a specific craft, the manual is to be submitted as well.

(c) Documentation needed for case-by-case approval of the software

With a case-by-case approval of the software, the following documentation is to be submitted:

(i) Software description and specifications, including flow chart.

(ii) User's manual, including flow chart.

(iii) Preliminary test conditions (print of point and output data).

(iv) Stored characteristic data. (e.g. hydrostatics, cross curves, VCG or GM limit curves, lightweight definition, tank data and associated limits to still water shear force, bending moments and torque, as applicable, and with explanation as found necessary.).

(v) Number, position and limits of read-out points

The shear force limits are to be specially considered for craft sides and longitudinal bulkheads. The loading computer is to take into account the local correction of the shear forces for conditions with greater pressure differences on the craft's bottom structure.

(vi) Final test conditions (print of input and output data)

A1.1.5 General software requirements

(a) Software

(i) The software and the stored characteristic data must be protected against erroneous use.

(ii) The software design is to be such that it limits possible input errors by the user, for instance tank volume input is not to exceed maximum tank volume, or negative volume input to be accepted.

(iii) The software is to be user-friendly, preferably with graphic presentation of loading conditions and on-line user's task help.

(iv) The software is to include loading limitations. A warning is to be given if these limits are exceeded.

Note:

Loading limitations should include minimum/maximum draught, maximum trim, shear force and bending moment limits, minimum/maximum metacentric height (GM), cargo tank filling height as a function of cargo density, limits to distributed loads on deck, filling of ballast and cargo tanks etc.

(v) The software is to present relevant parameters of loading conditions, such as displacement, draughts forward, midship and aft, trim, center of gravity, metacentric height, free surface correction, shear forces, bending moments, torque and local strength as well as the limiting values for those parameters and an overall judgment whether all loading parameters are within the limiting values.

(vi) If intended for stability calculations, the software must include effect of free surface from slack tanks on the initial metacentric height (GM) and the righting lever (GZ) as well as the effect of external heeling moments, if applicable.

Note:

If the software is based on interpolation on even keel hydrostatics only, the limiting trim will be considered as maximum 1% of the ship's length.

(vii) If the software calculates damage stability, a list of damage cases is to be included. Any intended loading condition must be checked for these damage cases. The results are to include the equilibrium position and the GZ curve after damage, as well as criteria control.

Software is to give an overall judgment whether all the damage cases were found comply with the applicable requirements, within an acceptable time.

(viii) If the software includes on-line interface, for instance remote tank sounding, or draught reading, a warning is to be given in case of on-line interface failure. Further, it is to be possible to give the on-line input manually.

(ix) In case of discrepancy between calculated and actual displacement, the software is to use the actual value and correct the center of gravity in a satisfactory manner. The normal procedure is located in the center of gravity of the deadweight.

A1.2 Approval and Testing Requirements

A1.2.1 Approval principles

(a) The requirements of hardware is to be complied with the Rules.

(b) The software can be either type approved or case-by-case approved. The latter case is only in condition with system installation on board a specific craft. In either case, relevant requirements stated in section A1.1 are to be complied with.

(c) Approval and certification.

(i) Documentation according to A1.1.4 including preliminary test conditions in accordance with A1.2.2 is to be submitted for approval.

(ii) Final test conditions according to A1.2.2, are to be tested on board in presence of the Surveyor as described in A1.2.3.

(iii) Certificate of the loading computer system will be issued after checking of final test conditions on board.

A1.2.2 Test conditions

(a) General

(i) Preliminary test conditions are based on estimated lightweight data. Final test conditions are those conditions which are based on lightweight data obtained from the inclining test or the lightweight survey.

(ii) Special or additional test conditions as specified in (vii) may be required by the Society in case the standard test conditions do not fully expose critical aspects of software, e.g. limitations which need to be demonstrated in particular.

(iii) The units and reference system of the test conditions are to be the same as used in the loading manual and the stability booklet.

(iv) At least 4 preliminary test conditions are to be submitted. The corresponding final test conditions are to be submitted after satisfactory result on board in presence of the Surveyor.

(v) The selected test conditions are to be representative of the service conditions and the same as the conditions presented in the approved loading manual or the stability booklet. The 4 standard test conditions are to be as follows:

(1) Light ship condition.

(2) Ballast or partly loaded condition.

(3) Fully loaded condition.

(4) Arbitrary loading condition given extreme values.

(vi) Documentation of test conditions is to include input and output data for each condition.

(vii) Additional test conditions, if required, are to be tested of limiting loading parameters, such as maximum draught, maximum trim or maximum KG. Further, they are to include extreme loading conditions, with varying loading parameters such as tank filling heights as a function of cargo density, limits to distributed loads on deck, shear force limits, bending moments and torque as far as applicable.

A1.2.3 Testing and certification

(a) General

(i) At least 4 of the final test conditions are to be tested on board in presence of the Surveyor, before the loading computer certificate is issued.

(ii) The results from the test conditions must not deviate significantly from the results in the approved loading manual or stability booklet. If found unacceptable, the reason for the deviation is to be clarified.

(iii) A copy of the final test conditions endorsed by a Surveyor is to be kept on board.

(iv) If the final loading manual or the final stability booklet has not been approved before delivery, testing on board may take place after these documents have been approved.

Appendix 2

Guidance for Inclining Test

A2.1 General

This annex shows the standard method of inclining test.

A2.2 Preparation for the Test

A2.2.1 Data to be submitted

The following plans are to be available at the time of the test as necessary.

(a) General arrangement drawing.

(b) Tank capacity plan.

(c) Hydrostatic curves.

(d) Draft marks locations

A2.2.2 Inclining test condition

(a) The craft is to be as near to completion in lightweight condition as possible. Equipment used by the yard on board is to be moved outboard as far as possible.

(b) Prior to the inclining test, lists of all items which are to be added, removed, or relocated are to be prepared. These weights and their locations are to be accurately recorded.

(c) The total value of missing weights is not to exceed 2% and surplus weights, excluding liquid ballast, fuel oil, diesel oil and fresh water, not exceed 2% of the light ship displacement. For smaller craft, higher percentages may be allowed.

(d) All objects are to be secured in their regular positions. All weights which may swing or shift are to be secured in their sea stowage position. If more than one sea stowage positions are possible, the actual stowage position used during the test is to be recorded.

(e) The craft is to be cleared of residues of cargo, tools, debris, scaffolding and snow. Icing of the inner and outer surfaces, the underwater hull included, is not permitted.

(f) Bilge water and liquids accumulated on deck are to be removed in order to exclude an influence on measurements.

(g) Only the persons participating in the inclining test are to be stay on board the craft.

A2.2.3 Tank contents

(a) As a rule, all tanks are to be either full or empty. The number of tanks containing liquids is to be kept to a minimum.

(b) Soundings and density of liquids in tanks are to be taken in tanks containing liquids. Where tanks are partly filled, free surface effect which has an influence on the result of the test is to be estimated from the shape of tanks.

(c) Where tanks are intended to be filled completely, removal of air pockets is to be paid attention. All empty tanks are to be adequately dried.

(d) All connections between tanks are to be closed.

A2.2.4 Mooring arrangements and environmental conditions

(a) Mooring lines are to be free of any transverse tension during the reading. No external moments are to be brought upon the craft from mooring lines. If possible, the craft is to be located in a calm, protected area free from external forces.

(b) The depth of water under the hull is to be sufficient to ensure that the hull will be entirely free of the bottom even if the craft is inclined, taking into account tide differences, if applicable.

(c) The following mooring arrangements are to be referred to as the standard.

(i) A craft is moored by bow and stern lines on both sides of the craft attached at or near the center-line. Longitudinal mooring lines are to be as long as practicable.

(ii) A craft is moored by bow and stern lines on one side only and supplemented by spring lines.

(d) Where a single bow or stern line is proposed, the craft's freedom of movement is to be checked not adversely to effect the conduct of the experiment.

(e) When tidal currents are present, the experiment is to be conducted at or around slack tide as far as possible.

(f) The craft's gangway is to be in the stowed position, and any shore gangway is to be removed during the inclining test. Cables, hoses, etc. are as few as possible to be connected to shore. Those which are needed are to be slack.

(g) To carry out the inclining test under the influence of wind and currents may be permitted, provided the accuracy of the test is assured.

A2.2.5 Inclining weights

(a) As a rule, not less than four solid weights are to be used for the inclining test. Use of water ballast transfer to incline the craft may be permitted only in cases where it is impracticable to incline the craft using solid weights.

(b) The solid weights are to be heavy enough to comply with the requirements in A2.3.3(a). Each solid weight is to be almost equal in mass.

(c) Each weight is to be compact, impervious to water. Its center of gravity is to be accurately determined.

(d) Each inclining weight is to be marked with an identification number. The inclining weights are to be weighted with a calibrated instrument to the satisfaction of the Surveyor.

A2.2.6 Measuring devices

(a) In general, not less than two measuring devices, one of which is to be a pendulum or a U-tube, are to be used to determine the craft's inclination.

(b) Where pendulums are used, the pendulums are normally to be long enough to give a measured deflection, to each side of upright, of at least 100 mm, and be suspended at sheltered locations to protect from the wind.

(c) Where U-tubes are used, the length and arrangement of the U-tube is to be such as to ensure the accuracy of its readings.

(d) Where stabilographs are used, the calibration of the instrument are to be verified to the Surveyor's satisfaction prior to the experiment.

A2.2.7 Initial Condition and Stability

(a) The craft is to be preferably upright prior to the inclining. However, an initial list of the craft not exceeding 0.5° is permissible.

(b) Initial trim of the craft is not to exceed 1% of the ship's length.

(c) The persons conducting the test are to be satisfied that the craft has adequate, positive stability and acceptable stress levels during the test.

A2.3 Inclining Test and Record of Data

A2.3.1 Accuracy of data

Measurement of inclining test data is to be as accurate as possible and to the satisfaction of the attending Surveyor.

A2.3.2 Draught and water density measurements

(a) Draught is to be measured at fore, aft and midship draught mark at both sides immediately before the test.

(b) The distance from the draught mark, which is used as a reference point, to base line is to be verified prior to the test.

(c) It is to be ensured that no significant changes have occurred in the condition of the craft during the test.

(d) In case of non-coincidence of separate measuring points, additional measurements are to be taken.

(e) Water samples are to be taken at suitable depth to keep away from surface water which could contain rainwater.

A2.3.3 Weight shifts

(a) Positioning of inclining weights which gives a maximum heeling moment is to result in a minimum heel angle of 1° up to a maximum 4° from upright, depending upon ship type and size. Where it is impracticable that the craft is inclined above 1° because of too large GM or other factors, the precision of measurement is to be enhanced taking account of characteristic and condition of the craft and condition of the test.

(b) Procedures of shifting weights are shown in Table I A2-1.

(c) The transverse shift distance is to be as great as practicable. The inclining weights are to be positioned symmetrically to the center line in order to measure the transverse shift distance easily.

(d) The inclining weight positions are to be marked on the deck to ensure that consistency in placement is achieved.

A2.3.4 Measurement of heel angle

(a) Pendulum, or U-tube reading on the recording batten or scale is to be registered by either of the following ways:

(i) On the final stable position of the pendulum or liquid column after stopping of craft motions due to shifting of the inclining weight;

(ii) By marking the center of residual motion about the mean position.

(b) When using other devices, angles of inclination are to be recorded according to instructions supplied for each device.

(c) Whenever the inclining weights are shifted, the plot of heel angle against heeling moment is to be made. If there is a deviation of points from the straight line passing through the initial position, the deflections and moments are to be checked and corrected prior to the next weight movement.

(d) It is to be checked that weights remain on assigned positions and all mooring lines and so on remain slack during measurement.

A2.3.5 Other relevant data

(a) In the case where the inclining test is carried out by means of transfer of water, it has to be possible to evaluate accurately the weight and the center of the shifted liquid in relation to the craft's heel and trim.

(b) The weather conditions, i.e., wind speed and direction relative to the craft, sea state, air and water temperatures, etc., during the test are to be recorded.

A2.4 Postponement of the Test

If during the course of inclining test circumstances arise such that the requirements in this chapter are not complied with, the Surveyor may advise the person in charge to postpone the test.

A2.5 Inclining Test Report

A2.5.1 The Surveyor is to ensure that the data given in the report is consistent with that gathered during the test and to sign the report.

A2.5.2 Test report containing all data gathered during the test, the result calculated from these data and calculating papers is to be made, and to be submitted to the Society.

Table I A2-1
Procedures of Shifting Weights

	Four		Six	
	Port Side	Starboard Side	Port Side	Starboard Side
No.0	2, 4	1, 3	2, 4, 6	1, 3, 5
No.1	4	1, 2, 3	4, 6	1, 2, 3, 5
No.2		1, 2, 3, 4		1, 2, 3, 4, 5, 6
No.3	1	2, 3, 4	6	1, 2, 3, 4, 5
No.4	1, 3	2, 4	2, 4, 6	1, 3, 5
No.5	1, 2, 3	4	1, 2, 3, 4, 6	5
No.6	1, 2, 3, 4		1, 2, 3, 4, 5, 6	
No.7	2, 3, 4	1	1, 2, 4, 6	3, 5
No.8	2, 4	1, 3	2, 4, 6	1, 3, 5

Notes:

(1) The numbers shown in this table show identification number of the weights

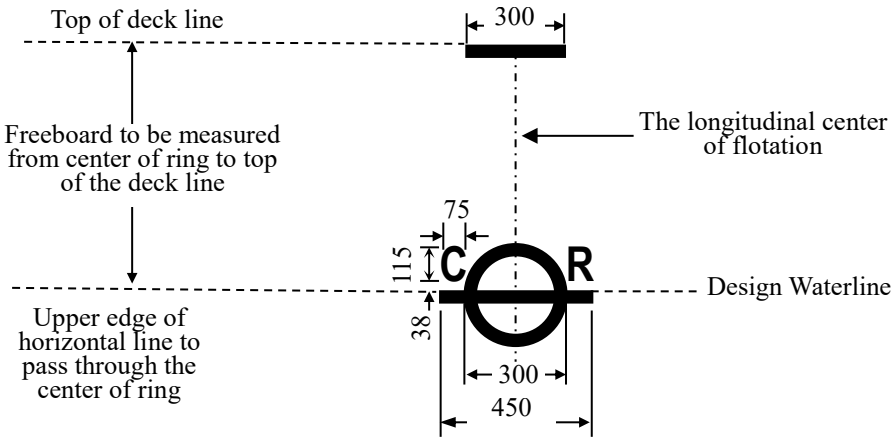
(2) The underlined number indicates the last weight or weight group shifted.

Appendix 3

Load Line Markings

A3.1 Load Line Markings

A3.1.1 For high-speed craft, the load line marking is to be in accordance with Fig. I A3-1.



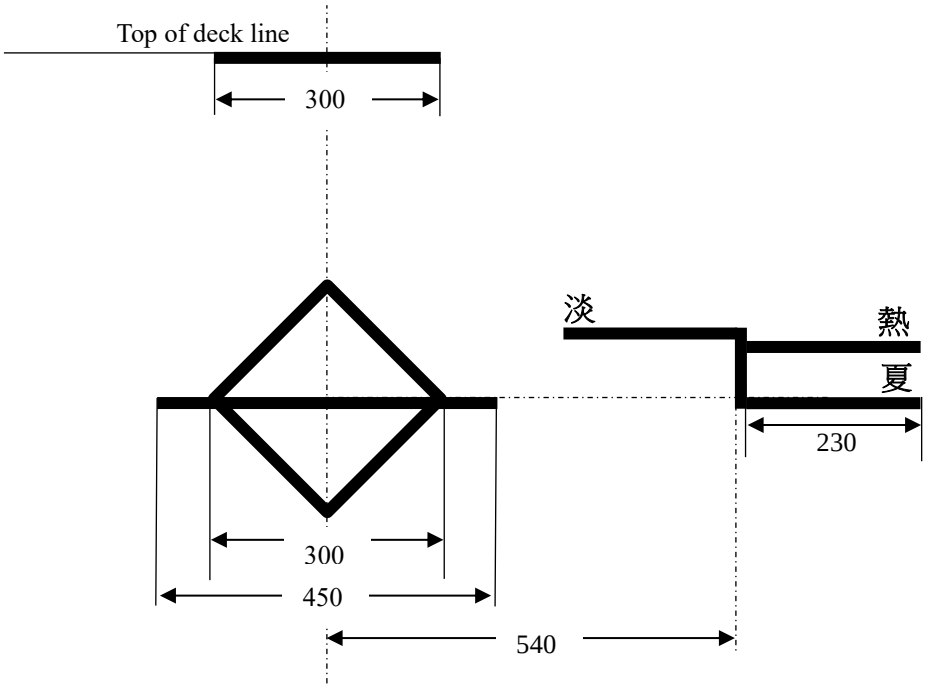
Notes:

(1) The center of the ring is to be placed on each side of the craft at the longitudinal center of flotation. The ring and lines are to be permanently marked on the craft's outer side.

(2) The thickness of all lines are 25 mm.

Fig. I A3-1
Load Line Markings for High-Speed Craft

A3.1.2 For craft not engaged in international voyages, the load line marking is to be assigned in accordance with the requirements of the Administration and may refer to Fig. I A3-2.



Notes:

(1) The center of the diamond is to be placed on each side of the ship at the middle of the length as defined in the Load Line Regulations. The diamond and lines are to be permanently marked on the ship's outer side.

(2) The thickness of all lines are 25 mm.

(3) The size of the Chinese characters 「淡」,「夏」,「熱」 are 50 × 45 mm.

Fig. I A3-2
Load Line Markings for Craft not Engaged in International Voyages

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PART II — MATERIALS AND WELDING

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RULES FOR THE CONSTRUCTION AND CLASSIFICATION OF HIGH-SPEED CRAFT 2021

PART II MATERIALS AND WELDING

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Chapter 1

Fiber Reinforced Plastics for Hull Construction

This Part includes the requirements of aluminium alloy welding in hull construction and FRP materials for hull construction. Other materials and steel welding are to be respectively in accordance with the requirements in Part XI, XII of the Rules for Steel Ships.

1.1 General

1.1.1 FRP materials for hull construction, including the requirements for works, moulding and connection and fastening, are to comply with the requirements of Part I of the Rules for FRP Ships.

Chapter 2

Aluminium Alloy Welding in Hull Construction during Construction

2.1 General

2.1.1 Hull Welding During Construction

Welding in aluminium hull construction is to comply with the requirements of this Chapter, unless specially approved otherwise. It is recommended that appropriate permanent welded markings be applied to the side shell of welded craft to indicate the location of bulkheads for reference. In all instances, welding procedures and welding consumables are to be applied which will produce sound welds that have strength in accordance with Table II 2-1; the chemical compositions of the welding consumables are to be generally in accordance with Table II 2-2. The selection of welding consumables for welding various aluminium alloys is to be in accordance with Table II 2-3 and Table II 2-4.

2.1.2 Plans and Specifications

The plans submitted are to clearly indicate the extent to which welding is proposed to be used. The welding process, welding consumable and joint design are to be shown on the detail drawings or in separate specifications submitted for approval, which are to distinguish between manual, semi-automatic and automatic welding. The shipbuilders are to prepare and file with the Surveyor a planned procedure to be followed in the erection and welding of the important structural members.

2.1.3 Workmanship and Supervision

It shall be the responsibility of the contractor to insure that personnel, procedures and NDT equipment used for fabrication and inspection comply with these requirements. However, the Surveyor is to satisfy himself that all welders and welding operators to be employed in the construction of craft to be classed are properly qualified and are experienced in the type of work proposed and in the proper use of the welding processes and procedures to be followed. The Surveyor is to be satisfied with the employment of a sufficient number of skilled supervisors to ensure a thorough supervision and control of all welding operations.

2.1.4 Welding Procedures

Procedures for the welding of all joints are to be established in writing for each welding test, process, type of electrode, edge preparation, welding technique and position proposed. Details of proposed welding procedures and sequences are required to be submitted for review. Procedure qualifications previously prepared and approved by the Society may be submitted for consideration for the current designs, if applicable. Welding procedures qualification is to be in compliance with 2.7 of this Chapter.

2.2 Preparation for Welding

2.2.1 Edge Preparation and Fitting

The edge preparation is to be accurate and uniform and the parts to be welded are to be fitted in accordance with the approved welding detail. Joint edges may be prepared by mechanical means, such as saws, millers and routers and by plasma arc cutting. Thermal cutting methods may be employed, provided it can be demonstrated to the satisfaction of the Surveyor that their use does not have deleterious effects on the base material or completed weld. All means for correcting improper fitting are to be to the satisfaction of the Surveyor. Where excessive root openings of butt weld connections are encountered, weld build up of the plate edges may be allowed, at the discretion of the Surveyor, before welding the plates together. Unless specially approved otherwise, such build up of each plate edge, where permitted, is not to exceed 0.5t or 12.5 mm whichever is less, where t is the thickness of the thinner plate being welded. Where sections to be joined differ in thickness and have an offset on either side of more than 3 mm, a transition having a length not less than three times the offset is to be provided. The transition may be formed by tapering the thicker member or by specifying a weld joint design which will provide the required transition.

(a) Grinding

Grinding of aluminium, except as a final weld contouring and finishing operation, is discouraged because it leaves a rough, torn metal surface that is difficult to clean. When used, care should be taken to select

nonloading type grinding discs specifically intended for aluminium and to maintain them free of lubricants and other foreign material.

Grinding has been employed for back gouging and weld metal removal for repairs. Satisfactory weld quality can be obtained when care is taken to maintain cleanliness of the grinding discs and the aluminium surfaces prior to welding.

2.2.2 Alignment

Means are to be provided for maintaining the parts to be welded in correct position and alignment during the welding operation. In general, strong backs or other appliances used for this purpose are to be arranged so as to allow for expansion and contraction during production welding. The removal of such items is to be carried out to the satisfaction of the Surveyor.

(a) Plate Alignment Tolerances

(i) Butt Welds

Where plates are tacked in preparation for butt welding, the deviation of alignment of surfaces at the weld joint shall meet the requirements specified below:

Plate Thickness	Maximum Allowance Deviation
Less than 9.5 mm	1.5 mm
9.5 mm to 19 mm	3 mm
19 mm to 38 mm	5 mm
38 mm	6 mm

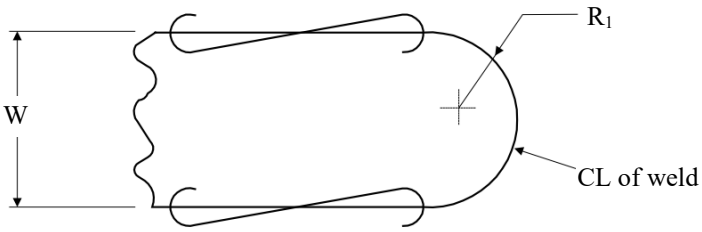
(ii) Fillet Welds

When the opening between elements of a fillet welded joint exceeds 1.5 mm but not more than 5 mm as a nominal condition along the joint, the fillet size shall be increased by an amount equal to the excess of the opening above 1.5 mm. Where the gap between members exceeds 5 mm as a nominal condition along the joint fillet, methods outlined below shall be used. Fillet welds shall be extended around the ends of members to form closed loops, where possible.

(1) Buttering and Buildup
Buttering or buildup by welding on the weld joint surface to correct oversized root opening or errors in joint preparation is allowed, provided such buildup of each joint edge shall not exceed t or 12 mm, whichever is less, where t is the thickness of the thinner member being welded. Where one side of a joint may not be accessible, the total buttering or buildup (that is 2t or 25 mm, whichever is less) may be deposited on one member. Temporary backing may be used to assist in the buttering or buildup. When root openings cannot be corrected within this limitation, repair shall be made using patches, insert plates and so forth, in accordance with (2) and (3) below.
Buttering or buildup may be employed for fairing or for other corrections over or adjacent to welds, provided the above restrictions are not exceeded. This buildup shall be considered part of the involved weld.

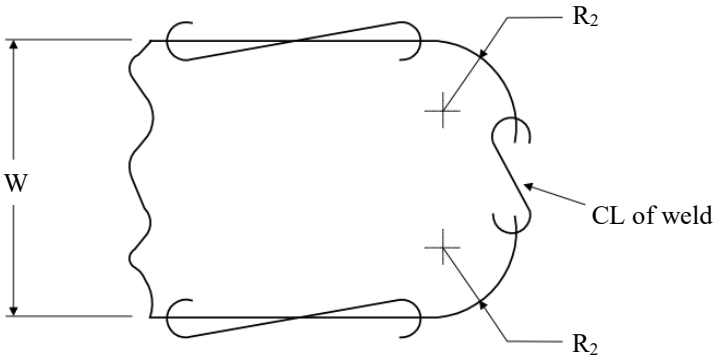
(2) Insert Plates
Insert plates welded into primary structure shall have a minimum width of 75 mm and shall have full penetration, 100% efficient butt welds.

(3) Access and Closure Plates
Boundaries of access and closure plates shall be located between principal boat framing or bulkheads, and shall be at least 75 mm from any of these members. When variance from this 75 mm minimum is required by special circumstances, such variances shall be subject to approval by the Surveyor. The boundaries of access and closure plates should land on existing butts or seams, wherever practical. See Fig. II 2-1 below.
Corners of access or closure plates shall have a minimum radius of 75 mm, except when a boundary lands on an existing hull longitudinal or transverse butt joint. In the latter instance, the corners shall intersect the weld at an angle of 90 ± 15 degrees (see Fig. II 2-1 below). Closure plate weld joints shall be full penetration 100% efficient butt welds.



WHEN W= 75 mm min.
Then R_1=W/2

Figure 1A



WHEN W=150 mm min.
Then R_2=75 mm or 2t, whichever is larger

Figure 1B

Fig. II 2-1
Inserts and Patches in Plating

2.2.3 Cleanliness

Suitable solvents or mechanical means are to be used to remove oil, grease, indelible markings, and all other contaminants from the vicinity of all joints prior to welding. Oxide films that cannot be removed by the specific welding process, including any water stains (hydrated alumina oxide) are to be removed from the groove surfaces that are to be welded, including joint and faying surfaces as well as adjacent surfaces within 25 mm of the weld. Removal may be by mechanical means, such as a power driven, clean stainless steel wire brush, sanding with a 36-100 grit aluminium oxide sanding disk or by approved chemical means. Welding shall take place within eight hours of removal of oxide films except in way of faying surfaces of fillet welds. Interpass cleaning to remove slag, soot, overlap conditions, spatter, etc., is required. Degreasers are not to be used when the joint is such that the degreaser can collect in crevices such as faying surfaces between plate and backing bars or in way of lapped connections. Fusion welding is not to be performed on anodically-treated aluminium, except when the surface oxide is removed from the joint areas to be welded.

2.2.4 Tack Welds

Tack welds shall be made with the same type of electrode as the final weld and should be deposited to facilitate incorporation into the final weld. Tack welds of poor quality or workmanship shall be removed.

2.2.5 Stud Welding

The attachment of pins, hangers, studs and other related items by stud welding may be approved at the discretion of the Surveyor. At the Surveyor's discretion, trial stud welds should be tested to demonstrate that stud welds and base material in way of stud welds are sufficiently sound for the intended application, prior to actual production work. The use of stud welding for structural attachments is subject to special approval and may require special procedure tests appropriate to each application.

2.2.6 Temporary Back-up Plates and Tapes

A temporary back-up plate may be applied to the opposite side of the joint during welding to assist in reducing distortion and to decrease heat concentration. Anodized "hard" aluminium back-up plates are recommended for this purpose, although clean stainless steel or rust-free mild steel plates may also be used. Back-up plates when used are to be free of contaminants and oxides which would interfere with welding. Welding is to be controlled so as not to allow arcing of the aluminium welding consumable to the temporary back-up plate. Any accidental arcing to the back-up plate is to be corrected by removal of all contaminated weld or base metal. Approval of procedures involving the use of backing tapes may be considered, provided it is demonstrated to the Surveyor's satisfaction that their use results in satisfactory welding and that plate distortion is not excessive.

2.2.7 Run-on and Run-off Tabs

When used, run-on and run-off tabs are to be designed to minimize the possibility of high-stress concentrations and cracking of the base metal and weld metal.

2.2.8 Forming

Cold forming of 5000 series aluminium alloys is to be conducted at temperatures below 52°C, except for the 5454 alloy, where the maximum temperature may be 149°C. See Table II 2-5 below for minimum cold-forming radii. When the extent of cold forming is such that base plate properties are changed beyond acceptable limits, appropriate reheat or stress relief treatments are to be used to reestablish acceptable properties. Hot forming of 5000 series aluminium alloys is generally conducted at temperatures between 260°C and 425°C. Hot or cold forming is not to be performed in structures of any aluminium alloy unless supporting data is presented to the Surveyor's satisfaction indicating that significant material property changes will not result. Appropriate temperature control methods are to be used in all hot forming and stress relieving operations. In hot forming or stress relieving, exposure of the 5000 series alloys to the 65°C to 200°C temperature range is to be minimized by the use of appropriate cooling techniques. Typically, 6000 series aluminium is not to be formed. For 6000 series aluminium to be considered for forming, supporting technical data is to be submitted for review and approval prior to forming.

2.3 Production Welding

2.3.1 Environment

Proper precautions are to be taken to insure that all welding is done under conditions where the welding site is protected against deleterious effects of moisture, wind and severe cold. Paint or oil mist and other contaminants which tend to cause weld porosity are to be excluded from the vicinity where welding is in progress.

2.3.2 Preheat

Preheating is not generally required for aluminium alloys. The use of preheat may be desirable when welding materials of thick cross section, materials subject to high restraint, and when welding is performed under high humidity conditions or when the temperature of the aluminium alloy is below 0°C. When preheating is used, appropriate production controls are to be used to maintain the specified temperatures, in accordance with accepted procedures and to the satisfaction of the Surveyor. Preheating temperatures which sensitize an alloy to corrosion are to be avoided. For the 5000 series alloys, it is generally recommended to avoid prolonged exposure to the 65°C to 200°C temperature range. Preheat and interpass temperatures shall be verified by temperature sticks, small contact thermometer, pyrometer, etc. a minimum of 25 mm away from the weld area.

2.3.3 Postheating

Weldments of work hardenable 5000 series aluminium alloys are not to be postweld heat treated unless the procedures have been specially approved. Where use of a heat-treatable alloy has been approved, any postweld heat treatment proposed is to be as established in procedure qualification tests. Post weld heat treatment is not required on 5000 series aluminium materials, stainless steels, copper alloys or nickel alloys.

2.3.4 Accessibility

Assembly and welding is to be arranged to provide sufficient accessibility to the joint by the welder, the welding equipment and for inspection.

2.3.5 Sequence

Welding is to be planned to progress symmetrically so that shrinkage on both sides of the structure will be equalized. The ends of frames and stiffeners are to be left unattached to the plating at the sub-assembly stage for a distance of about 300 mm until connecting welds are made in the intersecting systems of plating, framing and stiffeners at the erection stage. Welds are not to be carried across an unwelded joint or beyond an unwelded joint which terminates at the joint being welded unless especially approved.

2.3.6 Back Gouging

Chipping, routing, milling, grinding or other suitable methods are to be employed at the root or underside of the weld to obtain sound metal before applying subsequent beads for all full-penetration welds.

2.3.7 Fairing and Flame Shrinking

Shrink welds may be used, but fairing by heating or flame shrinking to correct distortion or defective workmanship in fabrication of main strength members within the midships portion of the craft and other plating which may be subject to high stresses is not generally recommended. If intended to be used, it is to be carried out only with the expressed approval of the Surveyor. For the 5000 series alloys, it is generally recommended that heating and cooling through the sensitizing range of 65°C-200°C is to be as rapid as practicable.

2.3.8 Inspection of Welds

(a) Visual inspection

Visual inspection during construction is to consist of inspecting the surface appearance of welds for the existence of flaws or defects, as stated below. The inspection zone includes the weld face and 12 mm of adjacent base metal. The surface of the welds is to be regular and uniform with proper contour, a minimum amount of reinforcement and reasonably free from undercut and overlap, slag, paint and weld splatter. The Surveyor can use a low-power (3X) magnifying glass to aid in visual examination of doubtful weld areas.

(i) Appearance

Welds shall be free of cracks, incomplete fusion and burn-through. Visible arc-strikes on welds and the adjacent base metal are not allowed and shall not exceed 1 mm in depth after removal. Weld spatter greater in diameter than 1 mm is not acceptable. Gouge marks, nicks and other fabrication scars in the weld inspection zone shall not exceed the requirements for undercut. Weld surfaces shall be free of slag to the extent that there is no interference with visual or other required nondestructive test. Crater pits are considered acceptable, provided the area contains no cracks, and the root concavity and convexity limits are not exceeded and the minimum weld thickness requirements are met.

(ii) Melt-through

Melt-through and repaired burn-through areas are acceptable, provided the areas do not contain cracks, crevices, excessive oxidation or globules, and provided that the root convexity and concavity limits are not exceeded.

(iii) Underfill

Underfill is unacceptable in a weld or base metal when it occurs as a sharp notch or where the depth reduces the weld thickness below the minimum base metal thickness.

(iv) Undercut

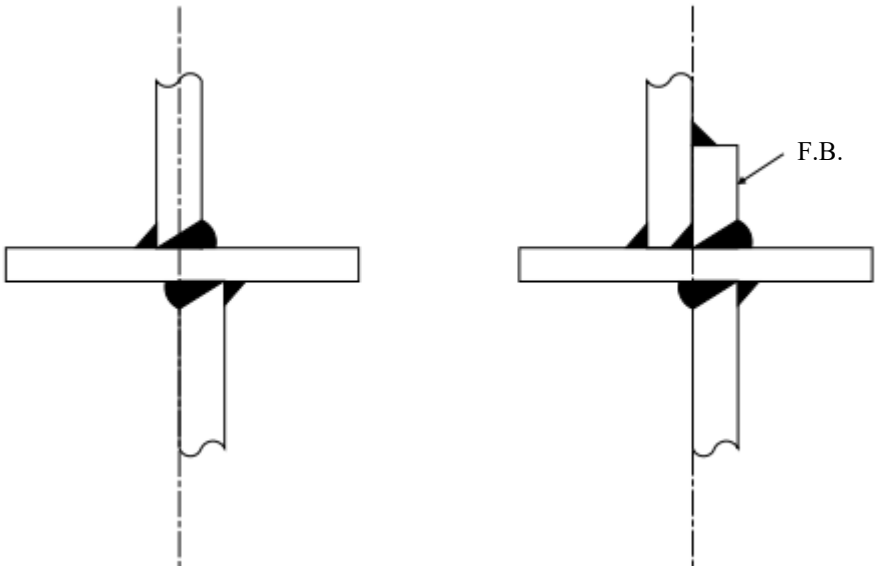
The minimum undercut shall be 1 mm or 10% of the adjacent base metal thickness, whichever is less. For base metal thickness 12 mm and greater, undercut from 1 mm to 1.5 mm is allowed if the accumulated length of undercut does not exceed 15% of the joint length or 300 mm, whichever is less.

(v) Welded joint offset

The maximum offset for all welded joints shall be as follows:

Base Metal Thickness	Maximum Offset
6 mm and less	25% of joint thickness
Over 6 mm to 19 mm	25% of joint thickness, but not to exceed 3 mm
Over 19 mm to 38 mm	5 mm
Over 38 mm	12.5% of joint thickness, but not to exceed 6 mm

For misalignments that exceed the table above and less than 0.5t, the structure may be fixed by using deep penetration welds. For misalignments that exceed 0.5t and are less than 1.0t, the structure may be fixed by aligning flat bar (F.B.) doubling strips. Misalignments greater than 1.0t are to be corrected by realignment of the structure. See Fig. II 2-2.



Misalignments less than 0.5t Misalignments between 0.5t and 1.0t

Fig. II 2-2
Repairs of Misalignments

(b) Dye Penetrant

Dye penetrant inspection is to be used when investigating the outer surface of welds or may be considered for use as a check of intermediate weld passes, such as root passes and also to check back-chipped, ground or gouged joints prior to depositing subsequent passes. Any dye penetrant used is to be thoroughly removed from the area before re-welding. Dye penetrant is not to be used where complete removal of the dye penetrant materials cannot be assured.

(i) Type of dye penetrant

Penetrant materials consist of solvent-removable, visible dye penetrant with associated penetrant remover (solvent) and nonaqueous wet developer.

(ii) Surface preparation

Surfaces to be inspected shall be free from scale, slag and adhering or imbedded sand or other extraneous materials. With the exception of undercuts which are within allowances, the contour of welds shall blend smoothly and gradually into the base metal. Weld surface irregularities shall be removed to the extent that they will not interfere with interpretation of the test results. The final liquid penetrant inspection shall be performed in the final surface condition, as specified herein.

Peening, shot, sand, grit and vapor blasting shall not be performed on surfaces before liquid penetrant inspection.

Surfaces for which a specific finish is required shall be given this surface finish prior to the final liquid penetrant inspection.

(iii) Test procedure requirements

All surfaces being tested shall be thoroughly cleaned of extraneous material. If a nonvolatile liquid is used for cleaning, the surface shall be heated or dried with hot air to assure complete removal of the cleaner. As a final cleaning operation, each surface shall be dipped, sprayed, wiped or brushed with an acceptable solvent and thoroughly dried by removing the excess with a clean dry cloth or absorbent paper, and allowing the remainder to evaporate for a minimum of 5 minutes. Prior to liquid penetrant inspection, the surface to be tested and any adjacent area within 25 mm of the surface to be tested shall be dry and free of any dirt, grease, lint, scale and salts, coatings or other extraneous matter that would obscure surface openings or otherwise interfere with the test.

Maximum penetration into extremely small openings requires that the penetrant and the test surface be maintained at the temperature recommended by the penetrant manufacturer, but in no case shall be less than 10°C. The temperature of the penetrant and the test surface shall not exceed 38°C. Due to the flammable nature of liquid penetrant inspection materials, the use of an open flame for heating purposes shall be prohibited. Special conditions requiring deviation from the above requirement requires approval of the Surveyor.

The surface to be tested shall be thoroughly and uniformly coated with penetrant by flooding, brushing, immersion or spraying. Unless otherwise recommended by the manufacturer and approved by the Surveyor, dwelling time for the penetrant shall be not less than 15 minutes and no greater than 20 minutes.

The excess penetrant shall be removed from all surfaces as follows:

(1) As much excess penetrant as possible shall be removed by wiping the surface thoroughly with a clean dry cloth or absorbent paper.

(2) The remaining excess penetrant shall be removed by wiping the surface with a clean cloth or absorbent paper dampened with a penetrant remover specified by the penetrant material manufacturer.

Flushing of the surface with any liquid following application of the penetrant and prior to developing is prohibited.

The drying of the test surface after the removal of the excess penetrant shall be accomplished only by normal evaporation, or by blotting with absorbent paper or clean, lint-free cloth. Forced air circulation in excess of normal ventilation in the inspection area shall not be used. Unless otherwise specified by the penetrant manufacturer, the time for surface drying after removal of excess penetrant and prior to application of the developer shall be limited to a maximum of 10 minutes.

A nonaqueous wet developer specified by the penetrant manufacturer shall be used. Immediately prior to application, the developing liquid shall be kept agitated in order to prevent settling of solid particles dispersed in the liquid. The developer shall be uniformly applied in a thin coating to the test surfaces by spraying. Pools of wet developer in cavities on the inspection surface is not permitted since these pools will dry to an excessively heavy coating in such areas resulting in the masking of indications. Inspection shall be made a minimum of 7 minutes and not later than 30 minutes after the developer has dried.

When the inspection is concluded, the penetrant materials shall be removed as soon as possible by means of wiping, water-wetted clean cloth or solvents, as described above, and with applicable cleaning procedures.

(c) Radiographic or Ultrasonic Inspection

Radiographic or ultrasonic inspection or both may be used when the overall soundness of the weld cross section is to be evaluated. Finished welding is to be sound and thoroughly fused throughout its cross section and to the base material. Production welds are to be crack free. Other discontinuities, such as incomplete fusion or incomplete penetration, slag and porosity, are only to be present to the degree permitted by the pertinent inspection standard. The procedures and standards for radiographic and ultrasonic inspection is to be in accordance with Part XII Chapter 1 of the Rules for Steel Ships or other recognized standards.

(d) Weld Plugs or Samples

The practice of taking weld plugs or samples by machining or cutting from the welded structure is not recommended and is to be considered only in the absence of other suitable inspection methods and is to be

subject to the special approval of the Surveyor. When such weld plugs or samples are removed from the welded structure, the holes or cavities formed are to be properly prepared and welded, using a suitable welding procedure approved by the Surveyor and as established for the original joint

2.3.9 Workmanship Requirements

The workmanship requirements include the visual acceptance criteria stated in 2.3.8(a) above plus the following structural fairness requirements provided below. In addition, welded attachments shall be removed to a minimum of 1.5 mm away from the permanent member to which they are attached by chipping, sawing or cutting, followed by grinding or sanding to restore the plate surface.

(a) Structural Fairness for Plating

Unfairness (deviation from the design molded line) of welded plating shall not exceed the tolerances shown on Fig. II 2-3 and Fig. II 2-4. Permissible unfairness should result in a generally fair curve across the panel, except that an additional deviation of 3 mm from the fair curve is permitted in way of welded butts and seams. Sharp knuckling or bend in way of stiffeners shall be avoided. A procedure for measuring fairness and taking corrective actions shall be developed and be available for review by the surveyor.

If aid is necessary in determining the acceptability of the fairness of welded structure, a measurement of the unfairness of plating may be made in the area of interest. In such cases, the measurement shall be made across the minor dimension of the panel. The tolerances specified on Fig. II 2-3 and Fig. II 2-4 are plus or minus the dimensions from a fair line.

For stiffener spacings greater or less than those shown on Fig. II 2-3 and Fig. II 2-4, the curves shall be extrapolated proportionately.

(b) Structural Fairness for Framing and Stiffeners

Frame, beam and stiffener bows in primary strength structure or structure subject to dynamic loading shall be corrected when it varies plus or minus from the designated or molded line in excess of the following:

$$T = C\left(\frac{l}{dw}\right)\ mm$$

Where:

T = tolerance in mm.
C = 530
l = span of member between the fixed ends at the support structure in m.
dw = depth of the stiffening member measured from the underside of the flange in mm.

(c) Underwater Exterior Surfaces

In general, weld surfaces shall not extend greater than 1.5 mm above the plate surface.

2.3.10 Quality Control

To maintain quality control, sample welds may be required to be made by welders and operators during each 3 month period, at the discretion of the Surveyor and at the location of production welding, using the same equipment, material and welding consumable as intended for production. The sample welds are to be examined for acceptable workmanship and may be required to be sectioned, etched and examined for weld soundness. When necessary, measures are to be taken to correct unacceptable workmanship.

(a) For stud welding

Aluminium stud welding requires attention to the following points to assure good reliability.

(i) Correctly designed studs and proper matching of stud and base metal.

(ii) Power source and welding equipment of sufficient capacity for stud size.

(iii) Surfaces that are clean and free of lubricants, oxides, and other contaminants

(iv) Proper positioning of the stud welding gun on the work surface, and correct stud lift and plunge settings.

Visual inspection of aluminium stud welds for acceptance is limited because the appearance of the weld fillet does not necessarily indicate soundness. Therefore, visual inspection of aluminium stud welds is recommended only to determine complete fusion and absence of undercut around the periphery of the weld.

Aluminium studs can be tested to establish acceptable welding procedures using a bend test. If the stud bends to 15° from the original axis without breaking the stud or weld, the stud welding techniques should be considered satisfactory. Production studs should not be bent and then straightened because of possible damage to them. In this case, the torque test or seperate qualification test plates may be substituted.

Torque testing of threaded aluminium studs is done in the same manner as that used for steel studs. Torque is applied to a predetermined value or until the stud fails. For a particular application, the acceptable proof load should be established by suitable laboratory tests, relating applied torque to tensile loading.

2.3.11 Repair Welding

Unsatisfactory welding, as determined by visual inspection, nondestructive test methods, or leakage under hydrostatic tests, is to be corrected by the removal of the defective weld or adjacent material or both and corrected by rewelding, using a suitable repair welding procedure consistent with the material being welded. The repair procedures shall be available for the welder. Multiple repairs (weld cycles) to 5000 series aluminium alloys in the same general area are allowed. Removal by mechanical means of minor surface defects such as arc strikes, scratches or shallow gouges may be permitted at the discretion of the attending Surveyor. Repaired welds must meet the inspection requirements for the original weld.

2.4 Butt Welds

2.4.1 Joint Design

Hull plating up to 5.0 mm in thickness may be square-butt welded without beveling the abutting plate edges. Plates exceeding 5.0 mm may be prepared for welding by similarly beveling the edges of both plates from one or both sides to form a single-Vee or double-Vee butt joint with an included angle from 60 degrees to 90 degrees. For single-Vee butt joints in material 5.0 mm and thicker, the root face or land may be up to 3.0 mm in depth. Root faces or lands below 1.5 mm are not generally recommended. For double-Vee butt joints in material 8.0 mm and thicker, the gap may vary from 0 to 5.0 mm. Joints of other designs and root openings, such as the square butt joints in heavy thicknesses used with automated procedures will be subject to special consideration. In general, use of double-Vee in lieu of single-Vee joints and the narrowest root gap practicable is recommended to minimize distortion.

Butt-type permanent backing strap joints welded from one side shall not be used. For both single-Vee and double-Vee joints, the weld metal at the root on the reverse side of a weld made without permanent backing is to be removed to sound metal by an approved method before applying subsequent weld passes. See 2.3.6. Welded butt joints made against removable backing and on which the root is inspected in accordance with these requirements shall be considered the equivalent of a joint welded from both sides.

2.5 Fillet Welds

2.5.1 General

(a) Size of fillet welds

The actual sizes of fillet welds are to be indicated on detail drawings or on a separate welding schedule and submitted for approval in each individual case.

(b) Intermittent welding at intersection

Fillet welds may be made by an approved manual, semi-automatic or automatic process. Completed welds are to be to the satisfaction of the attending Surveyor. The gaps between the faying surfaces of members being joined should be kept to a minimum. Where the opening between members being joined exceeds 1.0 mm and is not greater than 5 mm, the weld leg size is to be increased by the amount of the opening in excess of 2.0 mm. Spacing between plates forming tee joints is not to exceed 5 mm. Where the opening between members is greater than 5 mm, corrective procedures are to be specially approved by the Surveyor.

(c) Welding of longitudinal to plating

Special precaution such as the use of preheat or low-hydrogen electrodes or low-hydrogen welding processes may be required where small fillets are used to attach heavy plates or sections. When heavy sections are attached to relatively light plating, the weld size may be required to be modified. When terminating an aluminum weld, either continuous or intermittent, crater filling by back stepping is recommended to provide a sound ending for each fillet.

(d) For all welds in ballast tanks required to be in compliance with the IMO PSPC and/or IMO PSPC-COT Regulations, continuous welding is to be adopted.

2.5.2 Tee Connections

In general, the required size and spacing of the fillets is to be as given in 2.5.3.

(a) Size of fillet welds

Frames, beams, bulkheads stiffeners, floors and intercostals, etc. are to have at least the disposition and sizes of intermittent or continuous fillet welds, as required by Table II 2-6. Where it is desirable to substitute continuous welding for intermittent welding, as given in Table II 2-6, a reduction from the required size of fillet may be allowed if equivalent strength is provided.

(b) Intermittent welding at intersection

Where beams, stiffeners, frames, etc., are intermittently welded and pass through slotted girders, shelves or stringers, there is to be a pair of matched intermittent welds on each side of each such intersection and the beams, stiffeners and frames are to be efficiently attached to the girders, shelves and stringers.

(c) Welding of longitudinal to plating

Welding of longitudinals to plating is to have double continuous welds at the ends and in way of transverses equal in length to the depth of the longitudinal. For deck longitudinals only, a matched pair of welds is required at the transverses.

(d) Stiffeners and webs to hatch covers

Unbracketed stiffeners and webs of hatch covers are to be welded continuously to the plating and to the face plate for a length at ends equal to the end depth of the member.

2.5.3 Fillet Sizes and Spacing

Tee connections are to be formed by continuous or intermittent fillet welds on each side, the leg size, w, of the fillet welds is to be obtained from the following equations:

$$w = t_p \times C \times \frac{S}{l} + 1.5 \ mm$$

where:

w	=	size of the weld leg, in mm
t_p	=	thickness of the thinner of the two members being joined, in mm
C	=	weld factor given in Table II 2-6
S	=	distance between centers of weld fillets, in mm. See Fig. II 2-5.
l	=	actual length of the weld fillet, clear of crater, in mm. See Fig. II 2-5.

w is not to be taken less than $0.3t_p$ or 3.5 mm, whichever is greater.

The throat thickness of the fillet is to be not less than 0.7w.

In calculating weld factors, the leg length of matched fillet weld is to be taken as the designated leg length or $0.7t_p$ + 2.0 mm, whichever is less.

Where it is intended to use continuous fillet welding, the leg size of fillet welds is to be obtained from the above equations taking S/l equal to 1.

For intermittent welding with plate thickness less than 7 mm welds are to be staggered.

2.5.4 Thin Plating

For plating of 6.5 mm or less, the requirements of 2.5.3 may be modified as follows:

$$w = t_{pl} \times C \times \frac{S}{l} + 2.0\left[1.25 - \left(\frac{l}{S}\right)\right] \ mm$$

$$w_{min} = 3.5\ mm$$

For plates less than 4.5 mm, welds less than required above will be considered.

2.5.5 Length and Arrangement of Fillet

Where an intermittent weld is permitted by Table II 2-6, the length of each fillet weld is to be not less than 75 mm for t_{pl} of 7 mm or more, nor less than 65 mm for lesser t_{pl}. The unwelded length is to be not more than $32t_{pl}$.

2.5.6 Fillet Weld Arrangements

(a) Intersections

Where beams, stiffeners, frames, etc., are intermittently welded and pass through slotted girders, shelves or stringers, there is to be a pair of matched intermittent welds on each side of each such intersection and the beams, stiffeners and frames are to be efficiently attached to the girders, shelves and stringers. The length of the matched intermittent fillet welds is to be 0.125 times the length of the joint or 100 mm, whichever is greater.

(b) Unbracketed End Attachments

Unbracketed beams, frames, etc., and stiffeners of watertight and tank bulkheads and superstructure and house fronts are to have double continuous welds for length at each end equal to the depth of the member but not less than 0.125 times the length of the joint or 100 mm, whichever is greater.

(c) Bracketed End Attachments

Frames, beams, stiffeners etc., are to be lapped onto the bracket a length not less than 1.5 times the depth of the member, and are to have continuous fillet welds all around. Lapped end connections of longitudinal strength members are also to have a throat size, t, such that the total effective area of the lap welding is not less than the area of the member being attached.

(d) Lapped Joints

Lapped joints are typically not to be used in structural applications or on plates greater than 6 mm thick, unless specially approved. Lapped joints are generally to have a width of overlap not less than twice the thickness of thinner plate plus 25 mm with welds on both edges of the sizes required by 2.5.3.

(e) Plug Welds or Slot Welds

Plug welds or slot welds are to be specially approved for particular applications. When approved, an appropriate demonstration that adequate weld penetration and soundness is achieved is to be made to the Surveyor's satisfaction. When used in the attachment of doublers and similar applications, plug or slot welds may be spaced at 16 times the doubler thickness, but not more than 300 mm between centers in both directions. In general, elongated slot welds are recommended. For closing plates on rudders, slots are to be 75 mm in length spaced at 150 mm between centers. The periphery of the plugs or slots are to be fillet welded, of fillet size, w, generally not less than 0.70 times the plate thickness. Plugs and slots are not to be filled with welded deposit.

2.5.7 Bi-material Joints

Techniques required for joining two different materials will be subject to special consideration. The use of explosion bonding may be considered depending on the application and the mechanical and corrosive properties of the joint. The material is to meet the requirements specified in 11.3 in Part XI of the Rules for Steel Ships.

The following drawings/information are to be submitted to the Head Office of the Society that carries out the plan review:

(a) Drawing indicating the location on the vessel/craft of the bi-material joint

(b) Appropriate plate thickness and material specification

(c) Butt/fillet welding procedure

(d) Manufacturing procedure and control manual for bi-material joints.

(e) Material certificate and test results of the bi-material joints

(f) Calculation of maximum tensile and shear stress for the joints when installed at position

In addition to complying with the above mentioned requirements, the following points are to be considered:

(a) Tensile and shear strength of the structural arrangement is to comply with the requirements as mentioned in 11.3 in Part XI of the Rules for Steel Ships.

(b) Suitable insulation is to be provided for the joints.

(c) Such joints are required to be appropriately painted, coated, wrapped or protected by other methods to prevent the galvanic corrosion.

2.5.8 Alternatives

The foregoing are considered minimum requirements for welding in hull construction, but alternative methods, arrangements and details will be considered for approval. Fillet weld sizes may be determined from structural analyses based on sound engineering principles, provided they meet the overall strength standards of the Rules.

2.6 Welding Consumables

2.6.1 General

Welding consumables are to be of a type suitable to produce sound welds that have strength, ductility and corrosion-resistant properties comparable to the materials being welded. Appropriate precautions are to be used to prevent any critical property change of filler wire quality during storage and handling. A list of recommended welding consumables for different alloys is given in Table II 2-3 and Table II 2-4.

2.6.2 Approval Basis

Welding consumables will be approved in accordance with 4.8 in Part XII of the Rules for Steel Ships and listed, subject to tests conducted at the manufacturer's plant. Upon satisfactory completion of tests, a Product Works Approval Certificate (PWAC) will be issued for general approval indicating the grade or classification to which the welding consumable was tested and the relevant characteristics of the welding consumable. Test assemblies are to be prepared in the presence of the Surveyor and all tests are to be attended by and carried out to the satisfaction of the Surveyor. Procedure and testing is to comply with either of the following standards.

(a) Welding consumables will be considered for approval based upon tests conducted to standards established by the American Welding Society or other recognized organizations.

(b) Special approvals to manufacturer's specifications.

2.7 Approval of Welding Procedures

2.7.1 Scope of Application

This secion gives general requirements for the qualification tests of the welding procedures intended to be used for the aluminium alloys for hull construction and marine structures specified in Part XI Chapter 11 of the Rules for Steel Ships.

This section specifically excludes the welding procedure intended for LNG containment.

2.7.2 General Requirements

(a) It is the responsibility of the manufacturer to ensure compliance with all aspects of the Rules. All deviations are to be recorded as non-compliances and brought to the attention Surveyor along with the corrective actions taken. Failure to do this is considered to render the welding tests as not complying with the Rules.

(b) Welding tests are to be performed under survey at the manufacturer's works. Welding procedure qualification tests and welder qualifications tests specified in 2.8 are to be performed and approved prior to commencement of fabrication or construction.

(c) Weld procedure tests made in accordance with EN, ISO, JIS, ASME or AWS may be considered for acceptance provided that, as a minimum, they are equivalent to and meet the technical intent of this Chapter to the satisfaction of the Surveyor.

(d) Welding tests that have previously been carried out may be considered for acceptance, provided that they have been supervised by an independent body acceptable to the Society and the Surveyor is satisfied with the authenticity of such tests.

(e) The responsibility for the performance of the weld tests rests with the manufacturer. Aspects of the welding tests, such as mechanical testing, non-destructive testing and heat treatment, may be subcontracted by the manufacturer provided that the subcontractor performs the work under the technical control and direction of the manufacturer, and this is agreed with the Surveyor prior to commencing the work.

(f) In this Chapter, the term "manufacturer" is considered to include any firm or organisation that performs welding and is considered to be the shipyard, or construction firm, or fabricator, or material manufacturer.

(g) Welding procedure qualification tests are required to give assurance that construction welds made in accordance with the approved plans or the approved design have acceptable properties. It is the manufacturer's responsibility to establish and document whether a procedure is suitable for a particular application.

(h) The requirements relate to mechanical properties of the weld and heat affected zone, however, other tests may be required on certain materials, for example, corrosion or fatigue tests, in order to ensure suitability for the proposed application.

(i) Materials used for testing are to be of the same grade, type and from the same manufacturing process as those to be used for construction, unless prior agreement is obtained from the Surveyor. Such agreements will only apply on a case-by-case basis.

(j) All materials used for testing are to be suitably marked and identifiable to the original manufacturer's material certificate.

(k) All welding and subsequent testing is to be performed in accordance with the requirements of this Chapter.

(l) The manufacturer is responsible for monitoring the tests and for recording all the welding variables as specified in 2.7.2(c) and for compiling all the non-destructive examination (NDE) reports and mechanical test records for submission to the Surveyor.

(m) The laboratory or testing establishment used to perform the tests is to have the necessary equipment, maintained in good order and suitably calibrated. The laboratory personnel shall have the appropriate skills and qualifications, if necessary, to the satisfaction of the Surveyor.

2.7.3 Welding Procedure

(a) Welding processes

The welding processes below indicated, together with their relevant numbering according to ISO 4063, are in general used for welding aluminium alloys.

- 131 - metal-arc inert gas welding (MIG welding)
- 141 - tungsten inert gas arc welding (TIG welding)

- 15 - plasma arc welding

(b) Welding consumable

The welding consumables should be approved in accordance with the requirements specified in 4.8 in Part XII of the Rules for Steel Ships. Where non approved welding consumables are used at the discretion of the Society, the requirements for the qualification of the welding procedures should be established on a case by case basis. In general additional tests on deposited weld metal are required in accordance with 4.8 in Part XII of the Rules for Steel Ships.

(c) Welding procedure specification (WPS)

A welding procedure specification should be prepared by the shipyard or manufacturer and proposed for acceptance; this section is also referred to as preliminary welding procedure specification (pWPS) and can be modified and amended during the procedure tests as deemed necessary.

In its final version the welding procedure specification should be used as a basis for the production welds and should include all the parameters characterizing the welding process, in particular:

- type of welding process and equipment as appropriate
- type of joint, preparation and backing material, if any
- parent metal and thickness range
- welding consumable
- welding position/s
- minimum preheat and maximum interpass temperature
- post weld heat treatment (PWHT) if applicable
- shielding gas
- welding parameters
- other information relevant to the welding procedure as applicable.

(d) Welding procedure qualification

Welding procedure tests, according to the proposed pWPS, shall be carried out for the qualification of the welding procedure.

The test pieces should be chosen so as to cover all the production welds in accordance with the range of approval given in 2.7.6.

The actual parameters used for welding the qualification test pieces and the results of the inspection and tests carried out shall be recorded in the welding procedure test record.

The qualification tests (welding and testing) shall be witnessed by the Surveyor.

The welding procedure test record shall in general be issued by the shipyard or manufacturer and shall be signed by the Surveyor.

(e) Certificate of approval of the welding procedure

Upon the satisfactory completion of the qualification tests, a certificate of approval of the welding procedure shall in general be issued by the Society to the shipyard or manufacturer stating the conditions of the approval of the WPS such as thickness range, positions, type of Al alloy/s, welding consumable, etc.

2.7.4 Qualification of Welding Procedures

(a) Butt weld

(i) Assembly and welding

The test pieces should be of sufficient size to ensure a reasonable heat distribution during welding and to provide for the required test specimens, after sufficient discard at the ends, see Fig. II 2-6.

The edge preparation and fit up should be in accordance with the pWPS.

If tack welds are to be fused into the production joint they should be included in the test pieces.

The test assembly should have the following minimum size:

- manual and semiautomatic welding: length L = 350 mm; width W = 300 mm,

- automatic welding: length L = 1000 mm; width W = 400 mm.

The cleaning of the parts to be welded should be carried out in accordance with the welding procedure.

The welding should be carried out in accordance with the pWPS and under the general conditions of production welding which it represents.

(ii) Examinations and tests

Non destructive examinations and destructive tests should be carried out in accordance with the requirements of Table II 2-7.

Test specimens should be taken in accordance with Fig. II 2-7.

(iii) Non-destructive examination (NDE)

Non-destructive examinations should be carried out after any required post weld heat treatment, natural or artificial ageing, and prior to the cutting of the test specimens.

Welds should be free from cracks. Imperfections detected by visual or non-destructive testing should be assessed in accordance with ISO 10042, level B, except for excess weld metal or convexity, excess throat thickness and excess of penetration for which the level C applies.

(iv) Transverse tensile test

The specimens for transverse tensile tests should be machined to the dimensions given in Part XI Chapter 2 of the Rules for Steel Ships.

The tensile strength should meet the requirements stated in Table II 2-8.

(v) Bend test

The specimens for bend tests should be machined to the dimensions given in Part XI Chapter 2 of the Rules for Steel Ships. For dissimilar or heterogeneous butt joints longitudinal bend tests may be required instead of transverse bend tests.

The bend test specimens should be bent on a mandrel with maximum diameter as given in the formula below. The bending angle shall be 180°.

$$d = \frac{(100t_s)}{A} - t_s$$

where

d = the maximum former diameter

t_s = the thickness of the bend test specimen (this includes side bends)

A = the minimum tensile elongation required by the alloy grade, temper condition and thickness (for combination between different alloys, the lowest individual value should be used).

After testing the test specimens should not reveal any open defect in any direction greater than 3 mm. Defects appearing at the corner of the specimens may be disregarded, unless there is evidence that they result from lack of fusion.

Note: Wrap around method bend tests are recommended for the above mandrel diameter for each alloy.

(vi) Macro examination

The test specimen should be prepared and etched on one side to clearly reveal the fusion line, the HAZ and the build up of the runs and the unaffected base metal. The examination should reveal a regular weld profile, thorough fusion between adjacent layers of weld and base metal and the absence of defects such as cracks and lack of fusion.

The acceptance levels specified in (c) above apply.

(b) T-fillet weld

(i) Assembly and welding

The minimum size of the test assemblies should be as follows:

- manual and semiautomatic welding: length L = 350 mm; width W = 150 mm,
- automatic welding: length L = 1000 mm; width W = 150 mm.

The two plates should be positioned and tack welded edgewise so as to constitute a T assembly without clearance.

Welding on one or both sides and fit up should be as detailed in the pWPS.

In general for manual and semiautomatic welding a stop/restart position should be included in the test length and should be clearly marked for subsequent examination.

The cleaning of the parts to be welded should be carried out in accordance with the welding procedure.

(ii) Examination and tests

Non-destructive examination and destructive tests should be carried out in accordance with the requirements of Table II 2-9.

(iii) Visual examination and surface crack detection

The requirements specified in 2.7.4(a)(iii) should be complied with

(iv) Macro examination and fracture test

The fracture test as well as the macro examination should, in general, satisfy the acceptance level specified in 2.7.4(a)(iii).

Dimension of leg size, throat and penetration should in general be reported.

2.7.5 Re-testing

If the test assembly fails to comply with any of the requirements for visual examination or NDE, one further test assembly should be welded and subjected to the same examination.

If any test specimen fails to comply with the relevant requirements, two additional test specimens should be obtained for each one that failed. These specimens can be taken from the same assembly, if there is sufficient material, or from a new test assembly. For the acceptance both tests should give satisfactory results.

Where failed in the above re-testing, the pWPS should be modified before further consideration by the Society is given to a new test assembly for re-qualification.

2.7.6 Range of Approval

(a) General

The approval of the WPS obtained by a shipyard or a manufacturer is valid for welding in all its workshops under the same technical and quality control.

All the conditions of validity stated below should be met independently of each other.

Changes outside of the ranges specified may require a new welding procedure test.

(b) Parent metal

The aluminium alloys are grouped into three groups:

- Group A: aluminium-magnesium alloys with Mg content $\leq$ 3.5% (alloy 5754)
- Group B: aluminium-magnesium alloys with 4% $\leq$ Mg $\leq$ 5.6% (alloys 5059, 5083, 5086, 5383 and 5456)
- Group C: aluminium-magnesium-silicon alloys (alloys 6005A, 6061 and 6082)

For each Group, the qualification made on one alloy qualifies the procedure also for the other alloys of the same Group with equal or lower specified tensile strength after welding.

The qualification made on Group B alloy qualifies the procedure also for Group A alloys.

(c) Thickness

The qualification of a WPS carried out on a test assembly of thickness t is valid for the thickness range given in Table II 2-10.

In case of butt-joints between dissimilar thickness, t is the thickness of the thinner material.

In case of fillet joints between dissimilar thickness, t is the thickness of the thicker material.

In addition to the requirements of Table II 2-10, the range of qualification of the throat thickness "a" is given in Table II 2-11.

Where a fillet weld is qualified by means of a butt weld test, the throat thickness range qualified should be based on the thickness of the deposited weld metal.

Where the majority of production work is fillet welding, an additional fillet weld test may be required.

(d) Welding position

Provided that comparable welding parameters are used for the included welding positions a test in any one position qualifies for welding in all positions except for vertical downwards (PG) position where in any case separate welding procedure test is required.

(e) Type of joint

The range of approval for the types of joint in relation to the type of joint used in the procedure qualification test is as follows:

- butt-joint welded from one side with backing qualifies also for welding from both sides with gouging;
- butt-joint welded from one side without backing qualifies also for welding from one side with backing, from both sides with gouging and from both sides without gouging;
- butt-joint welded from both sides with gouging only qualifies that condition,
- butt-joint welded from both sides without gouging qualifies also for welding from both sides with gouging and from one side with backing.

(f) Welding process

The approval is valid only for the welding process used in the welding procedure test. It is not permitted to change a multi run deposit into a single run (or single run on each side) or viceversa for a given process. In the case of a multi-process procedure, the approval is only valid for applying the processes in the order used during the procedure qualification tests.

Note: For multi-process procedures each welding process may be approved separately or in combination with other processes. Similarly one or more processes may be deleted from an approved WPS provided the joint thickness is within the approved thickness range of the relevant welding process to be applied.

(g) Welding consumables

The welding consumable used in the qualification tests qualifies:

(i) Approved welding consumables of the same strength as the consumable used in the procedure qualification tests.

(ii) Approved welding consumables of higher strength than the consumable used in the procedure qualification tests.

The qualification given to shielding gas and backing gas is restricted to the gas/gas mixture used in the welding procedure test, see ISO 14175 or other recognised standards for gas designations.

(h) Type of current

Changes in the type of current (AC, DC, pulsed) and polarity require a new welding procedure qualification.

(i) Preheat and interpass temperature

The lower limit of approval is the preheat temperature applied at the start of the welding procedure test.

The upper limit of approval is the interpass temperature reached in the welding procedure test.

(j) Post-weld heat treatment or ageing

Addition or deletion of post weld heat treatment or ageing is not permitted except that artificial ageing for 6000 series alloys gives approval for prolonged natural ageing.

2.7.7 The Surveyor's Acceptance

The Surveyor may, at his discretion, accept a welding consumable, welding procedure, or both, in a shipyard or fabricator's plant where it is established to his satisfaction that they have been adequately used for similar work under similar conditions.

2.8 Welder Qualifications

2.8.1 General

The Surveyor is to be satisfied that the welders and operators are proficient in the type of work which they are called upon to perform, either through requiring any or all of the tests outlined in the following paragraphs or through due consideration of the system of employment, training, apprenticeship, plant testing, inspection, etc., employed.

2.8.2 Welder's Qualification Tests

The welder's qualification tests are to be in accordance with Part XII Chapter 3 of the Rules for Steel Ship. Qualification of welders for a particular alloy may be acceptable for qualification of the welder for other aluminium alloys. Separate qualification tests are to be made for the gas metal arc and gas tungsten arc processes.

2.9 Qualification of Friction Stir Welding of Aluminium Alloys

2.9.1 Scope

(a) The requirements of this Section relate to the Friction Stir Welding (FSW) of aluminium alloys. These requirements include requirements for verification of welding equipment, welding procedures, qualification of welding procedures and qualification of welding operators.

2.9.2 Welding Equipment

(a) Welding equipment (e.g. welding machines and FSW tools) is to be capable of producing welds that meet the specified acceptance levels.

(b) Welding equipment is to be maintained in a good condition and is to be repaired or adjusted when necessary.

(c) After installation of new or refurbished equipment, appropriate tests are to be performed to verify that the equipment functions correctly.

2.9.3 Weld Procedures

(a) This Section defines the requirements for welding procedures to be applied for FSW of aluminium alloys.

(b) Manufacturers are to prepare a preliminary welding procedure specification (pWPS) defining procedures for how FSW is to be conducted.

(c) A pWPS is to comply with the requirements of ISO 25239-4.

(d) Qualification of a pWPS is achieved by conducting welding procedure qualification tests in accordance with ISO 25239-4. Minimum acceptance criteria for destructive tests are to be in accordance with the Rules or other recognized standards. Reporting of the qualification tests are to be in accordance with ISO 25239-4.

(e) Provided that the procedure qualification record lists all the relevant variables and there are no inconsistent features and the results satisfy the requirements, the procedure qualification record may be endorsed by the Surveyor as satisfying the requirement of the Rules.

(f) A welding procedure specification (WPS) is to be prepared after the procedure qualification test report has been endorsed by the Surveyor.

(g) For welding procedure specifications, the range of approval is to be limited as follows:

(i) Manufacturer

A welding procedure qualified by a manufacturer is valid for welding in workshops under the same technical and quality management.

(ii) Range of material type

Approval is restricted to the specific aluminium grade and supply condition used in the qualification test.

(iii) Thickness

Approval is restricted to the thickness of the test piece in the qualification test.

(iv) Joint types

The joint types approved are to be those from the welding procedure qualification test only.

(v) Welding tool

Approval is restricted to the specific design of welding tool employed during the qualification test.

(vi) Other

A range of approval for any other variables will be subject to special consideration.

2.9.4 Qualification of Welding Operators

(a) Welding operators are to be qualified in accordance with ISO 25239-3.

(b) Welding operators are to be suitably trained and will be required to demonstrate a knowledge of FSW and have a working knowledge of the welding installation. Knowledge of the FSW process may be demonstrated by exams passed during the training period. Demonstration of a working knowledge of the welding installation will be subject to the Surveyor's satisfaction.

(c) Qualification of welding operators is to be by welding tests as specified in ISO 25239-3 or by conducting weld procedure qualification tests.

(d) Upon successful completion of all necessary examination and tests, the welding operator is to be considered qualified. The range of qualification is to be as specified in ISO 25239-3.

(e) A certificate of qualification is to be issued in accordance with ISO 25239-3.

2.10 Alternatives

The foregoing are considered minimum requirements for aluminium welding in hull construction, but alternative methods, arrangements and details may be considered for approval.

Table II 2-1
Minimum Mechanical Properties for Butt-Welded Aluminium Alloys(1)

Alloy	Ultimate Tensile Strength, $\mathbf{U}_{al}$ (N/mm^2)	Yield Strength, $\mathbf{Y}_{al}$(3) (N/mm^2)	Shear Strength, $\boldsymbol{\tau}_a$ (3) (N/mm^2)
5083-H111	269	145	83
5083-H116, H321	276	165	96
5083-H323, H343	276	165	96
5086-H111	241	124	69
5086-H112 6 mm –12 mm	241	117	65
5086-H112 12 mm –25 mm	241	110	62
5086-H112 Greater than 25 mm	241	96.5	55
5086-H32, H34, H116	241	131	76
5383-O, H111	290	145	83
5383-H116, H321	290	165(4)	83
5383-H34	290	145	83
5454-H111	214	110	65
5454-H112	214	83	48
5454-H32, H34	214	110	65
5456-H111	283	165	96
5456-H112	283	131	76
5456-H116, H321	290	179	103
5456-H323, H343	290	179	103
6061-T6(2) under 9.5 mm	165	138	83
6061-T6(2) over 9.5 mm	165	103	62

Notes:
(1) The adoption of test values higher than given in this table will be subject to special consideration. Filler wires are those recommended in Table II 2-2. Values shown are for welds in plate thicknesses up to 38 mm unless otherwise noted.
(2) Values when welded with 4043, 5183, 5356 or 5556 filler wire.
(3) Yield and shear strength is not required for weld procedure qualification.
(4) Yield strength values as high as 185 N/mm^2 have been satisfactorily demonstrated and statistically verified.

Table II 2-2
Aluminium Alloy Welding consumable Composition(1)

Alloy	Silicon	Iron	Copper	Manganese	Magnesium	Chromium	Zinc	Titanium	Other(2)		Aluminium
									Each	Total	
4043	4.5-6.0	0.80	0.30	0.05	0.05	-	0.10	0.20	0.05	0.15	Remainder
4943	5.0-6.0	0.40	0.10	0.05	0.10-0.50	-	0.10	0.15	0.05	0.15	Remainder
5183	0.40	0.40	0.10	0.50-1.0	4.3-5.2	0.05-0.25	0.25	0.15	0.05	0.15	Remainder
5356	0.25	0.40	0.10	0.05-0.20	4.5-5.5	0.05-0.20	0.10	0.06-0.20	0.05	0.15	Remainder
5554	0.25	0.40	0.10	0.50-1.0	2.4-3.0	0.05-0.20	0.25	0.05-0.20	0.05	0.15	Remainder
5556	0.25	0.40	0.10	0.50-1.0	4.7-5.5	0.05-0.20	0.25	0.05-0.20	0.05	0.15	Remainder

Notes:
(1) Composition in percent maximum unless shown as a range or specified. See also AWS A5.10.
(2) The maximum Beryllium content of all filler wires is to be 0.0003%.

Table II 2-3
Welding consumables for Welding Aluminium Alloy – Sheet, Plate and Extrusions (1), (2)

Base Metal Alloys	5083	5086	5383	5454 (3)	5456	6061, 6082
5083	5183	5356	5183	5356 (3)	5183	5356 (3)
5086	5356	5356	5356	5356 (3)	5356	5356 (3)
5383	5183	5356	5183	5356 (3)	5183	5356 (3)
5454 (3)	5356	5356	5356	5554 (3)	5356	5356 (3)
5456	5183	5356	5183	5356 (3)	5556	5356 (3)
6061, 6082	5356	5356	5356	5356 (4)	5356	4043, 4943 (4), (5)

Notes:
(1) Recommendations in this table apply to gas shielded-arc welding processes.
(2) Welding consumable alloys 5183, 5356 and 5556 may be used interchangeably, provided that strength, ductility and corrosion resistance are suitable for the service conditions.
(3) 5454 aluminium alloy welded with 5554 welding consumable is generally recommended for above 65°C, such as for smoke stacks and engine room enclosures
(4) 5183 or equivalents may be used.
(5) In case 4943 is selected, tensile test results are to be submitted to the Society for review.

Table II 2-4
Welding consumables for Welding Aluminium Alloy Castings to Castings and Plate

Castings		SG70A SG70B, 357	5154, 5454, 6061	5456, 5083, 5086
ASTM(1)	AA(2)			
SG70A	356.0	4043	4043	5356
SG70B	A356.0 357.0	4043 4043	4043 4043	5356 5356

Notes:
1. ASTM means American Society for Testing and Materials.
AA means Aluminum Association.
2. Welding consumable with same analysis as base metal is sometimes used.
3. 5183, 5356, 5554, 5556 and 5654 may be used. In some cases they may provide higher weld ductility and higher weld strength. 5554 is suitable for elevated temperature service.
4. 5183, 5356 or 5556 may be used. 4043 may be used for some applications where welding consumable properties are not of primary concern.

Table II 2-5
Minimum Cold-forming Radii for Aluminium Alloys (1), (2), (3)

Alloy and temper	3 mm	5 mm	6 mm	9.5 mm	12 mm
5083-0	1t	1t, 2t	1t, 2t	2t	2t
H113	1t, 1.5t	1t, 2t	1t, 2t	1.5t, 2t	2t, 3t
H323	1.5t, 3t	1.5t, 3.5t	2t, 4t	---	---
H343	1.5t, 3t	2t, 4t	2.5t, 4.5t	---	---
5052-0	1t	1t	1t	1t, 1.5t	1t, 2t
H32	1t, 1.5t	1t, 1.5t	1t, 1.5t	1t, 2t	1.5t, 2.5t
H34	1.5t, 2.5t	1.5t, 2.5t	2t, 3t	2t, 3t	2.5t, 3.5t
H36	1.5t, 3t	2t, 4t	2t, 4t	2.5t, 5t	3.5t, 5.5t
H38	2t, 4t	3t, 5t	4t, 6t	4t, 7t	5t, 8t
5086-0	1t	1t	1t	1t, 1.5t	1t, 2t
H32, H116, H117	1t, 2t	1t, 2t	1.5t, 2.5t	2t, 2.5t	2.5t, 3t
H34	1.5t, 2.5t	2t, 3t	2t, 3t	2.5t, 3.5t	3t, 4t
H36	2t, 3.5t	2.5t, 4t	3t, 4.5t	3t, 5t	3.5t, 5.5t
H112	---	---	1t, 2t	1t, 2t	1.5t, 2.5t
5456-0	1t	1t, 2t	1t, 2t	2t	2t
H116,H117	2t, 3t	2t, 3t	2t, 3t	3t, 4t	3t, 4t
H323	1.5t, 3t	1.5t, 3.5t	2t, 4t	---	---
H343	1.5t, 3t	2t, 4t	2.5t, 4.5t	---	---

Notes:
(1) Where two radii are shown, the larger radius is applicable when the bend is parallel to the direction of rolling.
(2) These bending radii are applicable to aluminium alloys which are free of visible oxide coating.
(3) The radii shall be the mandrel radii or inside radii.

Table II 2-6
Weld Factor C

	Aluminium	Steel
Floors, Bottom Transverses, and Bottom Longitudinal Girders to Shell		
At Bottom forward 3L/8,	0.25 DC	0.25 DC
At Bottom forward L/4, V ≤ 25 knots	0.18 DC	0.16 DC
In way of propellers and shaft struts	0.25 DC	0.25 DC
In machinery space	0.20	0.20
Elsewhere	0.16	0.14
Floors, Bottom Transverses and Bottom Longitudinal Girders to Inner Bottom or Face Bar		
In machinery space	0.25 DC	0.25 DC
To Inner bottom elsewhere	0.14	0.12
To face plate elsewhere	0.14	0.12
Floors and Bottom Transverse to Bottom Girders	0.30 DC	0.30 DC
Bottom Girders to Bulkheads and Deep Transverses or Floors	0.30 DC	0.30 DC
End Attachments	0.50 DC	0.50 DC
Longitudinals to Shell (including frames on transversely framed craft)		
Bottom and side forward 3L/8, V > 25 knots	0.25 DC	0.25 DC
Bottom and side forward L/4, V ≤ 25 knots	0.18 DC	0.16 DC
In way of propellers and shaft struts	0.25 DC	0.25 DC
Elsewhere	0.14	0.12
End Attachments	0.50 DC	0.50 DC
Side, Deck, and Bulkhead Girders, Transverses and Stringers		
To Shell 3L/8, V >25 knots	0.18 DC	0.16 DC
To Shell Forward L/4, V ≤ 25 knots	0.16 DC	0.14 DC
Insert To Shell Elsewhere	0.16	0.14
To Deck and Bulkheads Clear of Tanks	0.16	0.14
To Deck and Bulkheads In way of Tanks	0.18	0.16
To Face Bar	0.14	0.12
End Attachments	0.50 DC	0.50 DC
Beams, Longitudinals, and Stiffeners		
To Deck	0.14	0.12
To Tank Boundaries and House Fronts	0.14	0.12
To Watertight Bulkheads, House Side and Ends	0.14	0.12
End Attachments	0.50 DC	0.50 DC
Engine Foundations to Plating and Face Bar	0.50 DC	0.50 DC
Bulkheads and Tank Boundaries		
Non-tight, Internal	0.16	0.14
Watertight, weathertight, or exposed	0.38 DC	0.38 DC
Tank	0.40 DC	0.40 DC
Deck Peripheries		
Non-tight, Internal	0.25	0.25
Weathertight Strength	0.38 DC	0.38 DC
Deck	0.38 DC	0.38 DC
Rudders		
Diaphragms to Side Plating	0.30	0.30
Vertical Diaphragms to Horizontal Diaphragms, clear of Mainpiece	0.50 DC	0.50 DC
Horizontal Diaphragm to Vertical	0.50 DC	0.50 DC
Mainpiece Diaphragm	0.50 DC	0.50 DC
Shaft Brackets to boss and doubler	Full Penetration	Full Penetration

Notes:
1. DC means double continuous.

Table II 2-7
Type of Test and Extent of Testing

Type of Test	Extent of Testing
Visual examination	100%
Radiographic or ultrasonic examination	100%
Penetrant test	100%
Transverse tensile test	2 specimens
Transverse bend test (1)	2 root and 2 face specimens
Macro examination	1 specimen
Notes: (1) 2 root and 2 face bends can be substituted by 4 sides bends for $t \geq 12$ mm.	

Table II 2-8
Tensile Strength

Grade (Alloy designation)	Minimum tensile strength (N/mm^2)
5754	190
5086	240
5083	275
5383	290
5059	330
5456	290
6005A	170
6061	170
6082	170

Table II 2-9
Non-destructive Examination and Destructive Tests

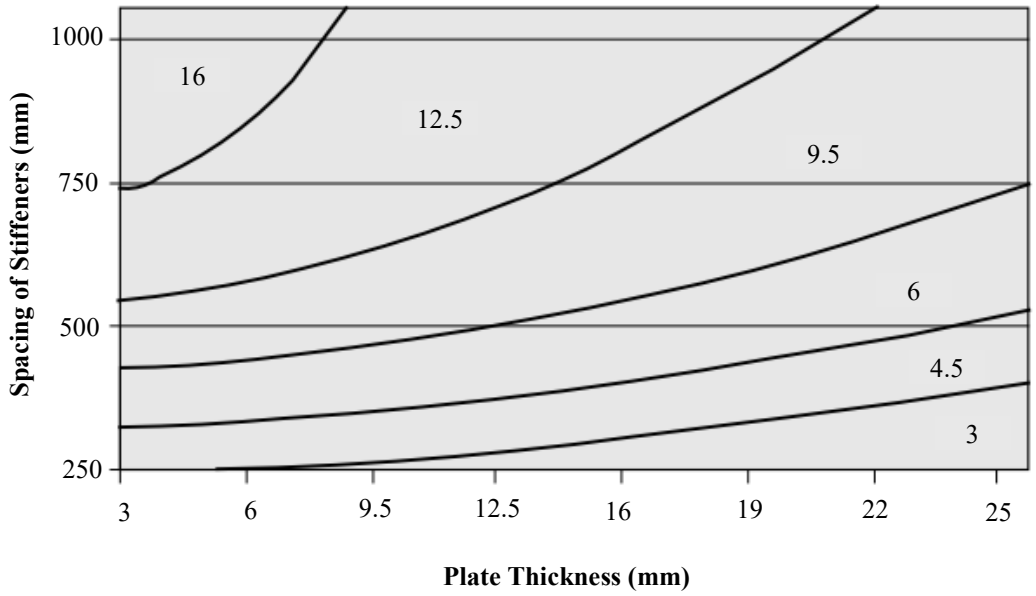
Type of Test	Extent of Testing
Visual examination	100%
Penetrant test	100%
Macro examination(1)	2 specimens
Fracture test	1 specimen
Notes: (1) One of the macro sections should be taken at the position of the stop/restart (see 2.7.4(b)(i)).	

Table II 2-10
Range of Qualification for Parent Material Thickness

Thickness of the test piece, t (mm)	Range of qualifications (mm)
$t \leq 3$	0.5 to 2t
$3 < t \leq 20$	3 to 2t
$t > 20$	$\geq 0.8t$

Table II 2-11
Range of Qualifications for the Throat Thickness of Fillet Weld

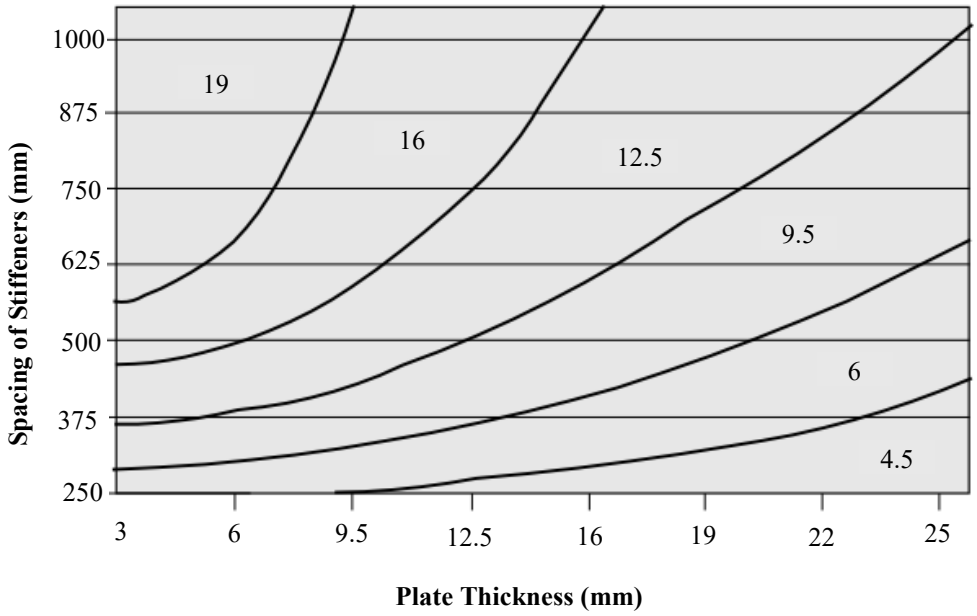
Throat thickness of the test piece, a (mm)	Range of qualifications (mm)
$a < 10$	0.75a to 1.5a
$a \geq 10$	≥ 7.5



Applicability of tolerances:

1. Entire shell plating
2. Uppermost strength deck
3. Longitudinal strength Deck structure which includes inner-bottom tank tops
4. Bulwarks and exterior superstructure bulkheads

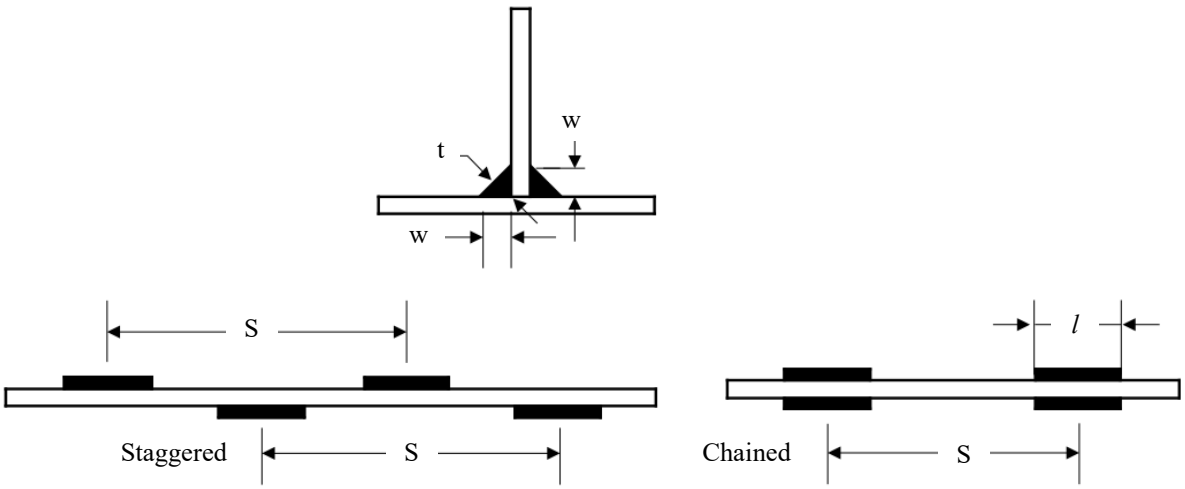
Fig. II 2-3
Permissible Unfairness in Aluminium Welded Structure



Applicability of tolerance

1. Structural bulkheads forming a boundary of living space (stateroom, office, berthing, messing or lounge area) and passageways contiguous to such spaces.
2. Decks within the hull and superstructure in way of the above living spaces.
3. Decks exposed to the weather.
4. Tank and main transverse bulkheads.
5. Inner-bottom plate and longitudinals and transverses.

Fig. II 2-4
Permissible Unfairness in Other Aluminium Welded Structure



w = leg size in mm

t = throat size in mm

Fig. II 2-5
Intermittent Fillet Welds

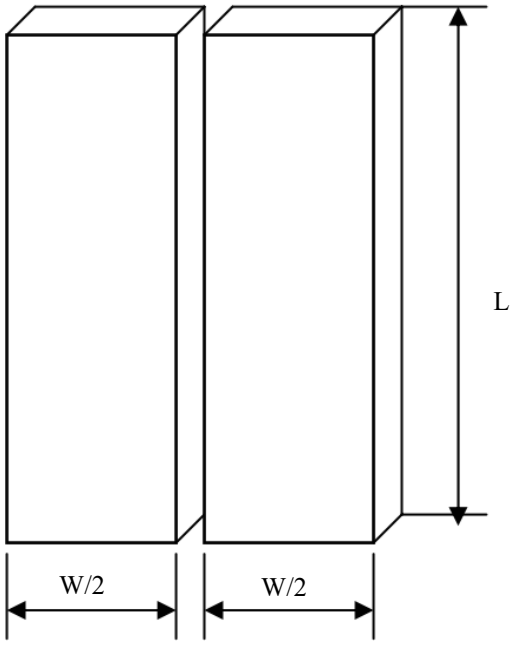


Fig. II 2-6
Test Assembly for Butt Weld

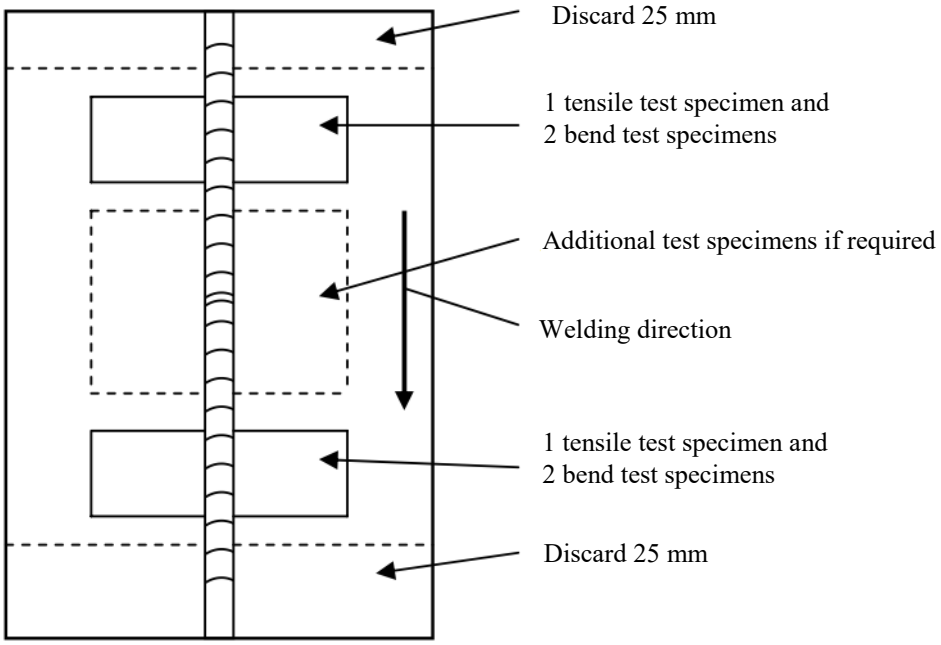


Fig. II 2-7
Location of Test Specimens for a Butt Joint in Plate

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PART III — HULL CONSTRUCTION AND EQUIPMENT

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PART III HULL CONSTRUCTION AND EQUIPMENT

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Chapter 1
General

1.1 Definition

1.1.1 Application
The following definitions of terms apply throughout the requirements in the Rules.

1.1.2 "Length (L)" is the distance, in meters, on the summer load waterline from the fore side of the stem to the after side of the rudder post, or to the center of the rudder stock if there is no rudder post. L is not to be less than 96 %, and need not be greater than 97 %, of the extreme length on the summer load waterline. The summer load waterline is the designed maximum load line corresponding to the full load condition. In crafts without rudder post and stock, L is to be taken equal to 97% of the extreme length on the summer load waterline. In crafts with unusual stem or stern arrangements, L is considered on a case by case basis.

1.1.3 "Freeboard Length (L_f)", in meters, means 96% of the total length on a waterline at 85% of the least molded depth measured from the top of the keel, or the length from the fore-side of the stem to the axis of the rudder stock on that waterline, if that be greater. Where the stem contour is concave above the waterline at 85% of the least molded depth, both the forward terminal of the total length and the fore-side of the stem respectively shall be taken at the vertical projection to that waterline of the aftermost point of the stem contour (above that waterline). In crafts designed with a rake of keel the waterline on which this length is measured shall be parallel to the designed waterline.

1.1.4 "Breadth (B)" is the horizontal distance, in meters, measured at the broadest part of the hull to the molded line of the frame in the craft.
Breadth used in 2.1.1(a)(i) for craft which have flare or tumblehome, is the mean breadth of the waterline breadth and the maximum breadth between the waterline and main deck at the longitudinal center of flotation (LCF).

1.1.5 "Depth (D)" is the vertical distance, in meters, at the middle of the length, L, from the top of keel to the top of the uppermost complete deck beam at side. On craft with rabbeted keel construction, D is to be measured from the rabbet line. In cases where watertight bulkheads extend to a deck above the freeboard deck and are to be recorded in the Register as effective to that deck, D is to be measured to the bulkhead deck.

1.1.6 "Draft for Scantling (d)" is the draft, in meters, measured at the middle of the length L from the molded keel or the rabbet line at its lowest point to the estimated summer load waterline or the design load waterline in the displacement mode.

1.1.7 "Freeboard deck" is normally the uppermost complete deck exposed to weather and sea, which has permanent means of closing all openings in the weather part thereof, and below which all openings in the sides of the craft are fitted with permanent means of watertight closing.
Where the designed load draught is less than derived from the provision of the International Convention on Load Lines, 1966 assuming the existing deck below the freeboard deck as the freeboard deck, the existing lower deck may be designated as the freeboard deck in the application of the Rules, provided it is to be continuous in a fore and aft direction at least between the machinery space and peak bulkheads and continuous athwartships. Where this lower deck is stepped, the lowest line of the deck and the continuation of that line parallel to the upper part of the deck is taken as the freeboard deck.

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

1.1.9 "Strength deck" is the deck which forms the top of the effective hull girder at any part of its length.

1.1.10 "Superstructure deck" is a deck above the freeboard deck to which the side shell plating extends or of which the sides are fitted inboard of the hull side not more than 4% of the breadth, B. Except where otherwise specified, the term superstructure deck where used in the Rules refers to the first such deck above the freeboard deck.

1.1.11 "Superstructure" is an enclosed structure above the freeboard deck having side plating as an extension of the shell plating, or not fitted inboard of the hull side more than 4% of the breadth B.

1.1.12 "Deckhouse" is an enclosed structure above the freeboard deck, having side plating set inboard of the hull side-shell plating more than 4% of the breadth B.

1.1.13 "Displacement Δ", is the mass displacement of the craft in the design condition in metric tons, unless otherwise specifically noted.

1.1.14 "Block Coefficient (C_b)" is the coefficient given by dividing the volume of moulded displacement by LBd as definded above.

1.1.15 "Gross tonnage" is the measurement of the internal volume of spaces within the craft as defined by the International Convention on Tonnage Measurement of Ships, 1969.

1.1.16 "Deadweight (DWT)", in metric tons, for the purpose of the Rules, is the difference, between the displacement of the craft at its summer load line or the craft with all tanks filled, maximum cargo loaded, maximum stores, and personnel or passengers and their effects on board, in water having a specific gravity of 1.025, and the unloaded weight of the craft. For the purpose of the Rules, the unloaded weight is the displacement of the craft, in metric tons, with no cargo, fuel, lubricating oil, ballast water, fresh water nor feed water in tanks, no consumable stores, and no personnel or passengers nor their effects.

1.1.17 "Significant wave height" is the average height of the one-third highest observed wave heights over a given period.

1.1.18 "Speed" is the designed speed, in knots at the maximum continuous rating of the propelling machinery when the craft with clean bottom runs ahead on calm sea at the designed summer load draught. Operational speed is 90% of design speed.

1.1.19 "Rabbet Line (Fiber Reinforced Plastic)" is the line intersection between the outside of a craft’s bottom and a craft’s keel. Where there is no keel, the rabbet line is the bottom of the craft.

1.1.20 "Administration" is the government of the state whose flag the craft is entitled to fly.

1.1.21 "Passenger Craft" is a craft which carries more than 12 passengers.

1.1.22 "Cargo Craft" is any craft other than a passenger craft, which is capable of maintaining the main functions and safety systems of unaffected spaces, after damage in any one compartment on board.

1.1.23 "Passenger" is every person other than the master and 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.

1.1.24 "Place of Refuge" is any naturally or artificially sheltered area which may be used as shelter by a craft under conditions likely to endanger its safety.

1.1.25 "Crewboat" is a craft specifically fitted for the transferring/transporting of industrial personnel in the offshore industry between a shore base facility and the offshore installations and vise versa. Crewboats may also carry cargo.

1.1.26 "Industrial Personnel" is any person carried onboard a Crewboat for the sole purpose of carrying out the business or functions of the offshore installations.

1.1.27 Fiber-Reinforced Plastic (FRP)

FRP consists of two basic components: a glass-filament or other material fiber reinforcement and a plastic, or resin, in which the reinforcing material is imbedded.

(a) Reinforcement

Reinforcement is a strong, inert material bonded into the plastic to improve its strength, stiffness and impact resistance. Reinforcements are usually fibers of glass (a lime-alumina-silicate composition having a low alkali content) or other approved material such as aramid or carbon fiber, in a woven or non-woven form, with a strong adhesive bond to the resin.

(i) Strand

A bundle of continuous filaments combined in a single, compact unit.

(ii) Roving

A band or ribbon of parallel strands grouped together.

(iii) Yarn

A twisted strand or strands suitable for weaving into a fabric.

(iv) Binder

The agent applied in small quantities to bond the fibers in mat form.

(v) Coupling Agent

An active water soluble chemical that allows resin to adhere to glass.

(vi) Chopped-strand Mat

A blanket of randomly oriented chopped-glass strands held together with binder.

(vii) Woven Roving

A coarse fabric woven from rovings.

(viii) Cloth

A fabric woven from yarn.

(ix) Peel-Ply

An “E” glass fabric that does not have any coupling agent applied, used as a protective covering on a laminate being prepared for a secondary bond to keep foreign particles from adhering to the surface.

(x) Uni-directional

A woven or non-woven reinforcement with substantially more fibers in one principal axis of the reinforcing ply.

(xi) Double Biased

A woven or non-woven reinforcement with fibers primarily at +45° to the principal axes of the reinforcing ply.

(xii) Knitted or Stitched Fabrics

Two or more layers of unidirectional fabrics that are stitched together.

(xiii) Bi-axial Fabric

A stitched or knitted reinforcement with fibers primarily in the two principal axes of the reinforcing ply.

(xiv) Tri-Axial Fabric

A stitched or knitted reinforcement with fibers running in one principal axis of the ply and in addition, with fibers running at + and -45° to the warp.

(xv) Ply Principal Axes

The two principal axes of a reinforcing ply are the axis that is parallel to the warp and the axis that is parallel to the fill.

(xvi) Warp

The roving or yarn running lengthwise in woven fabric (in the "roll direction")

(xvii) Fill, Weft or Woof

The roving or yarn running at right angles to the warp in a woven fabric.

(xviii) "E" glass

A family of glass reinforcement material of aluminoborosilicate composition and having high electrical resistivity.

(xix) "S" glass

A family of glass reinforcement material of magnesium aluminosilicate composition that contains a higher silicon content and provides higher strength and stiffness properties than “E” glass.

(xx) Kevlar

An aramid fiber reinforcement.

(xxi) Carbon Fiber

A reinforcement material made of mostly carbon produced by the pyrolysis of organic precursor fibers in an inert environment.

(b) Resin

Resin is a highly reactive synthetic that in its initial stage is a liquid, but upon activation is transformed into a solid.

(i) Accelerator

A material that, when mixed with a catalyst or resin, speeds the cure time.

(ii) Additive

A substance added to another substance, usually to improve properties, such as plasticizers, initiators, light stabilizers and flame retardants.

(iii) Catalyst or Initiator

A material that is used to activate resin, causing it to harden.

(iv) Crazing

Hairline cracks, either within or on the surface of resin, caused by mechanical or thermal stresses.

(v) Cure

To change resin from a liquid to a solid.

(vi) Cure Time

The time required for resin to change from a liquid to a solid after a catalyst has been added.

(vii) Exothermic Heat

The heat given off as the result of the action of a catalyst on resin.

(viii) Filler

A material added to resin to modify its working properties or other qualities, or to lower densities.

(ix) Gel

A partially cured resin in a semi-solid state similar to gelatin in consistency.

(x) Gel Time

The time required to change a flowable, liquid resin into a nonflowing gel.

(xi) Inhibitor

A material that retards activation or initiation of resin, thus extending shelf life or influencing exothermic heat or gel time.

(xii) Polymerization

The reaction that takes place when resin is activated or initiated.

(xiii) Pot Life

The length of time that a catalyzed resin remains workable.

(xiv) Shelf Life

The length of time that an uncatalyzed resin maintains its working properties while stored in a tightly sealed, opaque container.

(xv) Tack

The degree of stickiness of the resin.

(xvi) Thixotropy

The property or phenomenon, exhibited by some resins, of becoming jelly-like at rest but becoming fluid again when stirred or agitated. This facilitates the application of the resin to inclined or vertical surfaces.

(xvii) Polyester Resin

A thermosetting resin that is formed by combining saturated and unsaturated organic acids. Such as orthophthalic and isophthalic acids.

(xviii) Vinylester Resin

A thermosetting resin that consists of a polymer chain and an acrylate or methacrylate termination.

(xix) Epoxy Resin

A resin that contains one or more of the epoxide groups.

(c) Laminate

A laminate is a material composed of successive bonded layers, or plies, of resin and fiber or other reinforcing substances.

(i) Bi-directional Laminate

A laminate having essentially the same strength and elastic properties in the two in plane principal axes. Bi-directional laminates may be constructed of bi-axial, double bias, tri-axial, mat or unidirectional reinforcing layers, or a combination of any of these.

(ii) Uni-directional Laminate

A laminate with substantially more of the fibers in the plane of the laminate oriented in one of the two principal axis of the laminate plane so that the mechanical properties along that axis are appreciably higher than along the other natural axis.

(iii) Sandwich Laminate

A laminate consisting of two fiber reinforced plastic skins attached to a non-structural or structural core (see 1.1.27(d) of this Chapter"Encapsulation").

(iv) Barcol Hardness

A measurement of the hardness of a laminate and thereby the degree of completion of the cure.

(v) Delamination

The separation of the layers of material in a laminate.

(vi) Gel Coat

The first resin applied to mold when fabricating a laminate to provide a smooth protective surface for the laminate.

(vii) Layup

The process of applying to a mold the layers of resin and reinforcing materials that make up a laminate. These materials are then compressed or densified with a roller or squeegee to eliminate entrapped air and to spread resin evenly. Also a description of the component materials and geometry of a laminate.

(viii) Verified Minimum Mechanical Property

The mechanical properties of laminates differing from the basic, verified by the appropriate test(s) listed below.

Material	Density Kg/m^3	Minimum Shear Strength N/mm^2
Balsa, end-grain	104	1.6(1)
Balsa, end-grain	144	2.5(1)
PVC, crosslinked	180	0.9
PVC, crosslinked	100	1.4
PVC, linear(2)	80-96	1.2

Notes:

(1) These values are for Ecuadorian balsa.

(2) Caution is to be taken when linear PVC cores are used in areas that are susceptible to high temperatures because of their low heat distortion temperature.

(ix) Laminate Principal Axes

The two principal axes of a square or rectangular plate panel are for the application of the Rules those perpendicular and parallel to the plate panel edges.

(x) Vacuum Bagging

A method used to apply a uniform pressure over an area by applying a vacuum to that area.

(xi) Resin Impregnation

A process of construction for large layers of fabric that consists of running a roll of fabric through a resin bath to completely saturate the fabric.

(xii) Resin Transfer Molding

A closed mold method that mechanically pumps resin through dry fabric previously placed in the mold.

(xiii) Resin Infusion

A method of FRP construction that uses a vacuum to pull catalyzed resin through dry fabric.

(xiv) Primary Bond

The bond that is formed between two laminated surfaces when the resin on both surfaces has not yet cured.

(xv) Secondary Bond

The bond that is formed between two laminated surfaces when the resin on one of the two surfaces has cured.

(xvi) Post Cure

The act of placing a laminate in an autoclave and raising the temperature to assist in the cure cycle of the resin.

(xvii) Autoclave

A large oven used in post curing large laminated parts.

(d) Encapsulation

The containment of a core material, such as softwoods, balsa, PVC (cross linked) or linear polymer, within FRP laminates. The cores may be structurally effective or ineffective.

(i) Bedding Putty

Material used to adhere the core material to the FRP skins.

(ii) Scores

Slits cut into the core material to aid in forming the core to complex shapes.

1.2 General Requirements

1.2.1 Materials

The Rules are intended for welded craft constructed of steel, complying with the applicable requirements of Parts XI and XII of the Rules for Steel Ships; and fiber reinforced plastic (FRP) craft, and welded craft constructed of aluminum, complying with Part II Chapters 1 and 2 of the Rules; respectively. For Crafts, the use of materials other than those specified in Part II of the Rules and Part XI of the Rules for Steel Ships, and the corresponding scantlings will be specially considered.

(a) Selection of Material Grade

For craft 61 m and over in length, steel materials are not to be lower grades than those required by Table III 1-1 for the material class given in Table III 1-2 for the particular location.

Table III 1-1
Material Grades

Plate Thickness (t) mm	Material Class		
	I	II	III
$t \leq 15$	A, AH	A, AH	A, AH
$15 < t \leq 20$	A, AH	A, AH	B, AH
$20 < t \leq 25$	A, AH	B, AH	D, DH
$25 < t \leq 30$	A, AH	D, DH	D, DH
$30 < t \leq 35$	B, AH	D, DH	E, EH
$35 < t \leq 40$	B, AH	D, DH	E, EH
$40 < t \leq 100$	D, DH	E, EH	E, EH

Table III 1-2
Material Class of Structural Members

Structural Members	Material Class or Grade	
	Within 0.4L Amidships	Outside 0.4L Amidships
Shell		
Bottom plating including keel plate	II	A/AH
Bilge strake	II	A/AH
Side Plating	I	A/AH
Sheer Strake at strength deck[1]	II	A/AH
Decks		
Strength deck plating[2]	II	A/AH
Stringer plate in strength deck[1]	II	A/AH
Strength deck strake on tankers at longitudinal bulkhead	II	A/AH
Strength deck plating within line of hatches and exposed to weather, in general	I	A/AH
Longitudinal Bulkheads		
Lowest strake in single bottom craft	I	A/AH
Uppermost strake including that of the top wing tank	II	A/AH
Other Structures in General		
External continuous longitudinal members and bilge keels	II	A/AH
Plating materials for stern frames supporting rudder and propeller boss, rudders, rudder horns, steering equipment[3], propeller nozzles, and shaft brackets	-	I
Strength members not referred to in above categories and above local structures	A/AH	A/AH

Notes:
(1) A radius gunwale plate may be considered to meet the requirements for both the stringer plate and the sheer strake, provided it extends suitable distances inboard and vertically.
(2) Plating at the corners of large hatch openings are to be specially considered.
(3) Steering equipment components other than rudders, as described in 2.8 of this Part.

(b) Note for the Users

The attention of users is drawn to the fact that when fatigue loading is present, the effective strength of higher- strength steel in a welded construction may not be greater than that of ordinary-strength steel. Precautions against corrosion fatigue to higher strength steel and aluminum alloy materials may also be necessary.

(c) Ships Exposed to Low Air Temperatures

For crafts intended to operate in areas with low air temperatures (below –10°C), the materials in exposed structures to be selected based on the design temperature t_D, are to be taken as defined in 1.2.1(d) of this Chapter.

Materials in the various strength members above the lowest ballast water line (BWL) exposed to air (including the structural members covered by the Note (5) of Table III 1-4 of this Chapter) and materials of cargo tank boundary plating for which 1.2.1(e) of this Chapter is applicable are not to be of lower grades than those corresponding to Classes I, II and III, as given in Table III 1-4 of this Chapter, depending on the categories of structural members (secondary, primary and special). For non-exposed structures (except as indicated in Note 5 of Table III 1-4 of this Chapter) and structures below the lowest ballast water line, see 1.2.1(a) of this Chapter.

Table III 1-3
Application of Material Classes and Grades – Structures Exposed at Low Temperatures

Structural Member Category	Material Class	
	Within 0.4L Amidships	Outside 0.4L Amidships
Secondary	I	I
Deck plating exposed to weather, in general		
Side plating above BWL		
Transverse bulkheads above BWL(5)		
Cargo tank boundary plating exposed to cold cargo (6)		
Primary	II	I
Strength deck plating(1)		
Continuous longitudinal members above strength deck, excluding longitudinal hatch coamings		
Longitudinal bulkhead above BWL(5)		
Top wing tank bulkhead above BWL(5)		
Special	III	II
Sheer strake at strength deck(2)		
Stringer plate in strength deck(2)		
Deck strake at longitudinal bulkhead(3)		
Continuous longitudinal hatch coamings(4)		

Notes:

(1) Plating at corners of large hatch openings to be specially considered. Class III or Grade E/EH to be applied in positions where high local stresses may occur.

(2) Not to be less than Grade E/EH within 0.4L amidships in craft with length exceeding 250 meters.

(3) In craft with breadth exceeding 70 meters at least 3 deck strakes to be Class III.

(4) Not to be less than Grade D/DH.

(5) Applicable to plating attached to hull envelope plating exposed to low air temperature. At least 1 strake is to be considered in the same way as exposed plating and the strake width is to be at least 600 mm.

(6) For cargo tank boundary plating exposed to cold cargo for ships other than liquefied gas carriers, see 1.2.1(e) of this Chapter.

The material grade requirements for hull members of each class depending on thickness and design temperature are defined in Table III 1-4 of this Chapter. For design temperatures $t_D < –55$°C, materials are to be specially considered.

Table III 1-4
Material Grade Requirements for Classes I, II and III at Low Temperatures

Class I

Plate thickness	-11 / -15 ºC		-16 / -25 ºC		-26 / -35 ºC		-36 / -45 ºC		-46 / -55 ºC	
in mm	MS	HT	MS	HT	MS	HT	MS	HT	MS	HT
t ≤ 10	A	AH	A	AH	B	AH	D	DH	D	DH
10 < t ≤ 15	A	AH	B	AH	D	DH	D	DH	D	DH
15 < t ≤ 20	A	AH	B	AH	D	DH	D	DH	E	EH
20 < t ≤ 25	B	AH	D	DH	D	DH	D	DH	E	EH
25 < t ≤ 30	B	AH	D	DH	D	DH	E	EH	E	EH
30 < t ≤ 35	D	DH	D	DH	D	DH	E	EH	E	EH
35 < t ≤ 45	D	DH	D	DH	E	EH	E	EH	⌀	FH
45 < t ≤ 50	D	DH	E	EH	E	EH	⌀	FH	⌀	FH
⌀ = Not applicable										

Class II

Plate thickness	-11 / -15 ºC		-16 / -25 ºC		-26 / -35 ºC		-36 / -45 ºC		-46 / -55 ºC	
in mm	MS	HT	MS	HT	MS	HT	MS	HT	MS	HT
t ≤ 10	A	AH	B	AH	D	DH	D	DH	E	EH
10 < t ≤ 20	B	AH	D	DH	D	DH	E	EH	E	EH
20 < t ≤ 30	D	DH	D	DH	E	EH	E	EH	⌀	FH
30 < t ≤ 40	D	DH	E	EH	E	EH	⌀	FH	⌀	FH
40 < t ≤ 45	E	EH	E	EH	⌀	FH	⌀	FH	⌀	⌀
45 < t ≤ 50	E	EH	E	EH	⌀	FH	⌀	FH	⌀	⌀
⌀ = Not applicable										

Class III

Plate thickness	-11 / -15 ºC		-16 / -25 ºC		-26 / -35 ºC		-36 / -45 ºC		-46 / -55 ºC	
in mm	MS	HT	MS	HT	MS	HT	MS	HT	MS	HT
t ≤ 10	B	AH	D	DH	D	DH	E	EH	E	EH
10 < t ≤ 20	D	DH	D	DH	E	EH	E	EH	⌀	FH
20 < t ≤ 25	D	DH	E	EH	E	EH	E	FH	⌀	FH
25 < t ≤ 30	D	DH	E	EH	E	EH	⌀	FH	⌀	FH
30 < t ≤ 35	E	EH	E	EH	⌀	FH	⌀	FH	⌀	⌀
35 < t ≤ 40	E	EH	E	EH	⌀	FH	⌀	FH	⌀	⌀
40 < t ≤ 50	E	EH	⌀	FH	⌀	FH	⌀	⌀	⌀	⌀
⌀ = Not applicable										

Single strakes required to be of Class III or of Grade E/EH or FH are to have breadths not less than 800 + 5L mm, maximum 1800 mm.

Plating materials for sternframes, rudder horns, rudders and shaft brackets are not to be of lower grades than those corresponding to the material classes given in 1.2.1(a) of this Chapter

(d) Design Temperature t_D

The design temperature t_D is to be taken as the lowest mean daily average air temperature in the area of operation.

(i) Mean

Statistical mean over observation period

(ii) Average

Average during one day and night

(iii) Lowest

Lowest during year

For seasonally restricted service, the lowest value within the period of operation applies.

For the purpose of issuing a Polar Ship Certificate in accordance with the Polar Code, the design temperature t_D shall be no more than 13°C higher than the Polar Service Temperature (PST) of the craft.

In the Polar Regions, the statistical mean over observation period is to be determined for a period of at least 10 years.

Fig. III 1-1 illustrates the temperature definition.

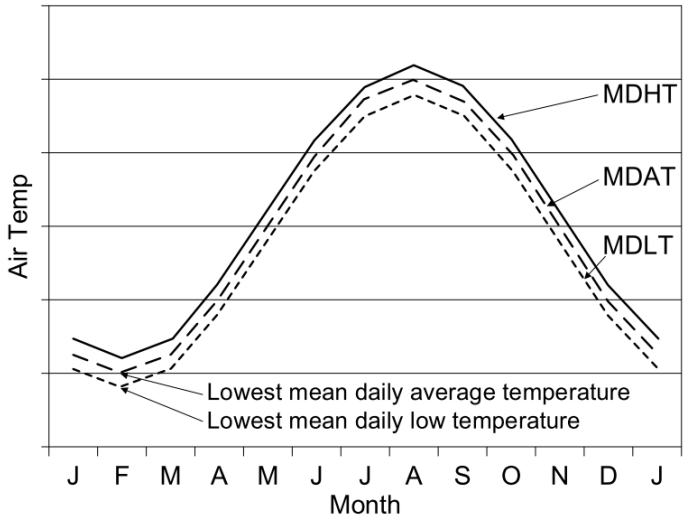


Fig. III 1-1
Commonly Used Definitions of Temperatures

MDHT = Mean Daily High (or maximum) Temperature
MDAT = Mean Daily Average Temperature
MDLT = Mean Daily Low (or minimum) Temperature

(e) Cold cargo for ships other than liquefied gas carriers

For ships other than liquefied gas carriers, intended to be loaded with liquid cargo having a temperature below -10°C, e.g. loading from cold onshore storage tanks during winter conditions, the material grade of cargo tank boundary plating is defined in Table III 1-4 of this Chapter based on the following:

- t_c design minimum cargo temperature in °C
- steel grade corresponding to Class I as given in Table III 1-3 of this Chapter

The design minimum cargo temperature, t_c is to be specified in the loading manual.

1.2.2 Workmanship

All workmanship is to be of commercial marine quality and acceptable to the Surveyor. Welding is to be in accordance with the requirements of Part II of the Rules and Part XII of the Rules for Steel Ships.

1.2.3 Design

(a) Continuity

Care is to be taken to provide structural continuity. Changes in scantlings are to be gradual, such that the maximum angle from horizontal is 45°, see Fig. III 1-2 below. Strength members are not to change direction abruptly, such that the maximum change in direction is 45°, see Fig. III 1-3 below. Where primary structural members terminate at another structural member, tapering of the primary member or tapering brackets may be required beyond the other structural member, as indicated in Fig. III 1-4 below, and as required in 2.5.1. Stanchions and bulkheads are to be aligned to provide support and to minimize eccentric loading. Major

appendages outside the hull and strength bulkheads in superstructures are to be aligned with major structural members within the hull.

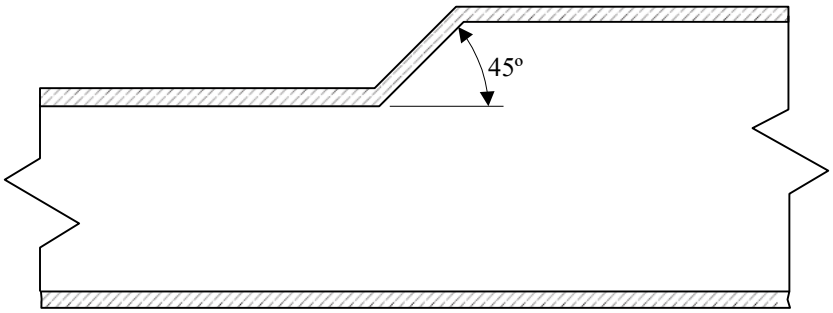


Fig. III 1-2

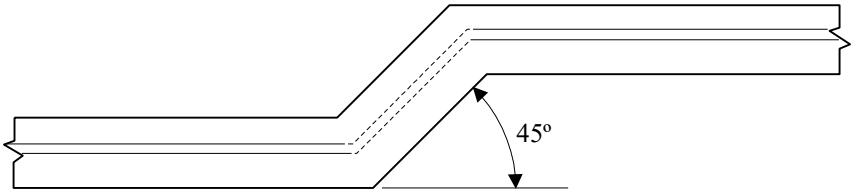


Fig. III 1-3

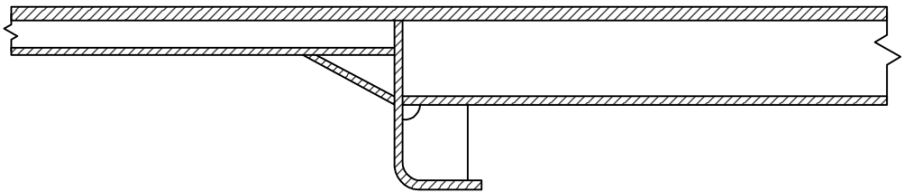


Fig. III 1-4

(b) Openings

The structural arrangements and details are to be in accordance with 2.6 of this Part. In general, major openings such as doors, hatches, and large vent ducts are to be avoided in the hull in close proximity to the gunwale. Corners of openings in strength structures are to have generous radii. Compensation may be required for openings.

(c) Brackets

(i) Steel Brackets

Where brackets are fitted having thicknesses as required by Table III 1-5 of this Chapter and faces at approximately 45 degrees with the bulkhead deck or shell, and the bracket is supported by a bulkhead, deck or shell structural member, the length of each member, *l*, may be measured at a point 25% of the extent of the bracket beyond the toe of the bracket as shown in Fig. III 1-5 below. The minimum overlap of the bracket arm along the stiffener is not to be less than obtained from the following equation:

$x = 1.4y+30$ mm

where

x = length of overlap along stiffener mm

y = depth of stiffener mm

Where a bracket laps a member, the amount of overlap generally is to be 25.5 mm.

(ii) Aluminum Brackets

Aluminum brackets are to comply with above 1.2.3(c)(i), except that the thicknesses shall be in accordance with Table III 1-6 insteads of III 1-5 below.

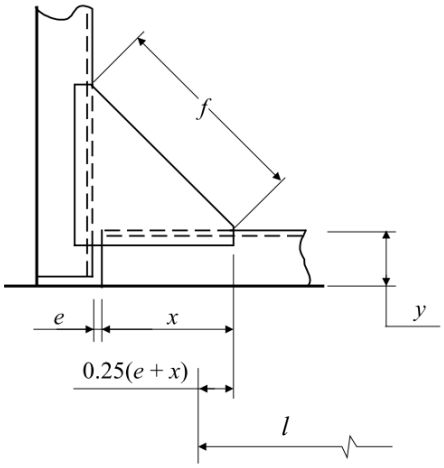


Fig. III 1-5
Bracket

Table III 1-5
Brackets (Steel)

Length of face, *f*, mm	Thickness, mm		Width of Flange, mm
	Plain	Flanged	
$f \leq 305$	5.0	—	—
$305 < f \leq 455$	6.5	5.0	40
$455 < f \leq 660$	8.0	6.5	50
$660 < f \leq 915$	11.0	8.0	65
$915 < f \leq 1370$	14.0	9.5	75

Table III 1-6
Brackets (Aluminum)

Length of face, *f*, mm	Thickness Millimeters, mm		Width of Flange, mm
	Plain	Flanged	
$f \leq 305$	7.0	—	—
$305 < f \leq 455$	9.5	7.0	40
$455 < f \leq 660$	11.5	9.5	50
$660 < f \leq 915$	16.0	11.5	65
$915 < f \leq 1370$	20.0	13.5	75

(d) Structural Design Details

The designer is to give consideration to the following:

(i) The thickness of internals in locations susceptible to rapid corrosion.

(ii) The proportions of built-up members to comply with established standards for buckling strength.

(iii) The design of structural details such as noted below, against the harmful effects of stress concentrations and notches:

(1) Details of the ends, the intersections of members and associated brackets.

(2) Shape and location of air, drainage or lightening holes.

(3) Shape and reinforcement of slots or cutouts for internals.

(4) Elimination or closing of weld scallops in way of butts, "softening" of bracket toes, reducing abrupt changes of section or structural discontinuities.

(iv) Proportions and thickness of structural members to reduce fatigue response due to engine, propeller or wave-induced cyclic stresses, particularly for higher-strength steels.

Standard construction details based on the above considerations are to be indicated on the plans or in a booklet submitted for review and comment.

(e) Termination of Structural Members

Unless permitted elsewhere in the Rules, structural members are to be effectively connected to the adjacent structures in such a manner to avoid hard spots, notches and other harmful stress concentrations. Where members are lightly loaded and not required to be attached at their ends, special attention is to be given to the end taper, by using soft-toed concave brackets or by a sniped end of not more than 30°. Bracket toes or sniped ends are to be kept within 25 mm of the adjacent member and the depth at the toe or snipe end is generally not to exceed 15 mm. Where a strength deck or shell longitudinal terminates without end attachment, it is to extend into the adjacent transversely framed structure or stop at a local transverse member fitted at about one transverse frame space beyond the last floor or web that supports the longitudinal.

1.2.4 Effective Width of Plating

The section modulus and moment of inertia of stiffening members are provided by the member and a portion of the plating to which it is attached. The effective width is as given in the following paragraphs. The section modulus and moment of inertia of a shape, bar, fabricated section, or laid-up member not attached to plating is that of the member only.

(a) FRP Laminates

Where the plating is an FRP single-skin laminate, the maximum effective width of plating for floors, frames, beams and bulkhead stiffeners is not to exceed either the stiffening member spacing or the width obtained from the following equation, whichever is less. See Fig. III 1-6 below.

$$w = 18t + b$$

where:

w	=	effective width of plating	mm
t	=	thickness of single skin plating	mm
b	=	net width of stiffening member, but not more than 18t	mm

Where the plating is an FRP sandwich laminate with a flexurally and compressively ineffective (balsa, cross linked PVC, or linear polymer core, t in the above equation is the thickness of a single skin laminate having the same moment of inertia per unit width as the two skins of the sandwich about the neutral axis of the sandwich, excluding the core.

For a stiffening member along an opening, the maximum effective width of plating is equal to either one-half the stiffening member spacing or the width obtained from the following equation, whichever is less.

$$w = 9t + b$$

where w, t and b are as defined above.

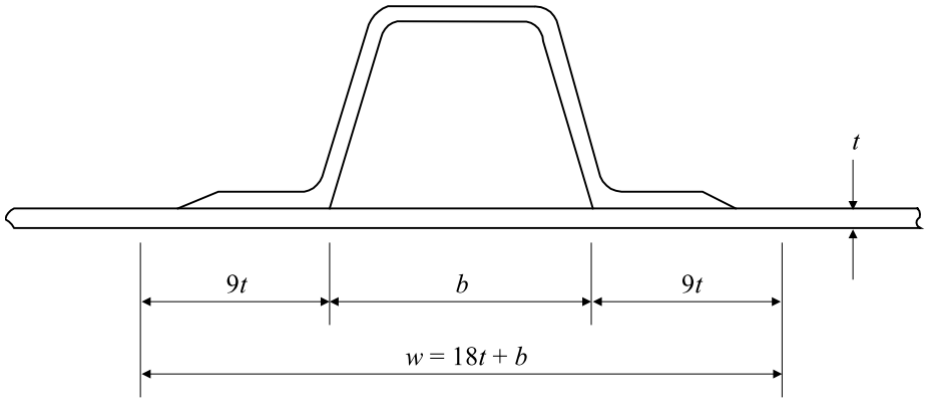


Fig. III 1-6
Effective Width of FRP Plating

(b) Steel and Aluminum Plating

(i) Primary structural Members

The effective width of plating for deep supporting members is equal to the lesser of either one half the sum of spacing on each side of the member, 0.33 time the unsupported span, *l*, or 750 mm. For girders and webs along hatch openings, the effective width of plating is to be half of that obtained from the above. Due account is to be taken in regards to plate buckling, see 2.3.1(a) of this Part.

(ii) All Other Structural Members

The maximum effective width of plating is equal to either one-half the sum of spacing on each side of the member or the width obtained from the following equation, whichever is less.

Steel Members w = 80t

Aluminum Members w = 60t

where:

w	=	effective width of plating	mm
t	=	thickness of plating	mm

For a stiffening member along an opening, the maximum effective width of plating is one-half of the effective width given above.

1.3 Direct Analysis Methods

1.3.1 General

This Section states requirements for a variety of direct analysis methods that can be used in lieu of or in conjunction with the specific requirements given in 2.1, 2.2, 2.3 and 2.4 of this Part.

1.3.2 Loading Conditions

(a) General

The loading conditions considered are to include all intended operational conditions of the craft as specified by the Designer. These operating conditions are to be defined by significant wave height, wave period, and maximum operating speed. Table III 1-7 below is to be used when the significant wave height is given in terms of Sea States. When the wave period is not given, the most probable modal period is to be used in the analysis.

Table III 1-7
Sea States

Sea State	Significant Wave Height m
0-1	0.10
2	0.50
3	1.25
4	2.5
5	4
6	6
7	9
8	14
>8	>14

(b) Environmental and Service Conditions

(i) General

The environmental condition is anticipated to be described by appropriate sets of wave data. The sources and reliability of this data are to be submitted. The wave parameters used in the analysis are to be selected and documented based on the conditions given in the craft specification. If these parameters are to be used in conjunction with the requirements in 1.3.2(c), 1.3.3(b), 1.3.4(a)(ii), 1.3.4(b), 1.3.5(a), 1.3.5(b)(iii) and 1.3.6(b) of this Chapter, then they are to be compatible with the stochastic response and extreme value prediction methods.

(ii) Types of Wave Spectra

(1) Deep-water Ocean Waves
Two-parameter spectra, such as the Bretschneider or P-M wave spectral formulations, are to be used. If the swell and wave components are known to interact, a bi-modal Ochi-Hubble spectrum is to be used. Directional spreading appropriate to coastal conditions is also to be applied.

(2) Shallow-Water Waves
Wave conditions that include the effects of bathymetry, wind field, coastal contours of the region are to be used. For fetch-limited sea conditions, JONSWAP spectrum or a modified version of the spectrum is to be used.

(c) Loading Conditions for Direct Analysis

(i) Dominant Load Parameters

A list of Dominant Load Parameters (DLP) is to be developed. This will include select motion and load effect parameters. Other loads, such as those due to wave impacts on the bow and stern, flare and bottom slamming, wet-deck slamming (multi-hulls) and vibration effects on local structural strength, have to be treated separately. Considerations for slamming analysis are given in 1.3.2(c)(vii) of this Chapter.

(ii) Load Cases

Load cases are defined by a combination of craft loading conditions, a set of global motion and load effect parameters set forth in terms of each of the DLPs, other load components accompanying the DLPs and an equivalent wave system for the specified DLP. Justification for load cases selected for use in the structural analysis is to be submitted to the Society for review.

(iii) Analyses of Ship Motions, Wave Loads, and Extreme Values

Calculations are to be made using the spectral analysis-based approach, which by definition relies on the use of Response Amplitude Operators (RAOs). Each RAO is to be calculated for regular waves of unit amplitude for a range of wave frequencies and wave headings that will be given below.

(iv) Essential Features of Spectral Analysis of Motions and Loads

(1) General Modeling Considerations
The model of the hull is to include the masses of all equipment, vehicles and supporting structure. There is also to be sufficient compatibility between the hydrodynamic and structural models so that the application of fluid pressures onto the finite element mesh of the structural model can be done appropriately.

For the load component types and structural responses of primary interest, software formulations derived from linear idealizations are deemed to be sufficient. The capabilities and limitations of the software are to be known, and in cases where the software is not known to the Society, it may be necessary to demonstrate the adequacy of the software.

(2) Diffraction-Radiation Methods
Computations of the wave-induced motions and loads are to be carried out through the application of seakeeping analysis codes utilizing three-dimensional potential flow based diffraction-radiation theory. Computation of the hydrodynamic pressures is to take account of, as a minimum, all six degree-of-freedom rigid-body motions of the hull. These codes may be based either on linear (small) wave and motion amplitude assumptions or nonlinear (large) amplitude motion and wave formulations.

(3) Panel Model Development
The Rankine source panel method is recommended for solving the hydrodynamic boundary value problem.

(4) Motion and Load-Effect Response Amplitude Operators
For each loading condition, RAOs of all the selected DLPs are to be calculated. The RAOs are to represent the pertinent range of wave headings (β), in increments not exceeding 15 degrees. A range of wave frequencies is to be considered based on the route-specific wave conditions (see 1.3.2(b) of this Chapter). The nominal range is 0.2 rad/s to 1.8 rad/s in increments of 0.05 rad/s.

The worst frequency-heading (ω, β) combination is to be determined from an examination of the RAOs for each DLP. Only the heading β_{max} and the wave frequency ω_e at which the RAO of the DLP is a maximum, need to be used in dynamic load approach or direct analysis.

(v) Extreme Values Analysis

Extreme value analysis is to be performed for each DLP to determine the maximum values. An extreme value method that follows the so-called long-term approach is to be used. The use of a validated short-term extreme value approach, which is appropriate to the craft type and route-specific environmental data, will also be considered. The supplementary use of such a short-term approach to confirm or test the sensitivity of the long-term based design values is recommended.

The relevant value to be obtained from the long-term response analysis is the most probable extreme value (MPEV) having a probability of level of 10^{-8} in terms of wave encounters.

(vi) Equivalent Wave

For each load case, an equivalent wave is to be determined which simulates the magnitude and location of the extreme value of the dominant load component of the load case.

The amplitude of the equivalent wave is to be determined using the extreme values of the DLP (see 1.3.2(c)(iv) of this Chapter) and the RAO of that DLP occurring at the wave frequency and wave heading corresponding to the maximum amplitude (peak) of the RAO. The amplitude of the equivalent wave is given by:

$$a_{wj} = MPEV_j / Max\ RAO_j$$

where

a_{wj}	=	wave amplitude
$MPEV_j$	=	Most Probable Extreme Value of the j^{th} DLP at a probability level equivalent to the design criterion
$Max\ RAO_j$	=	maximum amplitude of the j^{th} DLP's RAO

(vii) Slamming Loads

Loads due to slamming and wave impact on craft hulls are categorized into global slamming effects and local slam-induced structural response.

(1) Global Slamming Effects
The simplified formulae given in 2.1 of this Part may be used to account for global slamming effects in the preliminary design stage. For detailed analysis, a direct time-domain simulation involving short-term predictions are to be used for the global strength assessment of monohulls. In most cases involving high speeds, the absolute motions or relative motions will be of such

large amplitude that nonlinear calculations will be required. In catamarans, wet deck slam-induced global whipping effects of the hull is to be assessed using methods that account for coupling of the symmetric and anti-symmetric modes of responses. These calculations will require time-domain analysis methods.

(2) Local Impact Loads
Panel structures with horizontal flat or nearly flat surfaces such as a wet deck of a multi-hull craft will need to be hydroelastically modeled, where in the dynamics of the fluid and the elastic response of the plate and stiffeners are simultaneously modeled.

1.3.3 Motion Predictions

(a) Model Testing

Craft hull motions and accelerations obtained from scale model tests may be used to validate motions predicted by computer programs. Model testing is required to be performed and reported to the Society when loads are being submitted in lieu of the loads determined in 2.2 of this Part or other loads determined by the Society. The model is to accurately represent the structure that is to be built in both principal particulars and hull geometry.

(i) Testing Program

The model is to be tested over a range of speeds, headings, and wave characteristics (height, length, and period), as indicated by the Society. When this is not specified, the testing program is to include the following:

(1) Speeds
The model is to be tested at the minimum speed required by this Soceity and the maximum achievable speed of the craft for a particular wave profile and heading.

(2) Headings
The model is to be tested in head, beam, quartering, and following seas.

(3) Wave Parameters
The model is to be tested in both deep water and shallow water wave conditions. These are defined in 1.3.2(b)(ii) of this Chapter. For craft that are limited to operation in coastal regions (Coastal Craft and Riverine Craft), deep water wave profile testing is not required.

(ii) Model Measurements and Reporting

The parameters listed below are to be measured and reported based on the model test program. Some of the parameters listed may be derived through statistical analysis of measured data obtained from testing. When statistical analysis is used, the methods of analysis employed are to be indicated in the report.

(1) Vertical or Heave Acceleration
The significant, 1/10 highest, or 1/100 highest vertical acceleration at the longitudinal center of gravity, bow, and stern are to be reported. The accelerometer is to be adjusted such that the acceleration due to gravity is not measured. The 1/100 highest vertical acceleration at the longitudinal center of gravity may be used in place of n_{cg} in 2.2.1 and 2.2.2 of this Part.

(2) Roll Acceleration
The significant roll acceleration about a longitudinal axis through the center of gravity and the maximum roll angle are to be reported.

(3) Pitch Angle and Acceleration
The significant coupled pitch-and-heave acceleration at the bow and the stern and the maximum pitch angle are to be reported.

(b) Accelerations from Direct Analysis

(i) General

The wave-induced craft motions may be determined by direct analysis. When this analysis is not performed by the Society, it is to be verified by model testing as indicated in 1.3.3(a) of this Chapter.

(ii) Global Accelerations

Global accelerations are to be determined using the loading conditions indicated in 1.3.2(c) of this Chapter. The 1/100 highest vertical (heave) acceleration at the longitudinal center of gravity may be used in place of n_{cg} in 2.1 and 2.2 of this Part.

(iii) Local Accelerations

Local accelerations at points where the lightship weight of the structure, (non-liquid cargo), are located, including deck-mounted equipment, are to be calculated to determine the inertia loads. For vehicle decks, wheel loading is to be applied. An evenly distributed load equivalent to the weight of the vehicles may be used. The acceleration RAO at a location of interest is to be calculated to account for all translational and rotational components of motions.

The components of the gravitational acceleration in the craft's coordinate system are to be included.

1.3.4 Load Predictions

(a) Global Loads

As a minimum, the still-water hogging and sagging moments and shear forces, the wave-induced hogging and sagging moments and shear forces and the slam-induced moments and shear force, are to be determined for monohull craft. Multi-hulled craft are to have the transverse bending moment, the torsional (or pitch connecting) moment and the transverse shear force determined in addition to the moments and shear forces determined for monohull craft. These loads are to be reported so that they can be used in conjunction with the requirements in 1.3.5 of this Chapter or 2.1 of this Part.

(i) Computation of Global Load Effects

(1) Still-water Bending Moment and Shear Force
The still-water bending moments and shear forces are to be calculated in the light load, half load, and full load conditions. The light load condition consists of all components of the craft (structure, machinery, piping equipment, outfitting, wiring, interiors, paint, etc.) plus 10% of tank and cargo capacity. The half load condition is to include all components of the craft plus 50% of the tank and cargo capacity. The full load condition consists of all components of the craft plus 100% of the tank and cargo capacity. The distribution of the load is to capture all major weight discontinuities, and no single weight distribution segment is to be greater than 0.20L.

(2) Wave-Induced Longitudinal Bending Moment and Shear Force
The wave-induced bending moments and shear forces can be determined by using the environmental conditions outlined in 1.3.2(b) of this Chapter.

(3) Transverse Bending Moment and Shear Force – Multi-hulled Craft
The transverse bending moment and shear force may be determined by distributing the weights and loads athwartships across the craft and using the environmental conditions outlined in 1.3.2(b) of this Chapter.

(4) Torsion Bending Moment
The torsional bending moment may be determined by distributing the weights and loads on segments of the hull sliced at a 45° angle from centerline and using the environmental conditions outlined in 1.3.2(b) of this Chapter.

(5) Slamming Induced Bending Moment and Shear Force
The slam induced bending moment and shear force may be calculated by applying the acceleration determined in 1.3.3 of this Chapter or in 2.2.1 of this Part to the lumped masses developed for 1.3.4(b)(iii) of this Chapter.

(ii) Global Loads from Computations

Global loads from computer software programs are to be developed by loading the structure as outlined 1.3.2(c) of this Chapter. The computer program is to be capable of determining the moments and shear forces in 1.3.4(a) of this Chapter or developing loads that can be used in conjunction with finite element methods as outlined in 1.3.5(a) of this Chapter.

(b) Local Loads

Loads that differ from the pressure loads developed in 2.2 of this Part may be used to determine the required scantlings in conjunction with the requirements in 1.3.5(b) of this Chapter or 2.3 and 2.4 of this Part. These

loads are to be developed under the loading conditions in 1.3.2 of this Chapter and the following subparagraphs.

(i) External Hydrodynamic Pressure

The hydrodynamic pressures at selected points on the external contours of the hull sections, are to be calculated in regular waves.

(1) External Pressure Components
The total hydrodynamic pressure is to include the pressure components due to waves and the components due to craft motion. Components of the hydrodynamic pressure are to be calculated from the panel model analysis of 1.3.2(c)(iii) of this Chapter.

(2) Pressures Accompanying the Dominant Load Parameter and their Distribution
The external pressure is to be calculated either as a complex number or in terms of the amplitude and phase. Then, 'simultaneously' acting pressures over the wetted surface can be represented in the form:

$$P = (A)(a_w)\sin(\omega_e t + \varepsilon_I)$$

where

P	=	simultaneous pressure
A	=	amplitude of the pressure RAO
a_w	=	equivalent wave amplitude
ω_e	=	frequency of the equivalent wave when the RAO of the dominant load component of the load case reaches its maximum
t	=	time under consideration
ε_I	=	phase angle of the (other) load component's RAO

(3) Pressure Loading for Finite Element Models
The hydrodynamic pressure can be linearly interpolated to obtain the nodal pressures for the finite element models required for structural analysis.

(4) Pressure Loading for Rule Requirements
For pressures that are to be used in conjunction with the requirements in 2.3 and 2.4 of this Part for determining the local scantlings, the hydrodynamic pressures are to be resolved into kN/m^2.

(ii) Internal Tank Pressure

Liquid pressures in the cargo tanks are to be calculated and applied to the structural model used in finite element analysis. Both static and dynamic pressures are to be included in the analysis, assuming that there is no relative motion between the tank and the contained fluid.

(1) Pressure Components
The internal tank pressure is to account for both the quasi-static and motion-induced (dynamic) pressure components. The quasi-static component results from gravity and is to include craft roll and pitch rotations. The dynamic component is to be developed from the accelerations in the liquid at the tank boundary caused by the hull's motions in six degrees of freedom. These are to be obtained from motion analysis as specified in 1.3.2 of this Chapter.
The total instantaneous internal tank pressure for each of the tank boundary points is to be calculated by combining the inertial and quasi-static components as follows:

$$p = p_o + \rho h_t[(g_x + a_x)^2 + (g_y + a_y)^2 + (g_z + a_z)^2]^{1/2}$$

where

p	=	total instantaneous internal tank pressure at a tank boundary point
p_o	=	vapor pressure or the relief valve pressure setting
ρ	=	fluid density, cargo or ballast
h_t	=	total pressure head defined by the height of the projected fluid column in the direction of the total instantaneous acceleration vector
$a_{x,y,z}$	=	longitudinal, lateral, and vertical wave-induced accelerations relative to the craft's axis system at a point on a tank's boundary

$g_{x,y,z}$ = longitudinal, lateral, and vertical components of gravitational accelerations relative to the craft's axis system at a tank boundary point

(2) Roll and Pitch Motions
The influence of ship motions on tank pressures is to be taken into account using the maximum pitch and roll angles. As reflected in the previous formulations, the inclination of the tank due to craft roll and pitch is to be considered in the calculation of the hydrostatic pressure. The direction of gravitational forces in the ship-fixed coordinate system varies with roll and pitch, resulting in a change in pressure head and a corresponding change in the static pressure.

(3) Simultaneously Acting Tank Pressure
At each wave condition, for each load case described in 1.3.2(c) of this Chapter, simultaneously acting tank pressures (quasi-static and dynamic) are to be calculated. Each wave condition is defined by wave amplitude, frequency, heading angle and wave crest position, as explained in 1.3.2(c) of this Chapter. Using the wave amplitude and phase angle determined based on the RAO of a DLP, the simultaneously acting tank pressure is to be calculated for the instant when the maximum value of the DLP occurs. These internal tank pressures are to be used in the structural finite element model.

(iii) Inertia Force of Lumped Structural Mass

The inertia force, or point load, of a structural mass, such as deck equipment or cargo, can be determined by the following equation:

$$F = m(A_t)$$

where:
F = inertial load of the item
m = mass of the lumped weight of the structural member
A_t = amplitude of the acceleration RAO

For finite element models, the inertia forces in three (global) directions are to be calculated and applied. For a first-principles analysis, the inertia force in the vertical direction is to be calculated and applied.

1.3.5 Structural Response

(a) Global Response

The global bending moments developed in 1.3.4(a) of this Chapter can either be applied to the requirements in 2.1.1(a)(ii)(5), 2.1.1(c), 2.1.1(e)(iv) and 2.1.2(c) of this Part or to a global finite element model as outlined in this paragraph.

(i) General

The load cases of 1.3.2(c) of this Chapter are to be applied to the global structural analysis model described in 1.3.5(a)(iv) of this Chapter. Each load case is to include the hydrostatic and still-water load components that have not otherwise been directly included in the load component determination performed in accordance with 1.3.4(b)(i) and 1.3.4(b)(iii) of this Chapter. These hydrostatic or still-water load components are to be included in the hydrostatics analysis.

(ii) Equilibrium Check

The model of the hull girder structure is to be close to equilibrium when all the loads (static and dynamic) are applied.

The unbalanced forces in the model's global axis system for each load case need to be determined and resolved. The magnitudes of the unbalanced forces, and the procedure used to balance the structural model in equilibrium is to be fully documented.

(iii) General Modeling Considerations

To the maximum extent practicable, the overall model of the hull structure is to comprise the entire hull. There is also to be sufficient compatibility between the hydrodynamic and structural models so that the

application of fluid pressures onto the finite element mesh of the structural model can be done appropriately.

For the load component types and structural responses of primary interest, analysis software formulations derived from linear idealizations are sufficient. Enhanced bases of analysis may be required so that non-linear loads, such as hull slamming, may be required. The adequacy of the selected software is to be demonstrated to the satisfaction of the Society.

The results of overall (global) model analysis are to be directly employed in the creation and analysis of the required finer mesh, local structural models. Appropriate boundary conditions determined in the larger scale model are to be imposed onto the local models for appropriate structural continuity and load transfer between the various levels of models.

(iv) Analysis of the Global Hull Structure

The global structural and load model is to be as detailed and complete as possible. The stress results of the global model are used only to assess the hull girder plating of the deck (and wet deck for multi-hulled craft), side shell, bottom, inner bottom, longitudinal bulkheads, transverse bulkheads and stools or deck box girders. The main supporting members of the hull girder may be evaluated using 2-D fine-mesh local models. In developing the 3-D global finite element model, the following requirements apply:

(1) The finite element model is to include all primary load-carrying members. Secondary structural members which may affect the overall load distribution are also to be included.

(2) Structural idealization is to be based on the stiffness and anticipated response of the structure, not wholly on the geometry of the structure itself.

(3) The relative stiffness between associated structural members and their anticipated response under the specified loading is to be considered.

(4) A judicious selection of nodes, elements, and degrees of freedom is to be made to represent the stiffness and mass properties of the hull, while keeping the size of the model and required data generation within manageable limits. Lumping of plating stiffeners, use of equivalent plate thickness, and other techniques may be used for this purpose.

(5) The finite elements, whose geometry, configuration, and stiffness closely approximate the actual structure, can typically be of three types:

- Truss or bar elements with axial stiffness only
- Beam elements with axial, shear, and bending stiffness
- Membrane plate elements, either triangular or quadrilateral.

(6) When possible, the finite element structure is to be based on the use of gross or as-built scantlings.

(b) Local Response

The local loads developed in 1.3.4(b) of this Chapter may be used in conjunction with the scantling requirements in 2.3 and 2.4 of this Part. For local structure that forms a grillage, or that is arranged in a manner not indicative of the principles given in the other Sections of the Rules, or structure that is being examined in conjunction with a finite element analysis may be reviewed using the following:

(i) Non-Prismatic Beam Analysis

Beams that do not have uniform cross-sections may be analyzed using a non-prismatic beam program. The adequacy of the selected software is to be demonstrated to the satisfaction of the Society. In developing the non-prismatic beam model, the following requirements apply:

(1) The program is to be capable of calculating the shear and bending moment at all locations along the length of the beam.

(2) Section properties of the beam are to be inputted into the program to resemble the actual construction of the beam and are to have a maximum segment length of 300 mm.

(3) The loads for the beam may be derived from 2.2 of this Part or 1.3.4 of this Chapter.

(4) The boundary conditions of the beam are to reflect the structural arrangement.

(ii) Grillage or Plane Frame Analysis

Structure that forms a grillage, or an area of structure that is arranged in a manner that is different from the principles of the Rules, may be analyzed using a grillage or plane frame analysis program. The

adequacy of the selected software is to be demonstrated to the satisfaction of the Society. In developing the grillage or plane frame model, the following requirements apply:

(1) The beam elements in the model are to be arranged to reflect all of the structure in the area under consideration.

(2) The program is to be capable of applying off-axis loads to the elements and nodes.

(3) The program is to be capable of calculating and reporting the bending moments and shear forces at each node.

(4) The loads for the model may be derived from 2.2 of this Part or 1.3.4 of this Chapter.

(5) The boundary conditions of the model are to reflect the structural arrangement. Boundary conditions for model symmetry will be specially considered.

(iii) Local Fine Mesh Model from Global 3-D Model

Detailed local stresses are to be determined by fine mesh FEM analysis of local structures, based on the results of the global 3-D analysis.

The requirements for developing the 3-D coarse mesh global model in 1.3.5(b)(iv) of this Chapter are also applicable to the development of the 2-D fine-mesh models. In developing the 2-D fine mesh model, the following requirements apply:

(1) The mesh size of the 2-D finite element model are to be determined by adequately modeling the stiffness of the individual structural members forming the local structure.

(2) In modeling a local transverse structure, the web plating is modeled by membrane plates, using both quadrilateral and triangular elements. Stiffeners on the web plating, such as panel breakers, tripping brackets, flat bar stiffeners, etc., and the face plates of the webs are modeled by rod elements of equivalent cross sectional areas. Where face plates on brackets are tapered at the ends, the area of the rod elements is to be reduced accordingly. The out-of-plane hull girder plating (i.e., deck, side shell, bottom shell, girders, etc.) is also to be modeled by rod elements, using an appropriate effective width.

(3) The mesh size used is to be adequate to represent the overall stiffness of the considered local structure as a whole, such that smooth stress distributions in the structure can be obtained.

(4) Finer meshes are to be used in the probable high stressed areas in order to obtain more accurate stress distributions for these areas. The use of a uniform mesh with smooth transition and with avoidance to abrupt changes in mesh sizes is recommended.

(5) In laying out the mesh, the shapes of membrane elements created are to be as regular as possible. The aspect ratios of plate elements are to be kept within 2:1. Elements with an aspect ratio higher than 5:1 may be used for convenience of modeling in way of low stress areas, or areas of low interest.

(6) The grid line spacing and element sizes for the transverse section can be determined by the spacing of the longitudinals on the bottom shell, inner bottom, and topside tank. The grid lines can either be in line with the longitudinals, or for a finer mesh, an additional one division can be added between the longitudinal spacing.

(7) Cutout openings for longitudinals and access holes need not be considered in the 2-D models. This is also applies to all lightening holes or other small openings in the webs.

(8) The stiffeners, panel breakers, and ribs that prevent local buckling that are parallel to the principal direction of stress are to be included in the model.

Boundary displacements obtained from the 3-D global analysis are to be used as boundary conditions in the fine mesh analysis. As applicable, the fine mesh models are to include at least the following local structures:

- A number of transverse web frames
- Centerline longitudinal girder
- Side longitudinal girder
- Horizontal stringers of watertight transverse bulkhead
- Other areas of high stress indicated from the 3-D global analysis.

Where the 3-D global analysis is not comprehensive enough to determine adequately the total stress in the longitudinal plating (e.g., deck and shell) and transverse bulkhead plating of the craft, additional

analyses may be required. Such analyses may not require the performance of fine mesh FEM analysis, where the needed results can be provided by another acceptable method.

(iv) Local Fine Mesh Model without Global 3-D Model

Structure that forms a grillage or an area of structure that is arranged in a manner different from the principles of the Rules may be analyzed using a local finite element model. The adequacy of the selected software is to be demonstrated to the satisfaction of the Society. In developing the local finite element model, the following requirements apply:

(1) The requirements in 1.3.5(b)(iv) of this Chapter are to be applied as applicable.

(2) The loads for the model may be derived from 2.2 of this Part or 1.3.4 of this Chapter.

(3) The boundary conditions of the model are to reflect the structural arrangement. Boundary conditions that model symmetry will be specially considered.

1.3.6 Structral Acceptability

(a) Beam, Grillage, or Plane Frame Analysis

The allowable bending stress for elements in beam, grillage or plane frame models is given in Table III 2-15 or Table III 2-16 of this Part. The allowable shear stress for aluminum and steel elements is $0.5\tau_y$ ($0.75\tau_y$ for bottom primary structures) where τ_y is the minimum shear yield strength of the material. For aluminum structure, τ_y is to be in the welded condition. The allowable shear stress for composite members is $0.4\tau_u$, where τ_u is the lesser of the ultimate shear strength in either the warp or fill of the web laminate.

(b) Finite Element Analysis

(i) General

The adequacy of the finite element analysis results is to be assessed for the failure modes of material yielding and buckling. The requirements in this chapter are for steel, aluminum and FRP craft. The acceptance criteria for craft constructed of other materials will be specially considered.

(ii) Yielding

For a plate element subjected to biaxial stress, a specific combination of stress components, rather than a single maximum normal stress component constitutes the limiting condition. In this regard, the total equivalent stress is to be based on the Hencky von-Mises criterion as the following equation:

$$\sigma_e = \sqrt{\sigma_x^2 + \sigma_y^2 - \sigma_x\sigma_y + 3\tau_{xy}^2}$$

where:

σ_x = normal stress in the x coordinate direction of the element
σ_y = normal stress in the y coordinate direction of the element
τ_{xy} = in-plane shearing stress

The total equivalent stress (Hencky von-Mises stress) is to be less than or equal to the following design stress:

Steel: $0.95\sigma_{yield}$

Aluminum: $0.85\sigma_{yield}$

FRP: $0.37\sigma_u$

where σ_{yield} is the yield strength for steel structures or the welded yield strength for aluminum structure, and σ_u is the ultimate tensile or compressive strength of the laminate, whichever is less.

Component stresses (σ_x, σ_y, τ_{xy}) are to be less than or equal to allowable local structure design stress.

(iii) Design Global Hull Girder Stresses

The design stresses are as follows:

(1) Global Longitudinal Strength of All Hull Types

σ_a = 175 /CQ design longitudinal bending stress N/mm^2

τ_a = 110/Q design shear stress N/mm^2

C = 1.0 for steel craft
= 0.90 for aluminum craft
= 0.80 for fiber-reinforced plastic craft

Q for steel:
= 1.0 for ordinary strength steel
= 0.78 for grade H32 steel
= 0.72 for grade H36 steel

Q for aluminum:
= $0.9 + q_5$ but not less than Q_o

q_5 = $115/\sigma_y$

Q_o = $635/(\sigma_y+\sigma_u)$

σ_y = minimum yield strength of unwelded aluminum (not to be greater than $0.7\sigma_u$) N/mm^2

σ_u = minimum ultimate strength of welded aluminum N/mm^2

Q for fiber-reinforced plastic:
= $400/0.75\sigma_u$

σ_u = minimum ultimate tensile or compressive strength, whichever is less, verified by approved test results. Strength properties in the longitudinal direction of the craft are to be used. N/mm^2

(2) Global Transverse Strength of Multihulls

σ_a = design transverse bending stress, $0.66\sigma_y$ for aluminum and steel craft and $0.33\sigma_u$ for FRP craft N/mm^2

σ_{ab} = design torsional or combined stress，$0.75\sigma_y$ for aluminum and steel craft and $0.367\sigma_u$ for FRP craft N/mm^2

τ_a = design transverse shear stress, $0.38\sigma_y$ for aluminum and steel craft and $0.40\tau_u$ for FRP craft N/mm^2

σ_y = minimum yield strength of the material. For aluminum the yield strength is to be for the unwelded condition and not to be greater than $0.7\sigma_{uw}$ N/mm^2

σ_u = minimum tensile or compressive strength, whichever is less N/mm^2

σ_{uw} = ultimate tensile strength of material in the welded condition N/mm^2

δ_m = maximum deflection for FRP craft, $(\sigma_a/E)L_I$ m

τ_u = minimum ultimate through thickness shear strength N/mm^2

L_I = mean span of cross structure, as indicated in Fig. III A2-2 of this Part cm

E = tensile or compressive modulus of the FRP laminate, whichever is lesser N/mm^2

1.4 Guidelines for Finite Element Analysis

1.4.1 General

The intent of this section is to provide guidance on the use on fine element methods (FEM) for evaluating linear response of hull structural components, equipment foundations and reinforcement structure to applied loads.

Finite element methods can be applied with varying level of detail and complexity to determine stress levels, deflection magnitudes and other parameters of structural components. The choice of the type of finite element and evaluation criteria should match the desired level of detail, loading scenario, boundary conditions and complexity of the structural component.

1.4.2 Structural Modeling

(a) Finite Element Types

The choice of the type of finite element is guided by the complexity of the structural system or component being analyzed, the level of detail desired and the outcomes measured. Two node line element and three or four membrane/plate element are considered sufficient for representation of a structure and requirements in this section assumes the use of such element types in the models. Higher order elements may also be applied. Details of basic element types are given in Table III 1-8 of this Chapter.

Table III 1-8
Finite Element Type

Rod (or truss) element	Line element with axial stiffness only and constant cross-sectional area along length of the element
Beam element	Line element with axial, torsional and bi-directional shear and bending stiffness and with constant properties along the length of the element
Membrane (or plane-stress) element	Plate element with in-plane stiffness and with constant thickness
Shell (or bending plate) element	Plate element with in-plane and out-of-plane bending stiffness and with constant thickness

(b) Model Types

(i) Beam/Grillage Model

Beam/grillage models comprise of entirely of beam and rod elements, and are suitable for the solution of simple to more elaborate beam problems of one, two or three-dimensional configuration.

Examples where such models could be applied are for deck beams, girders, floors, and bulkhead stiffening. Such models provide bending moment and shear force distributions, axial, bending and shear stresses, and deflection magnitudes.

(ii) Plate Element Model

Plate element models are applied in cases where a precise representation of the geometry of the structural component or system is necessary, the complexity of the structure warrants it, or when the desired structural response cannot be determined from beam or grillage models.

(c) Modeling Guidance

(i) The model should include, as applicable, all primary load-carrying members of the structure being analyzed. Secondary structural members that may significantly affect load distributions and local response of the primary members may also be appropriately included in the model.

(ii) For beam elements, cross sectional properties are to be based on that of effective width of the attached plating. The effective width of plating of beam elements is not to exceed the sum of one-half of the spacing on either side of the structural member or 1/3 of the unsupported span of the member, whichever is less.

(iii) Plate element meshing is to follow the stiffening system as far as practicable. The mesh size used should be adequate to represent the overall stiffness of the considered structure. For meshing of large systems such as deck, shell or bulkhead plate/framing systems, the mesh size is to not exceed the spacing between the frames. The mesh should be progressively and smoothly refined to capture structural details where important or found necessary.

(iv) At least three elements are to be used, where practical, to model webs of primary supporting members such as girders, transverses, stringers and floors. Rod elements may be used to model flanges of primary supporting members and brackets. The cross sectional area of rods representing sniped or tapered flanges is to be considered proportionally using an average area over the length of the element.

(v) The aspect ratio of plate elements, in general, is not to exceed three. The use of triangular plate elements is to be kept to a minimum.

(vi) Shell elements are to be used for plate elements subjected to lateral loading.

(d) Boundary Conditions

Boundary conditions applied are to reflect, as closely as possible, the actual support conditions of the structure.

The extent of model should be sufficient to establish proper boundary conditions. Where the model has been extended to points well away from the areas of interest within the model, boundary conditions may be reasonably simplified, for example assuming fully fixed conditions for plate elements models.

(e) Loads

Loads applied on a model are to be as required by the relevant rule or the design loads of the structural member, whichever is greater.

In addition to static loads, other loads such as hull girder and dynamic loads arising out of acceleration, ship motion, etc. are to be considered where applicable and relevant.

In typical cases, it is not necessary to consider the self weight of the structure, unless it is expected to be a significant component of the loads acting on the structure.

Loads are to be applied in a manner so as to match, as closely as possible, the expected distribution and manifestation of the load within the structure in the actual situation.

(f) Stress Criteria

Unless otherwise specified in the Rules or relevant regulations, individual stress components and, as applicable, direct combinations of such stresses in beam or grillage models are not to exceed the allowable stress F.

$$F = F_y / FS$$

where

F_y = specified minimum yield strength of the material

FS = Factor of Safety

For static loadings:

= 1.67 for axial or bending stress

= 2.50 for shear stress

For loads combining static and dynamic:

= 1.25 for axial or bending stress

= 1.88 for shear stress

For plate element models, and unless otherwise specified in the Rules or relevant regulations, the Von-Mises equivalent stress is not to exceed the limits specified in Table III 1-9 of this Chapter for the specific mesh size.

Table III 1-9
Stress Limits for Plate Element Models

Mesh Size	Stress Limit
1 × stiffener spacing (SS)	0.90 S_mF_y
1/2 × SS	0.95 S_mF_y
1/3 × SS	1.00 S_mF_y
1/4 × SS	1.06 S_mF_y
1/5 × SS ~ 1/10 × SS(1)	1.12 S_mF_y

Note:

(1) Stress limits greater than 1.00 S_mF_y are to be restricted to small areas in way of structural discontinuities.

(2) S_m = 1.0 for mild steel
= 0.95 for HT 32
= 0.908 for HT 36

(3) For intermediate mesh size, the stress limit may be obtained by linear interpretation

(4) For longitudinally effective structure that is modeled without the hull girder loads, the allowable stresses are to be decreased by 10%

Chapter 2

Hull Structures and Arrangements

2.1 Primary Hull Strength

2.1.1 Longitudinal Hull Girder Strength – Monohulls

The equations are, in general, valid for craft having breadths, B, not greater than twice their depths, D, as defined in 1.1 of this Part. Finite element analysis of the longitudinal hull girder strength is an acceptable alternate analysis to the requirements in 2.1.1 through 2.1.3 of this Chapter. The failure criteria, seaway loads, and finite element method is to be submitted for review, see 1.3 of this Part.

(a) Section Modulus

(i) All Craft

The required hull girder section modulus SM at amidships is to be not less than given by the following equation:

$$SM = C_1C_2L^2B(C_b + 0.7)K_3CQ \qquad cm^2\text{-}m$$

where

C_1 = $0.044L + 3.75$ L < 90 m

= $10.75 - \left(\frac{300 - L}{100}\right)^{1.5}$ 90 m ≤ L

C_2 = 0.01

L = length of craft, as defined in 1.1 of this Part m

B = breadth, as defined in 1.1 m

V = maximum speed in calm water, in knots, for the loading condition under consideration

C_b = block coefficient at the design draft, based on the length, L, measured on the design load waterline. C_b is not to be taken as less than 0.45 for L < 35 m or 0.6 for L ≥ 61 m. C_b for lengths between 35 m and 61 m is to be determined by interpolation.

K_3 = $0.70 + 0.30\left(\frac{V/\sqrt{L}}{2.36}\right)$

K_3 is not to be taken less than 1, nor more than 1.30.

C = 1.0 for steel craft

0.90 for aluminum craft

0.80 for fiber-reinforced plastic craft

Q for steel:

= 1.0 for ordinary strength steel

= 0.78 for grade H32 steel

= 0.72 for grade H36 steel

For other steel grades:

Q_{other} = $490/(\sigma_y+0.66\sigma_u)$, where σ_y is not to be greater than 70% σ_u

Q for aluminum:

= $0.9 + q_5$ but not less than Q_o

q_5 = $115/\sigma_y$

Q_o = $635/(\sigma_y+\sigma_u)$

σ_y = minimum yield strength of unwelded aluminum (not to be greater than $0.7\sigma_u$) N/mm^2

σ_u = minimum ultimate strength of welded aluminum N/mm^2

Q for fiber reinforced plastic:

= $400/0.75\sigma_u$ N/mm^2

σ_u = minimum ultimate tensile or compressive strength, whichever is less, verified by approved test results. See 1.5 of Part II. Strength properties in the longitudinal direction of the craft are to be used. N/mm^2

(ii) Craft 61 m in Length and Over

In addition to meeting the above criteria in 2.1.1(a)(i), craft of 61 m in length or greater are to comply with the following requirements:

(1) Sign Convention of Bending Moment and Shear Force
The sign convention of bending moment and shear force is as shown in Fig. III 2-1 of this Chapter.

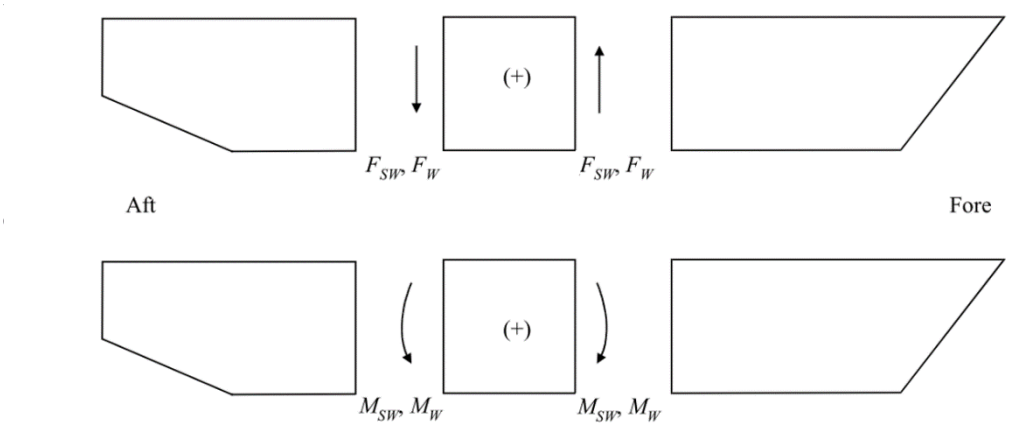


Fig. III 2-1
Sign Convention

(2) Wave Bending Moment Amidships
The wave bending moment, expressed in kN-m, may be obtained from the following equations:

$M_{ws} = -k_1C_1L^2B(C_b + 0.7) \times 10^{-3}$ Sagging Moment

$M_{wh} = +k_2C_1L^2BC_b \times 10^{-3}$ Hogging Moment

where

$k_1 = 110$

$k_2 = 190$

C_1, L, B and C_b are as defined in 2.1.1(a)(i) of this Chapter.

(3) Still Water Bending Moment
The maximum still water bending moment in both the hogging and sagging condition is to be submitted. In case the detailed information is not available in the early stages of design, or the still water bending moment is not required to be submitted, the still water bending moment in kN-m can be determined by the following:

$M_{sws} = 0$ Sagging Moment

$M_{swh} = 0.375f_pC_1C_2L^2B(C_b + 0.7)$ Hogging Moment

where

f_p = 17.5 kN/cm^2

C_1, C_2, L, B and C_b are as defined in 2.1.1(a)(i) of this Chapter.

(4) Slamming Induced Bending Moment

The slamming induced bending moment in kN-m can be determined by the following equation:

$M_{sl} = C_3\Delta(1+n_{cg})(L-l_s)$ kN-m

where

C_3 = 1.25

Δ = full load displacement ton

l_s = length of slam load m

= A_R/B_{wl}

A_R = $0.697\Delta/d$ m^2

B_{wl} = waterline breadth at the LCG m

n_{cg} = maximum vertical acceleration as defined in 2.2.1(a) of this Chapter, but $(1+n_{cg})$ is not to be taken less than indicated in Table III 2-1 of this Chapter.

Table III 2-1
Minimum Vertical Acceleration

Δ (metric tons)	Minimum Vertical Acceleration, $(n_{cg}+1)$ (g)
180	3
400	2
$\geq$ 1200	1

Note: Intermediate values of n_{cg} are to be determined by linear interpolation.

(5) Section Modulus

The required hull-girder section modulus for 0.4L amidships is to be obtained from the following equation:

$$SM = \frac{M_t CQ}{f_p} \quad \text{cm}^2\text{-m}$$

where:

M_t = maximum total bending moment kN-m
To be taken as the greatest of the following
= $M_{swh} + M_{wh}$
= $-M_{sws} - M_{ws}$
= M_{sl}

M_{swh} = maximum still-water bending moment in the hogging condition, as determined in 2.1.1(a)(ii)(3) of this Chapter kN-m

M_{sws} = maximum still water bending moment in the sagging condition, as determined in 2.1.1(a)(ii)(3) of this Chapter kN-m

M_{wh} = maximum wave induced bending moment in the hogging condition, as determined in 2.1.1(a)(ii)(2) of this Chapter kN-m

M_{ws} = maximum wave induced bending moment in the sagging condition, as determined in 2.1.1(a)(ii)(2) of this Chapter kN-m

M_{sl} = maximum slamming induced bending moment, as determined in 2.1.1(a)(ii)(4) of this Chapter kN-m

f_p = 17.5 kN-m

C and Q are as defined in 2.1.1(a)(i).

Consideration may be given to a seakeeping analysis based on craft speed and sea state to determine M_{ws} and M_{wh}.

(b) Extension of Midship Section Modulus

Where the still-water bending moment envelope is not submitted or where 2.1.1(a)(i) of this Chapter governs, the scantlings of all continuous and all effectively developed longitudinal material are to be maintained throughout 0.4L amidships and may be gradually tapered beyond. The area of the strength deck and other

effective decks comprising of plating and longitudinal members may be reduced linearly from 0.4L amidships to the ends. The ends of all continuous and effectively developed longitudinal members are to terminate with back-up brackets extending to and attached to an adjacent transverse member. The bracket is to extend for a distance not less than the depth of the member.

Structure that is not continuous throughout the midships 0.4L and beyond, but is effectively developed by brackets and welding to provide continuity of area, may be taken to contribute to the hull girder section modulus, provided the buckling strength required by 2.4.1(c) of this Chapter is maintained in way of the brackets.

Where the scantlings are based on the envelope curve of still-water bending moments, items included in the hull-girder section modulus amidships are to be extended as necessary to meet the hull-girder section modulus required at the location being considered, taking into account the distance required for the member to become fully effective (See 2.1.1(d)(ii) of this Chapter).

The envelope curve of M_{ws} and M_{wh} may be obtained by multiplying the midship value by the distribution factor M in Fig. III 2-2 of this Chapter.

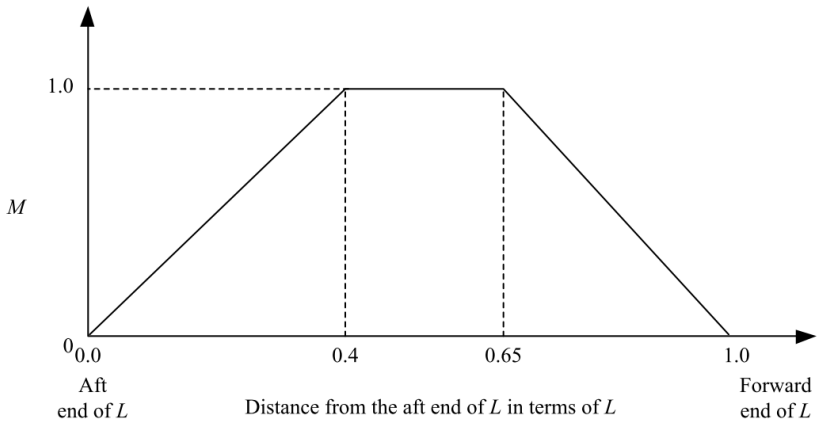


Fig. III 2-2
Distribution Factor M

(c) Moment of Inertia

The hull-girder moment of inertia, I, at amidships is to be not less than given by the following equation:

$$I = \frac{L}{QC}\frac{SM}{K} \qquad cm^2\text{-}m^2$$

where:

SM = required hull-girder section modulus in 2.1.1(a)(i) or 2.1.1(a)(ii) of this Chapter, whichever is greater cm^2-m

K = factor dependent on the material and craft length as given in Table III 2-2 of this Chapter

L, C and Q are as defined in 2.1.1(a)(i) of this Chapter

Table III 2-2
Factor, *K*

L (m)	Steel	Aluminum	FRP(Basic Laminate)
Restricted Service L < 61 m	50	13.33	1.8
Unrestricted Service L ≤ 61 m	40	13.33	1.8
All Craft L > 61 m	33.3	11.1	1.5

Note:

(1) For fiber reinforced plastic laminates that are greater than the basic laminate (as defined in 1.7.4(a) of Part II), the value for K can be adjusted by the ratio of E_o/E_b

where:

E_o = the elastic modulus of the actual hull laminate N/mm^2

E_b = 6890 N/mm^2

(d) Section Modulus and Moment of Inertia Calculation

(i) Items Included in the Calculation

In general, the following items may be included in the calculation of the section modulus and moment of inertia provided they are continuous or effectively developed within midship 0.4L, have adequate buckling strength, and are gradually tapered beyond the midship 0.4L.

(1) Deck plating (strength deck and other effective decks)

(2) Shell and inner bottom plating

(3) Deck and bottom girders

(4) Plating and longitudinal stiffeners of longitudinal bulkheads

(5) All longitudinals of deck, sides, bottom, and inner bottom, see also 2.5.1(a)(i) of this Chapter

(ii) Effective Areas Included in the Calculation

In general, the net sectional areas of longitudinal strength members are to be used in the hull girder section modulus calculations, except that small isolated openings need not be deducted provided the openings and the shadow area breadths of other openings in any one transverse section do not reduce the section modulus by more than 3%. The breadth or depth of such openings is not to be greater than 25% of the breadth or depth of the member in which it is located with a maximum of 75 mm for scallops. The shadow area of an opening is the area forward and aft of the opening enclosed by the lines tangential to the corners of the opening intersecting each other to form an included angle of 30 degrees.

(iii) Section Modulus to the Deck or Bottom

The section modulus to the deck or bottom is obtained by dividing the moment of inertia by the distance from the neutral axis to the molded deck at side amidships or baseline, respectively. Where a long deckhouse or superstructure is considered as part of the hull girder, the section modulus to the deck is obtained by dividing the moment of inertia by the distance from the neutral axis to the top of the bulwark, deckhouse or superstructure.

(iv) Breaks

Craft having partial superstructures are to be specially strengthened in way of breaks to limit the local increase in stresses at these locations. The main deck plate and side shell plate thickness is to be increased a minimum of 25%, but the increase need not exceed 6.5 mm. This increase is to extend well beyond the break in both directions in such a fashion to provide a long gradual taper. Where breaks of the superstructure (e.g., long forecastle) are appreciably beyond the amidships 0.5L, these requirements may be modified. Gangways, large freeing ports and other openings in the shell or bulwarks are to be kept well clear of breaks, and any holes which must be unavoidably be cut in the plating are to be kept as small as possible and are to be circular or oval in form.

(e) Hull Girder Shear Strength Calculation – For Craft 61 m in Length and Over

(i) General

The nominal total shear stresses due to still-water and wave-induced loads are to be based on the maximum algebraic sum of the shear force in still-water, Fsw, the wave-indicated shear force, Fw, and the slam induced shear force, Fsl, at the location being considered. The thickness of the side shell is to be such that the nominal total shear stress as obtained by 2.1.1(e)(iii) of this Chapter are not greater than $11.0/Q\ kN/cm^2$ where Q is as defined in 2.1.1(a)(i) of this Chapter. Consideration is also to be given to the shear buckling strength of the side shell plating.

(ii) Wave Shear Forces

The envelopes of maximum shearing forces induced by waves, Fw, as shown in Fig. III 2-3 and Fig. III 2-4 of this Chapter may be obtained from the following equations:

$F_{wp} = +kF_1C_1LB(C_b + 0.7) \times 10^{-2}$ For positive shear force

$F_{wn} = -kF_2C_1LB(C_b + 0.7) \times 10^{-2}$ For negative shear force

where:

F_{wp}, F_{wn}	=	positive and negative maximum shearing force induced by wave	kN
k	=	30	
F_1	=	distribution factor as shown in Fig. III 2-3 of this Chapter	
F_2	=	distribution factor as shown in Fig. III 2-4 of this Chapter	

C_1, L, B and C_b are as defined in 2.1.1(a)(i) of this Chapter.

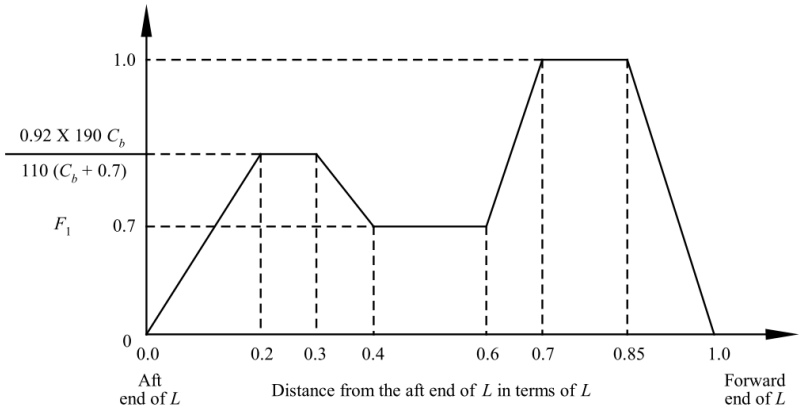


Fig. III 2-3
Distribution Factor F_1

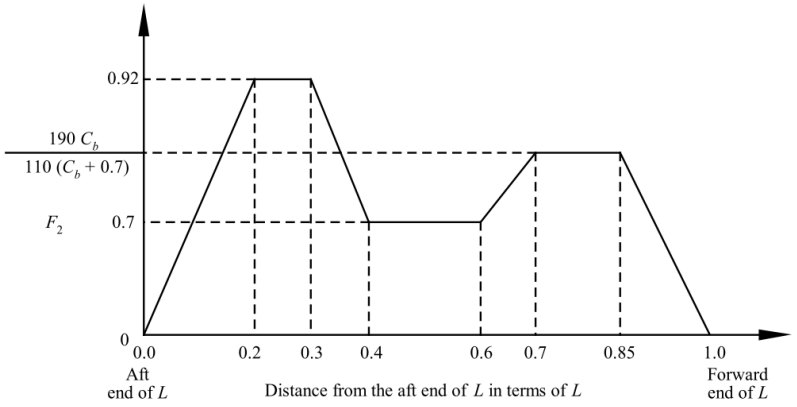


Fig. III 2-4
Distribution Factor F_2

(iii) Slam Induced Shear Force

The slamming induced shear force can be determined by the following equation:

$F_{sl} = C_4F_1\Delta(n_{cg} + 1)$ kN For positive shear force

$F_{sl} = C_4F_2\Delta(n_{cg} + 1)$ kN For negative shear force

where:

C_4	=	4.9	
Δ	=	full load displacement	metric tons

n_{cg} = maximum vertical acceleration as defined in 2.2.1(a) of this Chapter

(iv) Shear Strength

For craft without continuous longitudinal bulkheads, the nominal total shear stress f_s in the side shell plating may be obtained from the greater of the following equations:

$$f_s=(F_{sw} + F_w)m/(2t_sI)$$

$$f_s=F_{sl}\, m/(2t_sI)$$

where:

f_s	=	nominal total shear stress	kN/cm^2
I	=	moment of inertia of the hull girder section, at the section under consideration	cm^4
m	=	first moment about the neutral axis, of the area of the effective longitudinal material between the horizontal level at which the shear stress is being determined and the vertical extremity of effective longitudinal material, taken at the section under consideration	cm^3
t_s	=	thickness of the side shell plating, at the position under consideration	cm
F_{sw}	=	hull-girder shearing force in still-water	kN
F_w	=	F_{wp} or F_{wn} as specified by 2.1.1(e)(ii) of this Chapter, depending upon loading	kN
F_{sl}	=	slam induced shear force, as indicated in 2.1.1(e)(iii) of this Chapter. The slam induced shear force is to be applied in both the hogging and sagging conditions	kN

(v) Shearing Strength for Craft with Two or Three Longitudinal Bulkheads

For craft having continuous longitudinal bulkheads, the total shear stresses in the side shell and longitudinal bulkhead plating are to be calculated by an acceptable method. In determining the still-water shear force, consideration is to be given to the effect of non-uniform athwartship distribution of loads. The methods described in Part II, 3.3.2, of the Rules for Steel Ships may be used as a guide in calculating the nominal total shear stress fs related to the shear flow in the side shell or longitudinal bulkhead plating. Alternative methods of calculation will also be considered.

(vi) Hull Girder Shear Strength – FRP Craft

Hull girder shear strength will be specially considered on fiber reinforced plastic craft over 24 m in length.

(vii) Craft of Unusual Proportion

Craft having unusual proportions will be specially considered

(f) Hull Girder Torsional Loads

Torsional calculations may be required for craft with large deck openings. Racking load calculations may be required for craft with tall superstructures.

2.1.2 Primary Hull Strength – Twin-Hulled Craft

(a) Longitudinal Hull Girder Strength

The following applies to catamarans, surface effect craft, and similar configuration twin hulled craft.

The longitudinal strength requirements for twin-hulled craft are as given in 2.1.1(a) of this Chapter, with the following modifications:

(i) B is to be taken as the sum of the waterline breadths of each hull.

(ii) For craft less than 61 m, longitudinal shear strength need not be considered unless they have unusual or highly concentrated loads. For craft over 61 m the shear strength will be specially considered.

(iii) Items as listed in 2.1.1(d)(ii) of this Chapter may be included in the longitudinal strength calculation for the total cross section of the hulls, with the addition of the cross deck bridging structure. Consideration is to be given to the length over which the cross-deck structure becomes fully effective.

(b) Catamaran Transverse Loadings

The transverse primary hull loadings are determined by the following equations:

$M_{tb} = 2.5\Delta B_{cl}(1 + n_{cg})$ kN-m

$M_{tt} = 1.25\Delta L(1 + n_{cg})$ kN-m

$Q_t = 2.5\Delta(1 + n_{cg})$ kN-m

where:

M_{tb}	=	design transverse bending moment acting upon the cross structure connecting the hulls	kN-m
M_{tt}	=	design torsional moment acting upon the transverse structure connecting the hulls	kN-m
Q_t	=	design vertical shear force acting upon the transverse structure connecting the hulls	kN
Δ	=	craft displacement	ton
B_{cl}	=	distance between the hull centerlines	m
L	=	length of craft, as defined in 1.1.2 of this Part	m
n_{cg}	=	vertical acceleration at the craft's center of gravity, see 2.2.1(a) of this Chapter, but $(1 + n_{cg})$ is not to be taken less than indicated in Table III 2-1 of this Chapter	

(c) Transverse Strength for Catamarans and Surface Effect Craft

(i) Direct Analysis

The design loads that are to be applied to the structure are the transverse bending moment, M_{tb}, the torsional moment, M_{tt}, and vertical shear force, Q_t, as defined in 2.1.2(b) of this Chapter and the longitudinal bending moments as given in 2.1.1(a)(ii) of this Chapter. The requirements for the direct analysis are given in 1.3 of this Part.

(ii) Analysis for Simple Structures

Guidance for the analysis of cross deck structures that are symmetrical forward and aft of a transverse axis at amidships can be found in Appendix 2 of this Part.

(iii) Design Stresses and Deflections

Regardless of the method of analysis used, the design stresses are as follows:

σ_a	=	design transverse bending stress, $0.66\sigma_y$ for aluminum and steel craft and $0.33\sigma_u$ for FRP craft	N/mm^2
σ_{ab}	=	design torsional or combined stress, $0.75\sigma_y$ for aluminum and steel craft and $0.367\ \tau_u$ for FRP craft	N/mm^2
τ_a	=	design transverse shear stress, $0.38\sigma_y$ for aluminum and steel craft and $0.40\ \tau_u$ for FRP craft	N/mm^2
σ_y	=	minimum yield strength of the material. For aluminum the yield strength is to be for the unwelded condition and not to be greater than $0.7\sigma_{uw}$	N/mm^2
σ_u	=	minimum tensile or compressive strength, whichever is less	N/mm^2
σ_{uw}	=	ultimate tensile strength of material in the welded condition	N/mm^2
δ_m	=	maximum deflection for FRP craft, $(\sigma_a/E)L_I$	N/mm^2
τ_u	=	minimum ultimate through thickness shear strength	N/mm^2
L_I	=	mean span of cross structure, as indicated in Fig. III A2-2 of this Part	N/mm^2
E	=	tensile or compressive modulus of the FRP laminate, whichever is lesser	N/mm^2

(d) Items included in Transverse Moment of Inertia and Section Modulus Calculation

The following items may be included in the calculation of the transverse section modulus and moment of inertia provided that are continuous or effectively developed over the entire breadth of the cross structure or wet deck, and have adequate buckling strength:

(i) Deck plating, main deck and bottom plating of wet deck

(ii) Transverse stiffeners on wet deck

(iii) Transverse bulkheads or web frames which span the wet deck, and are effectively developed into the hulls

(iv) Transverse box beams, that are effectively developed into the hulls

(v) Continuous transom plating and attached horizontal stiffeners

In general, the effective sectional area of the deck for use in calculating the section modulus is to exclude hatchways and other large openings in the deck.

Superstructures and house tops are generally not to be included in the calculation of sectional properties of the cross structure. Craft having unusual configuration such as cross-deck structure out-of-line with the main hull structure will be specially considered.

(e) Craft with More Than Two Hulls

Transverse and torsional strength of craft with more than two hulls will be specially considered.

(f) Hull Girder Torsional Loads

Torsional calculations may be required for craft with large deck openings. Racking load calculations may be required for craft with high superstructures.

2.1.3 Strength Considerations for Hydrofoil Borne Craft

(a) Longitudinal Strength

The hull weight curve showing full load, lightship and partial load (if more severe) is to be submitted. The support reactions for each of the hydrofoils are to be shown. The resulting shear and bending moment diagrams, as derived from these curves, are to be submitted for approval.

Hull deflection under the condition of maximum bending moment is not to exceed 1/200 of the distance between the forward and aft foil attachment points.

(b) Calculation of Loads from Hydrofoil Appendages

The maximum forces transmitted by any hydrofoil to the craft structure is given by the following equations:

$$F_L = 13.847 C_L V^2 A_P$$

$$F_D = 13.847 V^2 (C_{DF} A_{FF} + C_{DS} A_{FS}) + \text{(Wetted surface drag)}$$

where:

F_L	=	maximum lift force on craft exerted by hydrofoil, This force is assumed to act perpendicular to the plane of the foil.	Kgf
F_D	=	maximum drag force on craft exerted by hydrofoil plus strut, This force is assumed to act directly aft from the center of the foil.	Kgf
C_L	=	peak coefficient of lift for the foil selected	
C_{DF}	=	peak coefficient of drag for the foil selected	
C_{DS}	=	peak coefficient of drag for the strut section selected	
V	=	maximum craft speed	knots
A_P	=	plan view area of foil	m^2
A_{FF}	=	frontal area of foil	m^2
A_{FS}	=	frontal area of strut	m^2

Total drag of the foil and strut (or similar appendage) is given by the drag term F_D that includes the frictional drag coefficient, as a function of wetted surface and Reynolds number.

The strength of the foils and struts are to be based on F_L and F_D and the resulting bending moments, shear forces, and vertical forces. The strength of the connections of the struts to the hull is to be based on the bending moments, shear forces, and vertical forces applied through the struts. A factor of safety on the yield strength of the material (aluminum use the as-welded condition) is to be not less than 2.0. Calculations of the bending moment, shear forces, and stiffness, are to be carried out and submitted by the designer.

Additionally, calculations supporting the "Fail-Safe" performance of each foil attachment structure are to be submitted.

Watertight integrity of the shell is to be maintained in the event of a collision of the hydrofoil appendages with a solid object in the water. A design safety factor of 2.0 on the yield strength or 3.0 on the ultimate strength of the foil strut bearing is to be used to assess the strength of the foil for the collision condition.

2.1.4 Effective Decks

To be considered effective for use in calculating the hull girder section modulus, the thickness of the deck plating is to comply with the requirements of 2.3 of this Chapter. The deck section areas are to be maintained throughout the midship 0.4L and may be gradually reduced to one half their midship value at 0.15L from the ends. Only that portion of deck which is continuous through the transverse structure may be considered effective.

2.1.5 Operating Manual

Craft are to be furnished with an CR approved operating manual providing guidance on:

(a) Means of identifying that the Manual is for the subject craft including principle particulars of the vessel.

(b) Loading conditions on which the design of the craft has been based, including cargo loading on decks, loading ramps, and double bottoms.

(c) There should also be evidence of approved loading and stability conditions on board the craft. These should preferably be included in the operating manual. If they are a separate document, they should be referenced in the operating Manual.

(d) Maximum approved speed and associated displacement.

(e) Service Limitations, any scope of operations and/or operational limits as applicable such as distance from port of refugee.

(f) Maximum operational speeds for the various sea-states (significant wave heights) in which the craft is intended to operate, exceeding the design significant wave height defined in Table III 2-3 of this Chapter.

(g) Permissible limits of still-water bending moments and shear forces, for craft 61m in length of greater.

(h) Position and application of watertight and weathertight (doors, hatches etc.) closing appliances necessary to meet the Load Line assignment; identification of doors and hatches to be kept closed at sea; information on storm shutters and their use; location of emergency escapes.

(i) From the aspect of the Flag Administration, depending on the Administration to which the craft is flagged, there will also be a need for other items to be included such as safety plan, fire fighting procedures, means of escape, evacuation procedures, operation of life saving appliances, and requirements for safe operation of the vessel.

2.2 Design Pressures

2.2.1 Monohulls

The bottom and side pressures are to be checked using the displacement (Δ), speed (V), draft (d), and running trim (τ) in the full load, half load, and light load conditions. If the craft is receiving a freeboard assignment, the parameters used in the full load condition are to coincide with the assigned freeboard. If the craft is not receiving a freeboard assignment, the parameters used in the full load condition are to correspond to the condition of the craft with the maximum operating

deadweight. The parameters used in the half load condition are to correspond to the condition of the craft with 50% of the maximum operating deadweight, and the parameters used in the light load condition are to correspond to the condition of the craft with 10% of the maximum operating deadweight plus the maximum speed of the craft.

(a) Bottom Design Pressure

The bottom design pressure is to be the greater of those, as given in the following equations, for the location under consideration. Bottom structure design pressures are dependent upon the service in which the craft operates. The bottom design pressure applies to hull bottoms below the chines or the upper turn of the bilge.

(i) Bottom Slamming Pressure

$$P_{bcg} = \frac{N_1 \Delta}{L_w B_w}[1 + n_{cg}]F_D \qquad \text{kN/m}^2$$

$$P_{bxx} = \frac{N_1 \Delta}{L_w B_w}[1 + n_{xx}]\left[\frac{70 - \beta_{bx}}{70 - \beta_{cg}}\right]F_D \qquad \text{kN/m}^2$$

(ii) Bottom Slamming Pressure for Craft Less Than 61 meters, The design pressure may be:

$$P_{bxx} = \frac{N_1 \Delta}{L_w B_w}[1 + n_{cg}]F_D F_V \qquad \text{kN/m}^2$$

(iii) Hydrostatic Pressure

$$P_d = N_3(0.64\text{H} + \text{d}) \qquad \text{kN/m}^2$$

where:

P_{bcg} = bottom design pressure at LCG kN/m^2

P_{bxx} = bottom design pressure at any section clear of LCG kN/m^2

P_d = bottom design pressure based on hydrostatic forces kN/m^2

n_{cg} = the vertical acceleration of the craft as determined by a model test, theoretical computation, or service experience (see 1.3 of this Part). If this information is not readily available during the early stages of design, the following formula utilizing the average 1/100 highest vertical accelerations at LCG can be used:

$$n_{cg} = N_2\left[\frac{12h_{1/3}}{B_w} + 1.0\right]\tau\left[50 - \beta_{cg}\right]\frac{V^2(B_w)^2}{\Delta} \qquad \text{g's}$$

note that g's are the dimensionless ratio of the acceleration at sea level (9.8m/s^2)
The vertical acceleration, n_{cg}, is typically not to be taken greater than the following:

$$n_{cg} = 1.39 + 0.256\frac{V}{\sqrt{L}} \qquad \text{g's}$$

for speeds greater than $18\sqrt{L}$, the maximum n_{cg} is 6.0 g (7.0 g for search and rescue type craft)
The vertical accelerations are typically not to be taken less than 1.0 g for craft lengths less than 24 m and 2.0 g for craft lengths less than 12 m. Intermediate values can be determined by interpolation. The vertical acceleration will need to be specially considered for craft fitted with seat belts or special shock mitigation seats

n_{xx} = average of the 1/100 highest vertical accelerations, at any section clear of LCG can be determined by the following equation:

= $n_{cg}K_v$ g's

N_1 = 0.1

N_2 = 0.0078

N_3 = 9.8

Δ = displacement at design waterline kg

L_w = craft length on the waterline with the craft at the design displacement and in the displacement mode m

B_w = maximum waterline beam m

H	=	wave parameter, 0.0172L + 3.653, generally not to be taken less than the maximum survival wave height for the craft	m
$h_{1/3}$	=	significant wave height, see Table III 2-3 of this Chapter	m
τ	=	running trim at V, in degrees, but generally not to be taken less than 4° for craft L < 50 m, nor less than 3° for L > 50 m. Special consideration will be given to, designers' values predicted from model tests.	°
β_{cg}	=	deadrise at LCG, in degrees, generally not to be taken less than 10° nor more than 30°	°
β_{bx}	=	deadrise at any section clear of LCG, in degrees, not to be taken less than 10° nor greater than 30°, see Fig. III 2-5 of this Chapter	°
V	=	craft design speed in knots, see Table III 2-3 of this Chapter	knot
F_D	=	design area factor given in Fig. III 2-7 of this Chapter for given values of A_D and A_R Generally not to be taken less than 0.4. See Table III 2-4 of this Chapter for minimum values of F_D for craft less than 24 m in length	
F_V	=	vertical acceleration distribution factor given in Fig. III 2-9 of this Chapter	
K_V	=	vertical acceleration distribution factor given in Fig. III 2-8 of this Chapter	
A_D	=	design area. For plating it is the actual area of the shell plate panel but not to be taken as more than $2.5s^2$. For longitudinals, stiffeners, transverses and girders it is the shell area supported by the longitudinal stiffener, transverse or girder; for transverses and girders the area used need not be taken less than $0.33l^2$.	cm^2
A_R	=	reference area, $6.95\Delta/d$	cm^2
s	=	spacing of longitudinals or stiffeners	cm
l	=	unsupported span of internals, see 2.4.1.(b)(i) of this Chapter	cm
d	=	stationary draft. Vertical measured from baseline to design waterline at middle of design waterline length, but generally not to be taken as less than 0.04L.	m

Table III 2-3
Design Significant Wave Heights, $h_{1/3}$, and Speeds, V

	Operational Condition	
	$h_{1/3}$	V
High-Speed Craft	4m (1)	V_m (2)
Coastal Craft	2.5m	V_m (2)
Riverine Craft	0.5m	V_m (2)

Notes:

(1) The design significant wave height for unrestricted service craft is greater than or equal to 4.0 m, generally not to be taken as less than L/12.

(2) V_m = maximum speed for the craft in the design condition specified in 2.2.1 of this Chapter.

Table III 2-4
Minimum Values for F_D (L ≤ 24m)

s mm	F_D
250	0.85
500	0.75
750	0.60
1000	0.50
1250	0.40

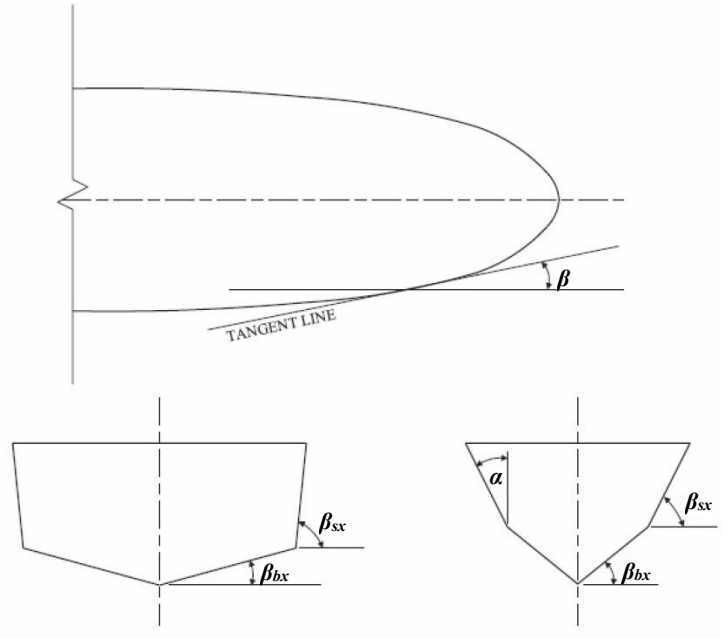


Fig. III 2-5
Deadrise, Flare, and Entry Angles

(b) Side and Transom Structure, Design Pressure

The side design pressure, kN/m^2, is to be not less than given by the equations:

(i) Slamming Pressure

$$P_{sxx} = \frac{N_1 \Delta}{L_w B_w}[1 + n_{xx}]\left[\frac{70 - \beta_{sx}}{70 - \beta_{cg}}\right] F_D \qquad \text{kN/m}^2$$

(ii) Hydrostatic Pressure

$$P_s = N_3(H_s - \mathrm{y}) \qquad \text{kN/m}^2$$

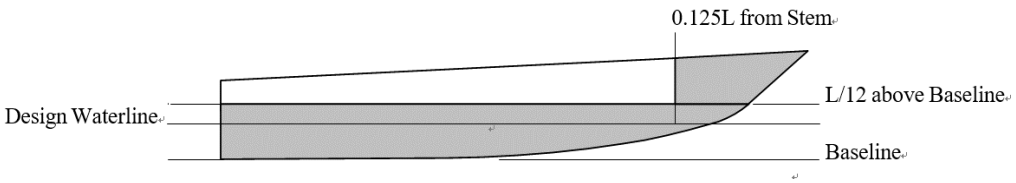
(iii) Fore End

$$P_{sf} = 0.28 F_a C_F N_3 (0.22 + 0.15\tan\alpha)(0.4\mathrm{V}\sin\beta + 0.6\sqrt{L})^2 \qquad \text{kN/m}^2$$

Where L is generally not to be taken less than 30 m

where:

P_{sxx} = side design slamming pressure at any section clear of LCG. For craft greater than 24 m in length, the side design slamming pressure applies both along the entire length below L/12 above baseline and to the region forward of 0.125L kN/m^2



P_s = side design pressure due to hydrostatic forces, but is not to be taken less than the following: kN/m^2

= $0.05N_3L$, at or below L/15 above the base line or any height above base line forward of 0.125L from the stem kN/m^2

= $0.033N_3L$, above L/15 above the base line, aft of 0.125L from the stem kN/m^2

P_{sf}	=	side design pressure for forward of 0.125L from the stem	kN/m^2
H_s	=	0.083L + d, but it is not to be taken less than D + 1.22 (D + 4) for craft less than 30 m	m
	=	0.64H + d for craft over 30 m	m
y	=	distance above base line of location being considered	m
L	=	craft length as defined in 1.1.2 of this Part	m
β_{sx}	=	deadrise of side at any section clear of LCG, not to be taken greater than 55°, see Fig. III 2-5 of this Chapter	°
C_F	=	0.0125L for L < 80 m	
	=	1.0 for L ≥ 80 m	
F_a	=	3.25 for plating and 1.0 for longitudinals, transverses and girders	
α	=	flare angle, the angle between a vertical line and the tangent to the side shell plating, measured in a vertical plane at 90° to the vertical tangent to the side shell, see Fig. III 2-5 of this Chapter	°
β	=	entry angle, the angle between a longitudinal line, parallel to the centerline and the horizontal tangent to the side shell, see Fig. III 2-5 of this Chapter	°

N_1, N_3, Δ, L_w, B_w, V, n_{xx}, β_{cg}, H, d and F_D are as defined in 2.2.1(a) of this Chapter.

2.2.2 Multi-Hull and Surface Effect Craft

The bottom and side pressures are to be checked using the displacement (Δ), speed (V), draft (d) and running trim (τ) in the full load, half load and lightship conditions. If the craft is receiving a freeboard assignment, the parameters used in the full load condition are to coincide with the approved freeboard assignment. If the craft is not receiving a freeboard assignment, the parameters used in the full load condition are to correspond to the maximum operating deadweight. The parameters used in the half load condition are to correspond to 50% of the maximum operating deadweight, and the parameters used in the lightship condition are to correspond to 10% of the maximum operating deadweight plus the maximum speed of the craft. The on-cushion speed is to be used for surface effect craft.

(a) Bottom Design Pressure

The bottom design pressure is to be the greater of the following equations, for the location under consideration. Bottom design pressures are dependent upon the service in which the craft operates. The bottom design pressure applies to hull bottoms below the chines or the upper turn of the bilge for catamarans, trimarans or other multihulled craft and surface effect craft. Bottoms of twin hull surface effect craft shall be considered as catamaran hulls for the purpose of calculation of the bottom slamming pressure.

(i) Bottom Slamming Pressure

$$P_{bcg} = \frac{N_1 \Delta}{L_w N_h B_w}[1 + n_{cg}]F_D \quad \text{kN/m}^2$$

$$P_{bxx} = \frac{N_1 \Delta}{L_w N_h B_w}[1 + n_{xx}]\left[\frac{70 - \beta_{bx}}{70 - \beta_{cg}}\right]F_D \quad \text{kN/m}^2$$

(ii) Bottom Slamming Pressure for Craft Less Than 61 meters

The design pressure may be:

$$P_{bxx} = \frac{N_1 \Delta}{L_w N_h B_w}[1 + n_{cg}]F_D F_V \quad \text{kN/m}^2$$

(iii) Hydrostatic Pressure

$$P_d = N_3(0.64\text{H} + \text{d}) \quad \text{kN/m}^2$$

where:

n_{cg}	=	the vertical acceleration of the craft as determined by a model test, theoretical computation, or service experience (see 1.3 of this Part). If this information is not readily available during the early stages of design, the following formula utilizing the average 1/100 highest vertical accelerations at LCG can be used:

$$n_{cg} = N_2\left[\frac{12h_{\frac{1}{3}}}{N_h B_w} + 1.0\right]\tau[50 - \beta_{cg}]\frac{V^2(N_h B_w)^2}{\Delta} \quad \text{g's}$$

The maximum and minimum vertical accelerations defined in 2.2.1(a) of this Chapter are applicable to multihull craft.

β_w = maximum waterline beam of one hull m

N_h = number of hulls

p_{bcg}, p_{bxx}, N_1, N_2, N_3, Δ, L_w, V, F_V, n_{xx}, β_{bx}, β_{cg}, H, d and F_D are as defined in 2.2.1(a) of this Chapter.

(b) Side and Transom Structure, Design Pressure

The side design pressure, kN/m^2, is to be not less than given by the equations:

(i) Slamming Pressure

$$P_{sxx} = \frac{N_1\Delta}{L_w N_h B_w}[1 + n_{xx}]\left[\frac{70 - \beta_{xx}}{70 - \beta_{cg}}\right]F_D \quad \text{kN/m}^2$$

(ii) Hydrostatic Pressure

$$P_x = N_3(H_s - \text{y}) \quad \text{kN/m}^2$$

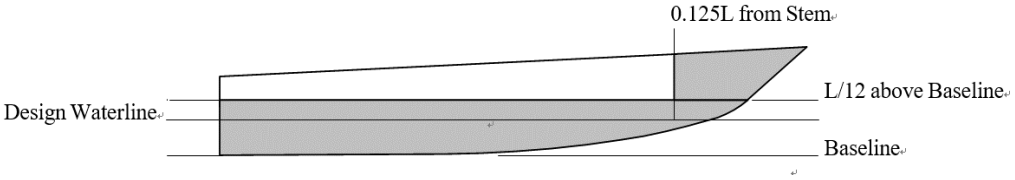
(iii) Fore End

$$P_{sf} = 0.28F_a C_F N_3(0.22 + 0.15\tan\alpha)(0.4\text{V}\sin\beta + 0.6\sqrt{L})^2 \quad \text{kN/m}^2$$

Where L is generally not to be taken less than 30 m

where:

P_{sxx} = side design slamming pressure at any section clear of LCG. For craft greater than 24 m in length, the side design slamming pressure applies both along the entire length below L/12 above baseline and to the region forward of 0.125L kN/m^2



P_s = side design pressure due to hydrostatic forces, but is not to be taken less than the following: kN/m^2

= $0.05N_3L$ at or below L/15 above the base line or any height above base line forward of 0.125L from the stem kN/m^2

= $0.033N_3L$ above L/15 above the base line, aft of 0.125L from the stem kN/m^2

P_{sf} = side design pressure for forward of 0.125L from the stem kN/m^2

y = distance above base line, of location being considered m

L = craft length, as defined in 1.1.2 of this Part m

F_a = 3.25 for plating and 1.0 for longitudinals, transverses and girders

C_F = 0.0125L for L < 80 m

= 1.0 for L ≥ 80 m

α = flare angle, the angle between a vertical line and the tangent to the side shell plating, measured in a vertical plane at 90° to the horizontal tangent to the side shell, see Fig. III 2-5 of this Chapter. °

β = entry angle, the angle between a longitudinal line, parallel to the centerline and the vertical tangent to the side shell, see Fig. III 2-5 of this Chapter. °

N_1, N_3, Δ, L_w, V, n_{xx}, β_{cg}, H_s, d and F_D are as defined in 2.2.1(a) of this Chapter, β_{sx}, is as defined in 2.2.1(b) of this Chapter. N_h and B_w are as defined in 2.2.2(a) of this Chapter.

(c) Wet Deck or Cross Structure

The wet deck design pressure is to be determined by the following equations:

$$P_{wd} = 30N_1F_DF_IVV_I(1 - 0.85h_a/h_{1/3}) \qquad \text{kN/m}^2$$

where:

N_1 = 0.10

h_a = vertical distance, from lightest draft waterline to underside of wet deck, at design point in question. h_a is not to be greater than $1.176h_{1/3}$ m

F_I = wet deck pressure distribution factor as given in Fig. III 2-10 of this Chapter

V_I = relative impact velocity as given below:

$$= \frac{4h_{1/3}}{\sqrt{L}} + 1 \qquad \text{m/s}$$

V, $h_{1/3}$ and F_D are as defined in 2.2.1(a) of this Chapter.

2.2.3 Deck Design Pressures – All Craft

The design pressures, P_d, are to be as given in Table III 2-5 of this Chapter, see Fig. III 2-6 of this Chapter.

2.2.4 Superstructures and Deckhouses – All Craft

The design pressures, P, are to be as given in Table III 2-6 of this Chapter

2.2.5 Bulkhead Structure, Design Pressure – All Craft

(a) Tank Boundaries

The design pressure for tank boundaries, for both integral and non-integral tanks is to be not less than the following equations, whichever is greater:

$$P_t = N_3h \qquad \text{kN/m}^2$$

$$P_t = \rho g(1 + 0.5n_{xx})h_2 \qquad \text{kN/m}^2$$

where:

N_3 = as defined in 2.2.1(a) of this Chapter

h = greatest of the following distances, from lower edge of plate panel or center of area supported by stiffener, to: m

(i) A point located above the top of the tank, at a distance of two-thirds the height from the top of the tank to the top of the overflow.

(ii) A point located at two-thirds of the distance to the main weather deck.

(iii) A point located above the top of the tank, not less than the greater of the following:

(1) 0.01L + 0.15 m

(2) 0.46 m

where L is the craft length as defined in 1.1.2 of this Part

ρ_g = specific weight of the liquid, not to be taken less than 10.05 kN/m^3

n_{xx} = vertical acceleration at midspan of the tank, as defined in 2.2.1(a) of this Chapter g's

h_2 = distance from lower edge of plate panel or center of area supported by stiffener to the top of the tank m

The heights of overflows are to be clearly indicated on the plans submitted for approval.

Pressurized tanks will be subject to special consideration.

(b) Watertight Boundaries

The design pressure for watertight boundaries is to be not less than the value given by the following equation:

$$P_w = N_3 h \qquad \text{kN/m}^2$$

where:

N_3 = as defined in 2.2.1(a) of this Chapter

h = distance from the lower edge of plate panel or the center of area supported by the stiffener to the bulkhead deck at centerline m

2.2.6 Operational Loads

Loads on the hull structure are dependent on the craft's mission, payload and operational environment. For classification purposes, the following payloads must be accounted for in addition to the other loads and pressures defined in this Section:

- Vehicle and human loads (see 2.3.1(e) and 2.4.1(h) of this Chapter)
- Take-off, landing, and stowage of helicopters

(a) Human Loads

Composite deck structures are to withstand a point load equivalent to the weight of a man (90.7 kg) in the middle of the plate or the midspan stiffener.

(b) Helicopter Decks

(i) General

Helicopter decks, where provided, are to meet the following structural and safety requirements.

Plans showing the arrangement, scantlings and details of the helicopter deck are to be submitted. The arrangement plan is to show the overall size of the helicopter deck and the designated landing area. If the arrangement provides for the securing of a helicopter or helicopters to the deck, the predetermined position(s) selected to accommodate the secured helicopter, in addition to the locations of deck fittings, for securing the helicopter are to be shown. The type of helicopter to be considered is to be specified and calculations for appropriate loading conditions are to be submitted.

(ii) Overall Distributed Loading

For a platform type helicopter decks, a minimum distributed loading of 2010 N/m^2 is to be taken over the entire helicopter deck. For all other helicopter decks, the minimum overall distributed load is to be as specified in Table III 2-5 of this Chapter.

(iii) Helicopter Landing and Impact Loading

A load of not less than 75% of the helicopter maximum take-off weight is to be taken on each of two square areas, 0.3 m × 0.3 m. Alternatively, the manufacturer's recommended wheel impact loading will be considered. The deck is to be considered for helicopter landings at any location within the designated landing area. The structural weight of the helicopter deck is to be added to the helicopter impact loading when considering girders, stanchions, truss supports, etc. Where the upper deck of a superstructure or deckhouse is used as a helicopter deck and the spaces below are normally manned (quarters, bridge, control room, etc.) the impact loading is to be multiplied by a factor of 1.15.

(iv) Stowed Helicopter Loading

If provisions are made to accommodate helicopter secured to the deck in a predetermined position, the structure is to be considered for a local loading not to be taken less than:

$$P_{HC} = W_{to}(1 + 0.5n_{xx}) + 0.49 \qquad \text{kN/m}^2$$

where

W_{to} = maximum take-off weight kN/m^2

n_{xx} = as defined in 2.2.1(a) of this Chapter g's

(v) Special Landing Gear

Helicopters fitted with landing gear other than wheels will be specially considered.

(vi) Loading due to Motions of Craft

The structure supporting helicopter decks is to withstand the loads resulting from the motions of the craft.

(vii) Environmental Loading

Calculations are to consider anticipated wind and wave impact loadings on helicopter decks and their supporting structures.

Table III 2-5
Deck Design Pressure, P_d

Location	kN/m^2
Exposed freeboard deck, and superstructure and deckhouse decks forward of 0.25L.	0.20L+7.6
Freeboard deck inside enclosed superstructures and deckhouses, exposed superstructure and deckhouse decks aft of 0.25L, and internal decks included in the hull girder bending moment	0.10L+6.1
Enclosed accommodations decks	5.0
Concentrated deck cargo loads, equipment foundations	$W(1+0.5n_{xx})$
Enclosed store rooms, machinery spaces, etc. decks	$\rho h(1+0.5n_{xx})$

Notes:

W = deck cargo load kN/m^2

n_{xx} = average vertical acceleration at the location under consideration as defined in 2.2.1(a) of this Chapter g's

ρ = cargo density, not to be taken less than 7.04 kN/m^3

h = height of enclosed store room, machinery space, etc. m

L = craft length as defined in 1.1.2 of this Part m

- Where permanently attached equipment are fitted and the live load associated with this equipment is greater than the deck design pressure, the equipment live loads govern.

Table III 2-6
Superstructures and Deckhouses Design Pressures

Location	$L \leq 12.2$ m kN/m^2	$L > 30.5$ m kN/m^2
Superstructure and Deckhouse Front Plating	24.1	37.9
Superstructure and Deckhouse Front Stiffeners	24.1	24.1
Superstructure and Deckhouse Aft End and House Side Plating	10.3	13.8
Superstructure and Deckhouse Aft End and House Side Stiffeners	10.3	10.3
House Tops, Forward of Midships, Plating and Stiffeners	6.9	8.6
House Tops, Aft of Midships, Plating and Stiffeners	3.4	6.9

Note:

For craft between 12.2 and 30.5 m, design pressure is to be obtained by interpolation.

L = craft length as defined in 1.1.2 of this Part.

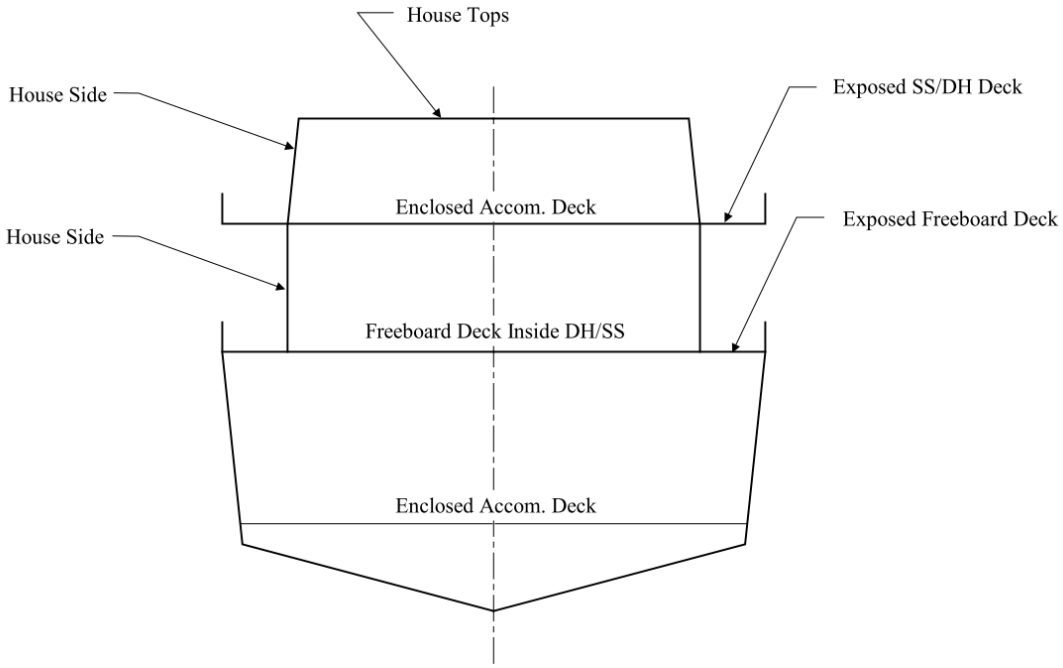


Fig. III 2-6
Decks, Superstructures, and Deckhouse Pressures

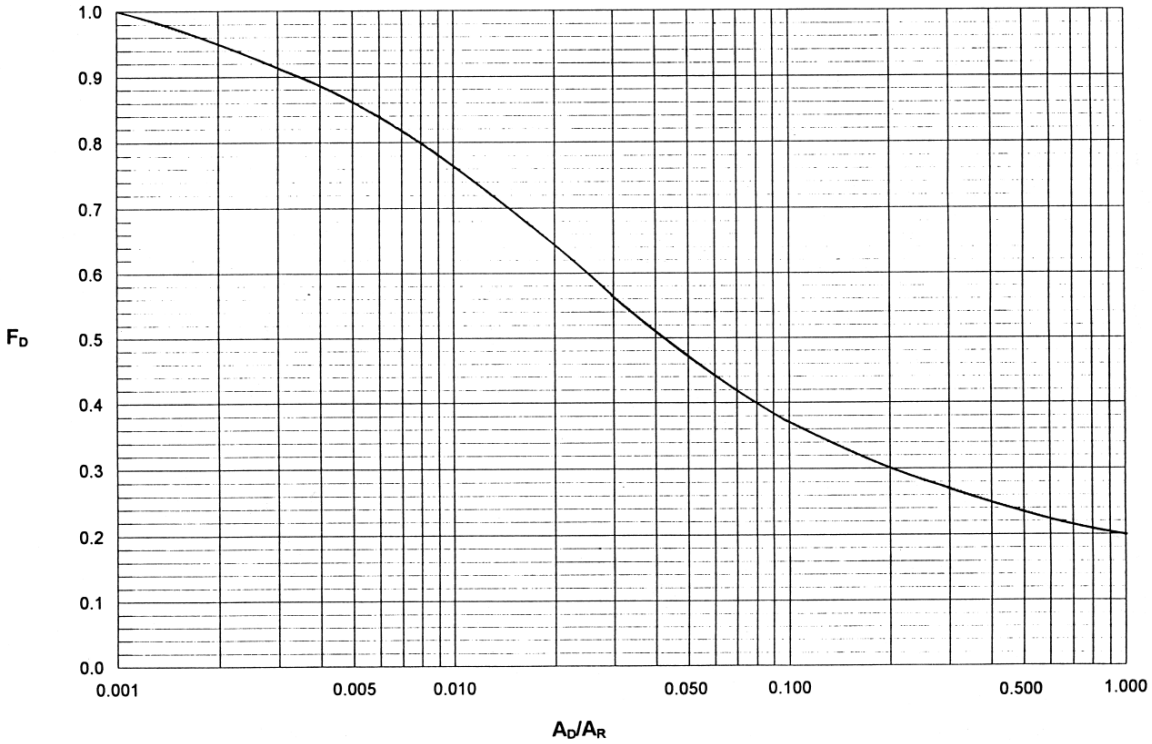


Fig. III 2-7
Design Area Factor F_D

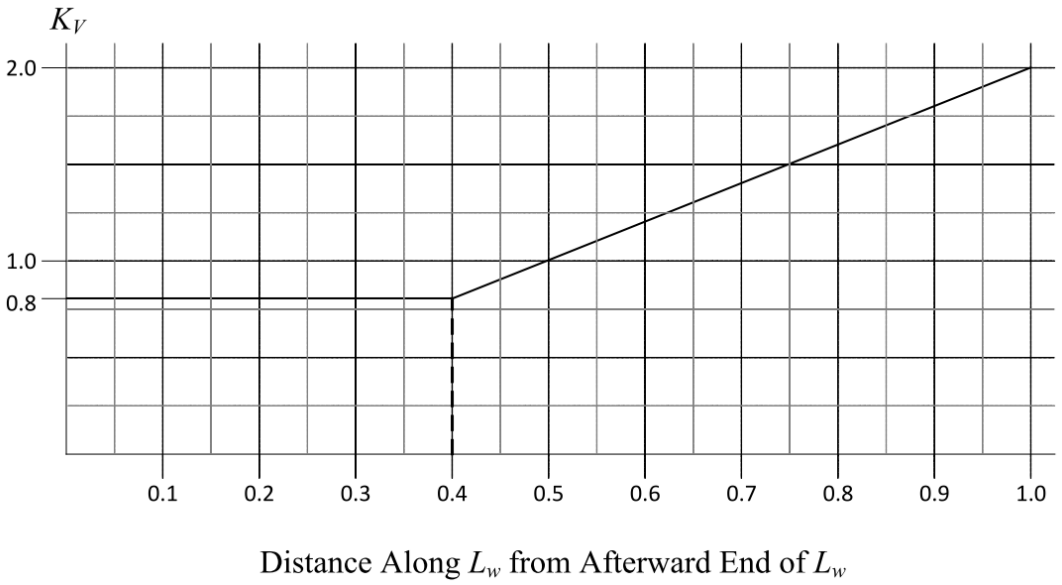


Fig. III 2-8
Vertical Acceleration Distribution Factor K_V

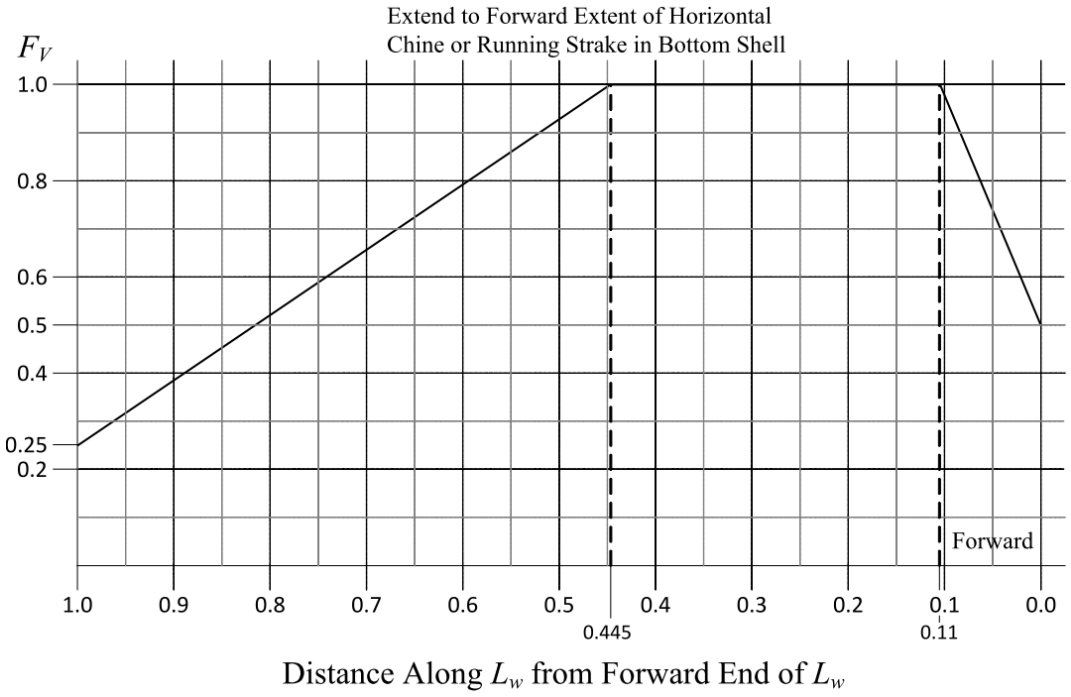


Fig. III 2-9
Vertical Acceleration Distribution Factor F_V

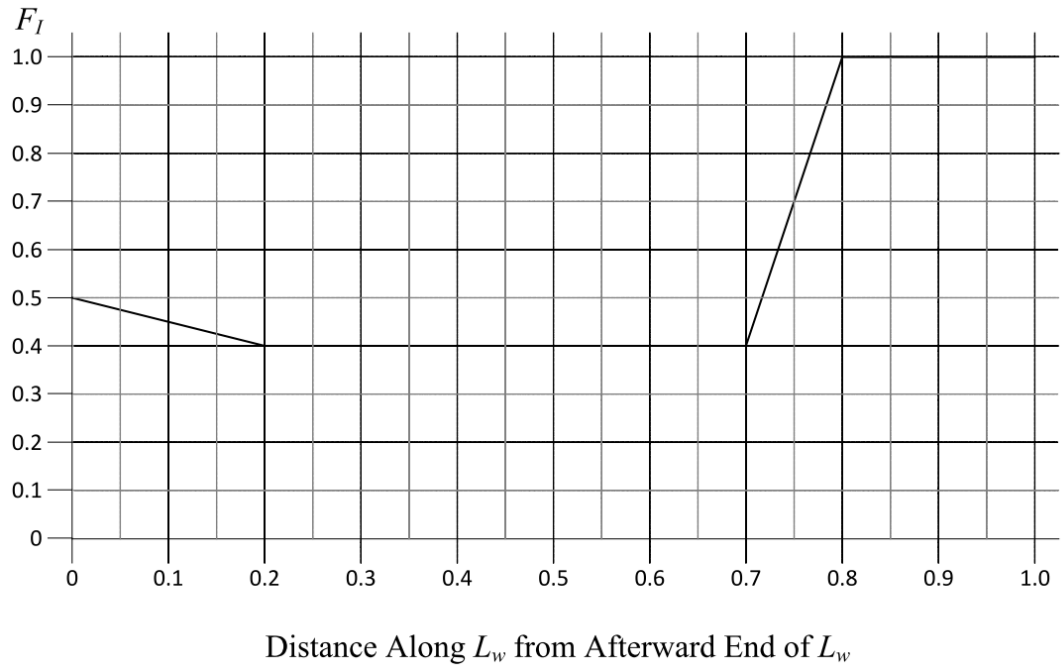


Fig. III 2-10
Wet Deck Pressure Distribution Factor F_I

2.3 Plating

2.3.1 Aluminum or Steel

(a) General

The bottom shell is to extend from the keel to the chine or upper turn of bilge. In general the side shell is to be of the same thickness from its lower limit to the gunwale.

All plating is to meet the requirements for thickness as given in 2.3.1(b) of this Chapter.

In addition those areas of plating associated with primary hull strength are to meet the buckling criteria as given in 2.3.1(c) of this Chapter. Where plate panels are subjected to other bending, biaxial, or a combination of stresses, they will be specially considered.

The thickness of the shell plating in way of skegs, shaft struts, hawse pipes, etc. is to be increased by 50% over that obtained from 2.3.1(b) of this Chapter.

The thickness of water jet tunnels and transverse thruster tubes is to be in accordance with 2.3.1(d) of this Chapter.

Where the plating forms decks for the access, operation or stowage of vehicles, the plating is in addition to meet the requirements of 2.3.1(e) of this Chapter.

(b) Thickness

The thickness of the shell, deck or bulkhead plating is to be not less than obtained by the following equations, whichever is greater:

(i) Lateral Loading

$$t = s\sqrt{\frac{pk}{1000\sigma_a}} \quad \text{mm}$$

where:

s = spacing, of the shell, deck, superstructure, deckhouse or bulkhead longitudinals or stiffeners mm

p = design pressure, given in 2.2 of this Chapter kN/m^2

k = plate panel aspect ratio factor, given in Table III 2-7 of this Chapter

σ_a = design stress, given in Table III 2-8 of this Chapter N/mm^2

Table III 2-7
Aspect Ratio Coefficient for Isotropic Plates

l/s	k	k_1
>2.0	0.500	0.028
2.0	0.497	0.028
1.9	0.493	0.027
1.8	0.487	0.027
1.7	0.479	0.026
1.6	0.468	0.025
1.5	0.454	0.024
1.4	0.436	0.024
1.3	0.412	0.021
1.2	0.383	0.019
1.1	0.348	0.017
1.0	0.308	0.014

Notes:

s = shorter edge of plate panel mm

l = longer edge of plate panel mm

Intermediate values may be determined by linear interpolation.

Table III 2-8
Design Stress, σ_a, Aluminum and Steel

Location		Design Stress, σ_a[1]	
Bottom Shell		Slamming Pressure	$0.90\sigma_y$[2]
		Hydrostatic Pressure	$0.55\sigma_y$
Waterjet Tunnels		Slamming Pressure	$0.60\sigma_y$
		Hydrostatic Pressure	$0.55\sigma_y$
Side Shell	Below Bulkhead Deck	Slamming Pressure	$0.90\sigma_y$
		Hydrostatic Pressure	$0.55\sigma_y$
	Above Bulkhead Deck (i.e. foc'sles)	Slamming Pressure	$0.90\sigma_y$
		Hydrostatic Pressure	$0.55\sigma_y$
Deck Plating	Strength Deck	$0.60\sigma_y$	
	Lower Decks/ Other Decks	$0.60\sigma_y$	
	Wet Decks	$0.90\sigma_y$	
	Superstructure and Deckhouse Decks	$0.60\sigma_y$	
Bulkheads	Deep Tank	$0.60\sigma_y$	
	Watertight	$0.95\sigma_y$	
Superstructure aft of 0.25L from F.P. & Deckhouses	Front, Sides, Ends, Tops	$0.60\sigma_y$[3]	

Notes:

(1) yield strength of steel or of welded aluminum in N/mm^2, but not to be taken greater than 70% of the ultimate strength of steel or welded aluminum

(2) The design stress for bottom shell plates under slamming pressure may be taken as σ_y for plates outside the midship 0.4L.

(3) The design stress for steel deckhouse plates may be taken as $0.90\sigma_y$.

(ii) Thickness Based on Secondary Stiffening

$t_s = 0.01s$ mm

$t_{al} = 0.012s$ mm

where:

t_s = required thickness for steel craft
t_{al} = required thickness for aluminum craft

s is as defined in 2.3.1(b)(i) of this Chapter.

(iii) Minumum Thickness

The thickness of shell plating, decks and bulkheads is to be not less than obtained from the following equations:

(1) Bottom Shell

$$t_s = 0.44\sqrt{Lq_s} + 2.0 \quad \text{mm}$$

$$t_{al} = 0.70\sqrt{Lq_a} + 1.0 \quad \text{mm}$$

where:

L	=	craft length, as defined in 1.1.2 of this Part	m
q_s	=	1.0 for ordinary strength steel; $245/\sigma_{ys}$ for higher strength steels, but not to be taken less than 0.72	
σ_{ys}	=	yield strength for higher strength steel	N/mm^2
q_a	=	$115/\sigma_{ya}$ for aluminum alloys	
σ_{ya}	=	minimum unwelded yield strength for aluminum alloys, but not to be taken as more than 0.7 of the ultimate tensile strength in the as-welded condition	N/mm^2

t_s and t_{al} as defined in 2.3.1(b)(ii) of this Chapter. However, ts is not to be taken less than 3.5 mm and t_{al} is not to be taken less than 4.0 mm.

(2) Side Shell

$$t_s = 0.40\sqrt{Lq_s} + 2.0 \quad \text{mm}$$

$$t_{al} = 0.62\sqrt{Lq_a} + 1.0 \quad \text{mm}$$

where t_s and t_{al} are as defined in 2.3.1(b)(ii) of this Chapter. However, t_s is not to be taken less than 3.0 mm and t_{al} is not to be taken less than 3.5 mm.
q_s, q_a and L are as defined in 2.3.1(b)(iii)(1) of this Chapter.

(3) Strength Deck

$$t_s = 0.40\sqrt{Lq_s} + 1.0 \quad \text{mm}$$

$$t_{al} = 0.62\sqrt{Lq_a} + 1.0 \quad \text{mm}$$

where t_s and t_{al} are as defined in 2.3.1(b)(ii) of this Chapter. However, t_s is not to be taken less than 3.0 mm and t_{al} is not to be taken less than 3.5 mm.
q_s, q_a, and L are as defined in 2.3.1(b)(iii)(1) of this Chapter.

(4) Lower Decks, W.T. Bulkheads, Deep Tank Bulkheads

$$t_s = 0.35\sqrt{Lq_s} + 1.0 \quad \text{mm}$$

$$t_{al} = 0.52\sqrt{Lq_a} + 1.0 \quad \text{mm}$$

where t_s, t_{al}, q_s, q_a and L are as defined in 2.3.1(b)(ii) of this Chapter. However, t_s is not to be taken less than 3.0 mm and t_{al} is not to be taken less than 3.5 mm.
Where the use is made of special purpose aluminum extrusions or special welding techniques are utilized the minimum plate thickness, as given in 2.3.1(b)(iii) of this Chapter, will be specially considered based on location, purpose and material grades.

(c) Buckling Criteria

(i) Uni-axial Compression

(1) Ideal Elastic Stress

$$\sigma_E = 0.9m_1E(\frac{t_b}{s})^2 \quad \text{N/mm}^2$$

where:

m_1	=	buckling coefficient as given in Table III 2-9 of this Chapter		
E	=	for steel:	2.06×10^5	N/mm^2
	=	for aluminum:	6.9×10^4	N/mm^2
t_b	=	thickness of plating		mm
s	=	shorter side of plate panel		mm
l	=	longer side of plate panel		mm

(2) Critical Buckling Stress
The critical buckling stress in compression, σ_c, is determined as follows:

$\sigma_c = \sigma_E$ when $\sigma_E \leq 0.5\ \sigma_y$

$\sigma_c = \sigma_y(1 - \frac{\sigma_y}{4\sigma_E})$ when $\sigma_E > 0.5\ \sigma_y$

where:

σ_y	=	yield stress of material Note: Generally the unwelded yield strength may be used, but due account is to be made for critical or extensive weld zones.	N/mm^2
σ_E	=	ideal elastic buckling stress calculated in 2.3.1(c)(i) of this Chapter	

(3) Calculated Compressive Stress
The compressive stresses are given in the following formula:

$\sigma_a = 10^5 \times \frac{M_t y}{I}$ N/mm^2

where:

σ_a	=	working compressive stress in panel being considered, but generally not less than the following: N/mm^2 $\frac{175}{CQ}\frac{SM_R}{SM_A}$ N/mm^2	
M_t	=	maximum total bending moment as given in 2.1.1(a)(ii)(5) of this Chapter kN-m	
y	=	vertical distance, from the neutral axis to the considered location	m
I	=	moment of inertia of the hull girder	cm^4
C, Q	=	applicable factor for steel or aluminum as defined in 2.1.1(a) of this Chapter	
SM_R	=	hull girder section modulus as required in 2.1 of this Chapter	cm^2-m
SM_A	=	section modulus of the hull girder at the location being considered	cm^2-m

(4) Permissible Buckling Stress
The design buckling stress, σ_c, of plate panels [as calculated in 2.3.1(c)(i)(2) of this Chapter] is to be such that:

$\sigma_c \geq \sigma_a$

(ii) Shear for Craft 61 m in Length and Over

(1) Ideal Elastic Buckling Stress

$\tau_E = 0.9 m_2 E \left(\frac{t_b}{s}\right)^2$ N/mm^2

where:

m_2	=	buckling coefficient as given in Table III 2-9 of this Chapter		
E	=	for steel:	2.06×10^5	N/mm^2
	=	for aluminum:	6.9×10^4	N/mm^2
t_b	=	thickness of plating		mm
s	=	shorter side of plate panel		mm
l	=	longer side of plate panel		mm

(2) Critical Buckling Stress
The critical buckling stress in shear, τ_c, is determined as follows:

$\tau_c = \tau_E$ when $\tau_E \leq 0.5\tau_y$

$\tau_c = \tau_y\left(1 - \frac{\tau_y}{4\tau_E}\right)$ when $\tau_E > 0.5\tau_y$

where:

τ_y = minimum shear yield stress of material N/mm^2

= $\frac{\sigma_{yw}}{\sqrt{3}}$

σ_{yw} = welded yield strength of material N/mm^2

τ_E = ideal elastic buckling stress calculated in 2.3.1(c)(ii)(1) of this Chapter N/mm^2

(3) Calculated Shear Stress
The working shear stress, τ_a, in the side shell or longitudinal bulkhead plating is to be calculated by an acceptable and recognized method.

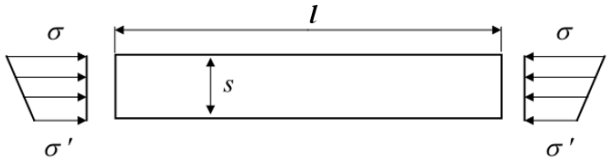
(4) Permissible Buckling Stress
The design buckling stress, τ_c, of plate panels [as calculated in 2.3.1(c)(ii)(2) of this Chapter] is to be such that:

$$\tau_c \geq \tau_a$$

Table III 2-9
Buckling Coefficients m_1 and m_2

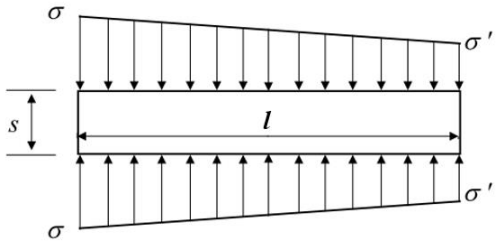
A Uniaxial Compression

1. Plates with longitudinal framing, $l \geq s$



a. for $\sigma' = \sigma$, $m_1=4$
b. for $\sigma' = \sigma/3$, $m_1=5.8$
c. For intermediate values m_1 may be obtained by interpolation between a and b

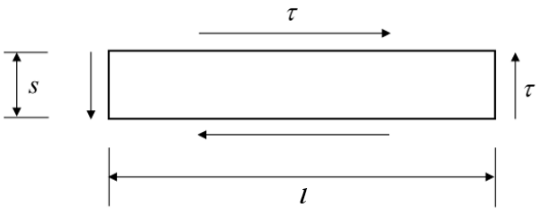
2. Plates with transverse framing, $l \geq s$



a. for $\sigma' = \sigma$, $m_1=C_2[1+(s/l)^2]^2$
b. for $\sigma' = \sigma/3$, $m_1=1.45C_2[1+(s/l)^2]^2$
c. For intermediate values m may be obtained by interpolation between a and b

Values of C_2 = 1.30 where supported by floors or deep members
= 1.21 where stiffeners are T-sections or angle bars
= 1.10 where stiffeners are bulb plates
= 1.05 where stiffeners are flat bars

B Edge Shear



$m_2 = 5.34+4(s/l)^2$

(d) Waterjet Tunnels and Transverse Thruster Tubes

(i) Waterjet Tunnels

The thickness for the waterjet tunnel plating is to be not less than required by 2.3.1(b) of this Chapter, neither is it to be less than the greater of the jet manufacturer's recommended thickness or that obtained from the following equation:

$$t = s\sqrt{\frac{p_t k}{1000\sigma_a}} \quad \text{mm}$$

where:

p_t = maximum positive or negative tunnel design pressure, as provided by the jet manufacturer — kN/m^2

s, k and σ_a are as given in 2.3.1(b) of this Chapter.

(ii) Transverse Thruster Tunnels

The thickness of the tunnel plating for the transverse thrusters is to be not less than required by 2.3.1(b) of this Chapter, nor less than obtained from the following equation:

$$t = 0.008d\sqrt{Q} + 3.0 \quad \text{mm}$$

where:

d = inside diameter of the tunnel, but is taken as not less than 968 mm — mm

Q is as given in 2.1.1(a) of this Chapter

(e) Decks Provided for the Operation or Stowage of Vehicles

Where provision is to be made for the operation or stowage of vehicles having rubber tires, and after all other requirements are met, the thickness of deck plating is to be not less than obtained from the following equation:

$$t = \sqrt{\frac{\beta W(1 + 0.5n_{xx})}{\sigma_a}} \quad \text{mm}$$

where:

W = static wheel load — N

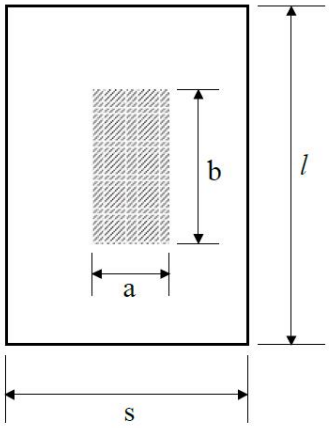
n_{xx} = average vertical acceleration at the location under consideration as defined in 2.2.1(a) of this Chapter

β = as given in Fig. III 2-11 of this Chapter

σ_a = design stress for decks, given in Table III 2-8 of this Chapter — N/mm^2

For wheel loading, strength deck plating thickness is to be not less than 110% of that required by the above equation, and platform deck plating thickness is to be not less than 90% of that required by the above equation.

Where the wheels are close together, special consideration will be given to the use of combined imprint and load. Where the intended operation is such that only the larger dimension of the wheel imprint is perpendicular to the longer edge of the plate panel, then b below may be taken as the smaller wheel imprint dimension, in which case, a is to be the greater one.



a/s \ l/s, b/s	l/s = 1						l/s = 1.4						l/s ≥ 2					
	0	0.2	0.4	0.6	0.8	1	0	0.2	0.4	0.8	1.2	1.4	0	0.4	0.8	1.2	1.6	2
0		1.82	1.38	1.12	0.93	0.76		2.00	1.55	1.12	0.84	0.75		1.64	1.20	0.97	0.78	0.64
0.2	1.82	1.28	1.08	0.90	0.76	0.63	1.78	1.43	1.23	0.95	0.74	0.64	1.73	1.31	1.03	0.84	0.68	0.57
0.4	1.39	1.07	0.84	0.72	0.62	0.52	1.39	1.13	1.00	0.80	0.62	0.55	1.32	1.08	0.88	0.74	0.60	0.50
0.6	1.12	0.90	0.74	0.60	0.52	0.43	1.10	0.91	0.82	0.68	0.53	0.47	1.04	0.90	0.76	0.64	0.54	0.44
0.8	0.92	0.76	0.62	0.51	0.42	0.36	0.90	0.76	0.68	0.57	0.45	0.40	0.87	0.76	0.63	0.54	0.44	0.38
1	0.76	0.63	0.52	0.42	0.35	0.30	0.75	0.62	0.57	0.47	0.38	0.33	0.71	0.61	0.53	0.45	0.38	0.30

Notes:

s = spacing of deck beams or deck longitudinals mm

l = length of plate pane mm

a = wheel imprint dimension, paralleled to the shorter edge, s, of the plate panel mm

b = wheel imprint dimension, parallel to the longer edge, *l*, of the plate panel mm

Fig. III 2-11
Values for β

2.3.2 Aluminum Extruded Planking, Aluminum Sandwich Panels and Corrugated Panels

(a) Aluminum Extruded Planking

Extruded planking is to be reviewed similar to a conventional stiffener and plate combination. The required thickness of the planking between stiffeners is given in 2.3.1(b) and 2.3.1(c) of this Chapter. For box and truss type extrusion, the plate spacing is to be taken as the maximum unsupported span of plate as indicated in Fig. III 2-12 of this Chapter. The stiffeners on the planking are to comply with the requirements in 2.4.1(b), 2.4.1(c) and 2.4.1(d) of this Chapter. The geometry of stiffeners in box and truss type extrusions is as indicated in Fig. III 2-12 of this Chapter. The individual planking pieces are to be attached by continuous welding for the main deck and can be welded intermittently for interior accommodation decks. The intermittent weld for the interior decks is to be sized in accordance with 2.5 of Part II for beams and stiffeners to deck. The use of adhesives for attaching planking members used for weather coverings is to be specially considered.

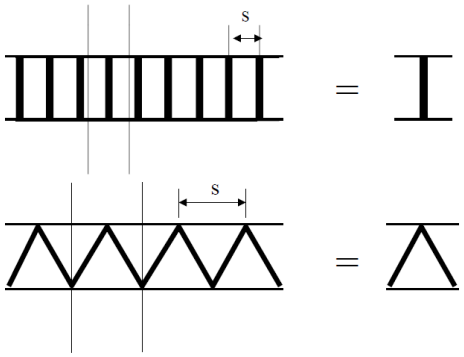


Fig. III 2-12
Extruded Planking

(b) Aluminum Sandwich Panels

An aluminum sandwich panel is a panel with thin aluminum skins attached to a thicker core material. These panels are to be typically used on enclosed decks or bulkheads. Where exposed panels are proposed the effects due to heat and the coefficients of thermal expansion are to be addressed. In general, the inner and outer skins are to be of the same thickness. The use of aluminum sandwich panels for helicopter decks and wheel loading will be specially considered. Aluminum sandwich panels are to comply with the equations given below:

(i) Section Modulus of Skins

The section modulus about the neutral axis of a strip of sandwich panel, 1 cm wide is not to be less than the following equation:

$$\mathrm{SM} = \frac{s^2 pk}{6 \times 10^5 \sigma_a} \qquad \mathrm{cm}^3$$

where:

s	=	spacing of the shell or deck longitudinals or superstructure, deckhouse or bulkhead stiffener. It is always to be the lesser dimension of the unsupported plate panels	mm
p	=	design pressure, given in 2.2 of this Chapter	kN/m^2
k	=	coefficient varying with plate panel aspect ratio, given in Table III 2-7 of this Chapter	
σ_a	=	design stress, given in Table III 2-8 of this Chapter	kN/m^2

(ii) Moment of Inertia of Skins

The moment of inertia about the neutral axis of a strip of sandwich panel, 1 cm wide is not to be less than the following equation:

$$I = \frac{s^3 pk_1}{120 \times 10^5 \cdot 0.24E} \qquad \mathrm{cm}^4$$

where:

s	=	spacing of the shell or deck longitudinals or superstructure, deckhouse or bulkhead stiffener. It is always to be the lesser dimension of the unsupported plate panels	mm
p	=	design pressure, given in 2.2 of this Chapter	
k_1	=	coefficient varying with plate panel aspect ratio, given in Table III 2-7 of this Chapter	
E	=	for aluminum: 6.9×10^4	N/mm^2

(iii) Core Shear Strength

The thickness of core and sandwich is to be not less than given by the following equation:

$$\frac{d_0 + d_c}{2} = \frac{vps}{1000\tau} \quad \text{mm}$$

where:

d_o	=	overall thickness of sandwich	mm
d_c	=	thickness of core	mm
v	=	coefficient varying with plate panel aspect ratio, given in Table III 2-12 of this Chapter	
s	=	lesser dimension of plate panel	mm
p	=	design pressure, as defined in 2.2 of this Chapter	kN/m^2
τ	=	design stress, as shown in Table III 2-13 of this Chapter	N/mm^2

(iv) Testing

The core material and the attachment of the skins to the core are to be tested in accordance with the requirements of Rules and Regulations for the Construction and Classification of Ships of Fibreglass Reinforced Plastics 2019.

(v) Attachment

Typically, beams and stiffeners are not to be considered as effectively attached. Panels are not to be welded to unless the possible damage from heat is addressed. The panels are to be bolted to surrounding structure. The use of adhesives will be specially considered.

(c) Corrugated Panels

(i) Plating

The plating of corrugated panels is to be of the thickness required by 2.3.1(b) of this Chapter with the following modification. The spacing to be used is the greater of dimensions a or c as indicated in Fig. III 2-15 of this Chapter.

2.3.3 Fiber Reinforced Plastic

(a) General

The shell, decks and bulkheads may be either single skin or sandwich construction. Where both are used, a suitable transition is to be obtained between them with a minimum 12:1 taper ratio.

The bottom shell is to extend to the chine or upper bilge turn. A suitable transition is to be obtained between the bottom and side shell plating. The shell thickness in way of the keel is to be 50% greater and in way of shaft struts and skegs is to be 100% greater than the thickness required by 2.3.3(c)(i) or 2.3.3(c)(ii) of this Chapter, as applicable. For this purpose, pressure P_b as obtained from 2.2.1(a) or 2.2.2(a) of this Chapter and actual frame spacing at the location of the member are to be used for 2.3.3(c)(i) of this Chapter. Suitable framing reinforcement is to be provided in way of shaft struts. Bow thruster tube thickness is to be equivalent to the surrounding shell thickness.

The shell, deck or bulkhead laminates may be bi-directional (having essentially same strength and elastic properties in the two in-plane principal axes of the shell, deck or bulkhead) or uni-directional (having different strength or elastic properties in the two principal axes of the shell, deck or bulkhead panels). Bonding angles or tapes are to have essentially same strength and elastic properties as the plating laminate being bonded, and are in general to be in accordance with 2.6 of this Chapter.

(b) Fiber Reinforcement

The basic laminate given in Part II, Chapter 1 or other approved laminate of glass, aramid or carbon fiber in mat, woven roving, cloth, knitted fabric or non-woven uni-directional reinforcing, plies may be used. Equivalent strength and thickness of other than E-glass base laminate is to be assessed in a laminate stack program on the basis of first ply failure. For the shell and deck a sufficient number of plies are to be laid-up with the warp in the 0° (longitudinal) axis. Warp and fill directions are to be aligned parallel to the respective edges of the shell and deck panels as closely as practicable. Depending on the directionality and fiber orientation of these plies, other plies may be required or permitted in the 90° (transverse) axis; reinforcing plies in other axes such as +45° (diagonal) may also be used, when approved.

Where the strength and stiffness in the two principal axes of the panel are different, panel bending in each of the panel principal axes is to be considered. See 2.3.3(c)(ii) and 2.3.3(d)(ii) of this Chapter.

(c) Single Skin Laminate

(i) With Essentially Same Properties in 0° and 90° Axes

The thickness of the shell, deck or bulkhead plating is to be not less than given by the following equations:

(1) All plating

$$t = sc\sqrt{\frac{pk}{1000\sigma_a}} \quad \text{mm}$$

(2) All plating

$$t = sc\sqrt[3]{\frac{pk_1}{1000k_2E_F}} \quad \text{mm}$$

(3) Strength deck and shell

$$t = k_3(c_1 + 0.26L)\sqrt{q_1} \quad \text{mm}$$

L is generally not to be taken less than 12.2 m.

(4) Strength deck and bottom shell

$$t = \frac{s}{k_b}\sqrt{\frac{0.6\sigma_{uc}}{E_c}}\sqrt{\frac{SM_R}{SM_A}} \quad \text{mm}$$

where:

s	=	spacing of the shell or deck longitudinals or superstructure, deckhouse or bulkhead stiffeners. It is always to be the lesser dimension of the unsupported plate panels mm	
c	=	factor for plate curvature in the direction parallel to s, given by (1 – A/s), but is not to be taken less than 0.70	
A	=	distance measured perpendicular from the chord length, s, to the highest point of the curved plate arc between the panel edges	mm
p	=	design pressure given in 2.2 of this Chapter	
k or k_1	=	coefficient varying with plate panel aspect ratio, given in Table III 2-7 of this Chapter	
k_b	=	2.5 with longitudinal framing	
	=	2.5 with transverse framing and panel aspect ratio of 1.0	
	=	1.0 with transverse framing and panel aspect ratio 2.0 to 4.0	
σ_a	=	design stress given in Table III 2-10 of this Chapter	
k_2	=	for bottom plating: 0.015 for patrol boats and similar service craft, 0.01 for other craft	
	=	for side plating: 0.020 for patrol boats and similar service craft, 0.015 for other craft	
	=	for superstructures and deckhouse fronts: 0.025	
	=	for other plating: 0.010	
E_F	=	flexural modulus of laminate, in the direction parallel to s	N/mm^2
q_1	=	170/F	
L	=	craft length, as defined in 1.1.2 of this Part m	
c_1	=	5.7 mm	
k_3	=	1.2 for bottom shell structure	
	=	1.0 for side shell and deck structure	
E_c	=	compressive modulus of elasticity N/mm^2	
F	=	minimum flexural strength of laminate N/mm^2	
σ_{uc}	=	minimum compressive strength of laminate N/mm^2	
SM_R	=	required hull-girder section modulus given in 2.1 of this Chapter	
SM_A	=	proposed hull-girder section modulus of midship section	

Table III 2-10
Design Stresses for FRP, σ_a

Bottom Shell	$0.33\sigma_u$
Side Shell	$0.33\sigma_u$
Decks	$0.33\sigma_u$
Superstructure and Deckhouses – Front, Side, Ends and Tops	$0.33\sigma_u$
Tank Bulkheads	$0.33\sigma_u$
Watertight Bulkheads	$0.50\sigma_u$

For single skin laminates:

σ_u = minimum flexural strength N/mm^2

For sandwich laminates:

σ_u = for shell or deck outer skin, minimum tensile strength N/mm^2
σ_u = for shell or deck inner skin, minimum compressive strength N/mm^2
σ_u = for bulkheads, lesser of tensile or compressive strength N/mm^2

Note: σ_u is to be verified from the approved test results. See 1.6 of Part II.

(ii) With Different Properties in 0° and 90° Axes

For laminates with different strength and elastic properties in the 0° and 90° axes where the strength is less or the stiffness greater in the panel direction perpendicular to s, the thickness is to be also not less than given by the following equations:

(1)

$$t = sc\sqrt{\frac{pk_s}{1000\sigma_{as}}} \quad \text{mm}$$

(2)

$$t = sc\sqrt{\frac{pk_l}{1000\sigma_{al}}}\sqrt[4]{\frac{E_l}{E_s}} \quad \text{mm}$$

where:

k_s, k_l = coefficient for plate panel aspect ratio, given in Table III 2-11 of this Chapter
σ_{as} = design stress, given in Table III 2-10 of this Chapter, based on strength properties in the direction parallel to s
E_s = flexural modulus of laminate, in the direction parallel to s N/mm^2
σ_{al} = design stress, given in Table III 2-10 of this Chapter, based on strength properties in the direction perpendicular to s
E_l = flexural modulus of laminate, in the direction perpendicular to s N/mm^2

s, c and p are as defined in 2.3.3(c) of this Chapter.

Table III 2-11
Aspect Ratio Coefficient for Isotropic Plates

$(l/s)\sqrt[4]{E_s/E_l}$	k_s	k_l
>2.0	0.500	0.342
2.0	0.497	0.342
1.9	0.493	0.342
1.8	0.487	0.342
1.7	0.479	0.342
1.6	0.468	0.342
1.5	0.454	0.342
1.4	0.436	0.342
1.3	0.412	0.338
1.2	0.383	0.333
1.1	0.348	0.323
1.0	0.308	0.308

(d) Sandwich Laminate

(i) Laminate with Essentially Same Bending Strength and Stiffness in 0° and 90° Axes

In general the outer and inner skins are to be similar in lay-up and in strength and elastic properties. Special consideration will be given where this is not the case. In general, single skin laminate is to be used in way of the keel and in way of hull appendages such as shaft struts, skegs and rudders and in way of deck fittings, bolted connections, and other areas of concentrated local loads.

The section modulus and moment of inertia about the neutral axis of a strip of sandwich panel, 1 cm wide are to be not less than given by the following equations:

(1)

$$SM_o = \frac{(sc)^2 pk}{6 \times 10^5 \sigma_{ao}} \quad \text{cm}^3$$

(2)

$$SM_i = \frac{(sc)^2 pk}{6 \times 10^5 \sigma_{ai}} \quad \text{cm}^3$$

(3)

$$I = \frac{(sc)^3 pk_1}{120 \times 10^5 k_2 E_{tc}} \quad \text{cm}^4$$

where:

SM_o	=	required section modulus, to outer skin	cm^3
SM_i	=	required section modulus, to inner skin	cm^3
I	=	required moment of inertia	cm^4
σ_{ao}	=	design stress, for outer skin, given in Table III 2-10 of this Chapter, based on strength of outer skin in direction parallel to s	
σ_{ai}	=	design stress, for inner skin, given in Table III 2-10 of this Chapter, based on strength of inner skin in direction parallel to s.	
E_{tc}	=	0.5 (E_c + E_t)	
E_c	=	mean of compressive moduli of inner and outer skins	N/mm^2
E_t	=	means of tensile moduli of inner and outer skins	N/mm^2

s, c, p, k, k_1 and k_2 are as defined in 2.3.3(c) of this Chapter.

(ii) Laminates with Different Bending Strength and Stiffness in 0° and 90° Axes

Where the strength is less or the stiffness greater in the direction perpendicular to s, the section modulus and moment of inertia about the neutral axis of a strip of sandwich, 1 cm wide are also to be not less than given by the following equations:

(1) In direction parallel to s

$$SM_o = \frac{(sc)^2 pk_s}{6 \times 10^5 \sigma_{aso}} \quad \text{cm}^3$$

(2) In direction parallel to *l*

$$SM_o = \frac{(sc)^2 pk_l}{6 \times 10^5 \sigma_{alo}} \sqrt{E_l / E_s} \quad \text{cm}^3$$

(3) In direction parallel to s

$$SM_i = \frac{(sc)^2 pk_s}{6 \times 10^5 \sigma_{asi}} \quad \text{cm}^3$$

(4) In direction parallel to *l*

$$SM_i = \frac{(sc)^2 pk_l}{6 \times 10^5 \sigma_{ali}} \sqrt{E_l / E_s} \quad \text{cm}^3$$

(5) In direction parallel to s

$$I = \frac{(sc)^2 pk_1}{120 \times 10^5 k_2 E_s} \quad \text{cm}^4$$

where:

SM_o	=	required section modulus, to outer skin	cm^3
SM_i	=	required section modulus, to inner skin	cm^3
k_l, k_s	=	modified coefficient for plate panel aspect ratio, given in Table III 2-11 of this Chapter	
σ_{aso}	=	design stress, for outer skin, given in Table III 2-10 of this Chapter, based on strength properties in direction parallel to s.	
σ_{alo}	=	design stress, for outer skin, given in Table III 2-10 of this Chapter, based on strength properties in direction perpendicular to s.	
σ_{asi}	=	design stress for inner skin, given in Table III 2-10 of this Chapter, based on strength properties in direction parallel to s.	
σ_{ali}	=	design stress, for inner skin, given in Table III 2-10 of this Chapter, based on strength properties in direction perpendicular to s.	
E_s	=	0.5 (E_{ts} + E_{cs})	
E_l	=	0.5 (E_{tl} + E_{cl})	
E_{ts}, E_{cs}	=	respectively, mean of tensile moduli of inner and outer skins, and mean of compressive moduli of inner and outer skins, in direction parallel to s	N/mm^2
E_{tl}, E_{cl}	=	respectively, mean of tensile moduli of inner and outer skins, and mean of compressive moduli of inner and outer skins, in direction parallel to *l*	N/mm^2

s, c, p, k_1, k_2 and E_{tc} are as defined in 2.3.3(c) of this Chapter.

(iii) Shear Strength

The thickness of core and sandwich laminate is to be not less than given by the following equation. Special consideration will be given where cores differing from those in Chapter 1 of Part II are proposed. See also 2.3.3(d)(v) of this Chapter for minimum thickness of skin.

$$\frac{d_0 + d_c}{2} = \frac{vps}{1000\tau} \qquad \text{mm}$$

where:

d_o	=	overall thickness of sandwich, excluding gel coat	mm
d_c	=	thickness of core	mm
v	=	coefficient varying with plate panel aspect ratio, given in Table III 2-12 of this Chapter. Where the elastic properties of the skins are different in the principal axes, v is to be taken not less than 0.5	
s	=	lesser dimension of plate panel	mm
p	=	design pressure, as defined in 2.2 of this Chapter	kN/m^2
τ	=	design stress, as shown in Table III 2-13 of this Chapter	N/mm^2

Where cores are scored to facilitate fitting, the scores are to be filled with putty or resin.

The density of polyvinyl chloride foam cores in the shell plating is to be not less than given in the following table:

Location	Density kg/m^3	Minimum Density kg/m^3
Bottom forward of 0.4L_{WL}; V≥25kts	4d_c	120
Bottom forward of 0.4L_{WL}; V< 25kts	4d_c	100
elsewhere; V≥25kts	3d_c	100
elsewhere; V< 25kts	3d_c	80
Side forward 0.4L_{WL}	2.5d_c	100
elsewhere	2.0d_c	80

Table III 2-12
Coefficient v for FRP Sandwich Panels Shear Strength

Plate Panel Aspect Ratio *l*/s	v
>2.0	0.500
2.0	0.500
1.9	0.499
1.8	0.499
1.7	0.494
1.6	0.490
1.5	0.484
1.4	0.478
1.3	0.466
1.2	0.455
1.1	0.437
1.0	0.420

s = shorter edge of plate panel mm
l = longer edge of plate panel mm

Note:
(1) Values of v less than 0.5 may be used only where the inner and outer skins have essentially the same strength and elastic properties in the 0° and 90° axes.

Table III 2-13
Core Shear Design Strength

Core Material	Design Core Shear Strength
Balsa Wood	$0.3\tau_u$
PVC(1)	$0.4\tau_u$

Note:
(1) May be taken as $0.55\tau_u$ where sheer elongation exceeds 40%.

τ_u = minimum core shear strength N/mm^2

(iv) Skin Stability

The skin buckling stress σ_c, given by the following equation, is in general to be not less than $2.0\sigma_{ai}$ and $2.0\sigma_{ao}$.

$$\sigma_c = 0.6\sqrt[3]{E_s \cdot E_{cc} \cdot G_{cc}}$$

where:
E_s = compressive modulus of skins, in 0° and 90° in-plane axis of panel N/mm^2
E_{cc} = compressive modulus of core, perpendicular to skins N/mm^2
G_{cc} = core shear modulus, in the direction parallel to load N/mm^2

(v) Minimum Skin Thickness

After all other requirements are met, the skin thicknesses of laminates complying with basic laminate requirements of Chapter 1 of Part II are in general to be not less than given by the following equations:

$$t_{os} = 0.35k_3(C_1 + 0.26L) \quad \text{mm}$$

$$t_{is} = 0.25k_3(C_1 + 0.26L) \quad \text{mm}$$

where:
t_{os} = thickness of outer skin mm

t_{is} = thickness of inner skin mm
k_3 = 1.2 bottom shell
= 1.0 side shell and deck
C_1 = 5.7 mm
L = craft length, as defined in 1.1.2 of this Part, generally not to be taken as less than 12.2 m m

(vi) Wheel Loading

Special consideration will be given to the required thickness where provision is made for the operation or stowage of vehicles having rubber tires after all other requirements are met.

2.3.4 Plating Subject to Specific Payloads

A first principles analysis is to be performed for all plates that are subject to a specific load. The maximum stresses and deflections in these plates are not to exceed the stresses given in Table III 2-14 of this Chapter.

Table III 2-14
Maximum Stresses

		Steel	Aluminum	FRP	
				σ	δ
Human Load		---	---	$0.33\sigma_u$	0.01s
Helicopter Decks(2)	Overall Dist. Loading	$0.6\sigma_y$	$0.6\sigma_{yw}$	See Note (1)	See Note (1)
	Landing Impact Loading	σ_y	σ_{yw}	See Note (1)	See Note (1)
	Stowed Aircraft Loading	σ_y	σ_{yw}	See Note (1)	See Note (1)

σ_y = yield strength of steel N/mm^2
σ_{yw} = welded yield strength of aluminum N/mm^2
s = panel spacing

For single skin laminates:

σ_u = minimum flexural strength N/mm^2

For sandwich laminates:

σ_u = for shell or deck outer skin, minimum tensile strength N/mm^2
σ_u = for shell or deck inner skin, minimum compressive strength N/mm^2
σ_u = for bulkheads, lesser of tensile or compressive strength N/mm^2

σ_u is to be verified from the approved test results, see 1.6 of Part II.

Notes:

(1) Composites will be specially considered for use in this location.

(2) The minimum plate thickness is generally not to be less than obtained from the following:

Beam Spacing	t_s	t_{al}
460 mm	4.0 mm	$0.9t_s\sqrt{Q}$
610 mm	5.0 mm	$0.9t_s\sqrt{Q}$
760 mm	6.0 mm	$0.9t_s\sqrt{Q}$

t_s = required thickness for steel

t_{al} = required thickness for aluminum

Q = material factor as defined in 2.1.1(a) of this Chapter

2.4 Framing

2.4.1 Aluminum and Steel

(a) General

Structural arrangements and details are to be in accordance with 2.5 and 2.6 of this Chapter. The scantlings given in this section are minimum values. Direct analysis may be specifically required by the Rules or may be submitted by designers in support of alternative arrangements and scantlings.

(b) Strength and Stiffness

(i) Section Modulus

The ends of members are to be effectively attached to the supporting structure. The section modulus of each longitudinal, stiffener, transverse web, stringer and girder is to be not less than that given by the following equation:

$$\mathrm{SM} = \frac{83.3 \times psl^2}{\sigma_a} \qquad \mathrm{cm}^3$$

where:

p	=	design pressure, as given in 2.2.1 or 2.2.3 of this Chapter	kN/m^2
s	=	spacing, of the longitudinal, stiffener, transverse web or girder, etc.	m
l	=	length, of the longitudinal, stiffener, transverse web or girder, between supports; where bracketed end connections are supported by bulkheads, l may be measured onto the bracket, the distance as given on III 2-13 of this Chapter, provided both bracket arms are about the same length. Where transverse members span chines or "knuckles," l is to be measured as shown in Fig. III 2-13 and Fig. III 2-14 of this Chapter	m
σ_a	=	design stress, as given in Table III 2-15 of this Chapter	N/mm^2

Stiffeners without end attachments are permitted on watertight bulkheads provided the section modulus is increased by 50%, and provided the bulkhead plating and boundary can transmit the shear forces on the stiffeners.

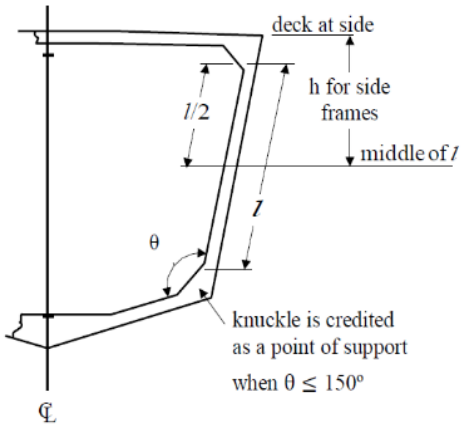


Fig. III 2-13
Transverse Side Frame

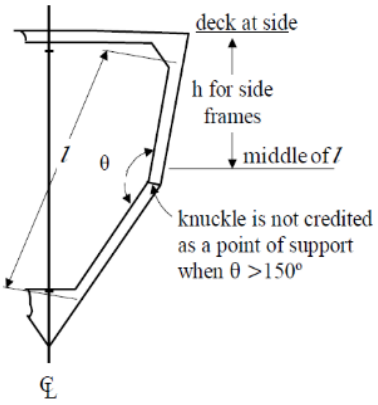


Fig. III 2-14
Transverse Side Frame

Table III 2-15
Design Stress, σ_a

Location	Steel and Aluminum	FRP
Bottom Longitudinals – Slamming Pressure	$0.65\sigma_y$	$0.33\sigma_u$
Bottom Longitudinals – Sea Pressure	$0.50\sigma_y$	$0.40\sigma_u$
Side Longitudinals – Slamming Pressure	$0.60\sigma_y$	$0.40\sigma_u$
Side Longitudinals – Sea Pressure	$0.50\sigma_y$	$0.40\sigma_u$
Deck Longitudinals – Strength Decks	$0.33\sigma_y$	$0.40\sigma_u$
Deck Longitudinals – Other Decks	$0.40\sigma_y$	$0.40\sigma_u$
Wet Deck Longitudinals	$0.75\sigma_y$	$0.40\sigma_u$
Bottom Transverses and Girders – Slamming Pressure	$0.80\sigma_y$	$0.33\sigma_u$
Bottom Transverses and Girders – Sea Pressure	$0.60\sigma_y$	$0.33\sigma_u$
Side Transverses and Girders – Slamming Pressure	$0.80\sigma_y$	$0.33\sigma_u$
Side Transverses and Girders – Sea Pressure	$0.60\sigma_y$	$0.33\sigma_u$
Deck Transverses and Girders – Strength Deck	$0.75\sigma_y$	$0.33\sigma_u$
Deck Transverses and Girders – Other Decks	$0.75\sigma_y$	$0.33\sigma_u$
Wet Deck Transverses and Girders	$0.75\sigma_y$	$0.33\sigma_u$
Watertight Bulkheads	$0.85\sigma_y$	$0.50\sigma_u$
Tank Bulkheads	$0.60\sigma_y$	$0.33\sigma_u$
Superstructure and Deckhouse	$0.70\sigma_y$	$0.33\sigma_u$

σ_y = minimum yield strength, unwelded condition N/mm^2
For aluminum, minimum yield stress, welded condition
σ_u = ultimate tensile strength N/mm^2

(ii) Moment of Inertia

The moment of inertia of each longitudinal, stiffener, transverse web, stringer or girder, including the plating to which it is attached, is to be not less than given by the following equation:

$$I = \frac{260psl^3}{K_4 E} \qquad \text{mm}^4$$

where

K_4 = for shell and deep tank girders, stringers and transverse webs, constructed of steel.
= for deck girders and transverses constructed of steel.
= 0.0021 for shell and deep tank stringers and transverse webs constructed of aluminum.
= 0.0018 for deck girder and transverses constructed of aluminum.

E = 2.06×10^5 for steel N/mm^2
= 6.9×10^4 for aluminum N/mm^2

p, s and *l* are as given in 2.4.1(b)(i) of this Chapter.

(c) Elastic Buckling of Longitudinal Members

The moment of inertia of the deck or shell longitudinal together with attached plating is not to be less than to satisfy the following criteria:

(i) Axial Compression

The critical buckling stress σ_E of a beam-column (i.e., the longitudinal and the associated effective plating) with respect to axial compression may be obtained from the following equation:

$$\sigma_E = \frac{EI_a}{c_1 A l^2} \qquad \text{N/mm}^2$$

where:

E = as defined in 2.4.1(b)(ii) of this Chapter
I_a = moment of inertia, of longitudinal, including plate flange cm^4
c_1 = 1000
A = cross-sectional area, of longitudinal, including plate flange cm^2
l = span of longitudinal m

(ii) Torsional/Flexural Buckling

The critical torsional/flexural buckling stress with respect to axial compression of a longitudinal including its associated plate may be obtained from the following equation:

$$\sigma_E = \frac{\pi^2 E I_w}{10 c_1 I_p l^2}\left(m^2 + \frac{K}{m^2}\right) + 0.385E\frac{I_t}{I_p} \qquad \text{N/mm}^2$$

where:

c_1 = 1000
K = $c_2 \frac{Cl^4}{\pi^4 E I_w}$
m = 1 for $0 < K \leq 4$
= 2 for $4 < K \leq 36$
= 3 for $36 < K \leq 144$
= 4 for $144 < K \leq 400$
E = as defined in 2.4.1(b)(ii) of this Chapter
c_2 = 10^6
I_t = St. Venant's moment of inertia, in cm^4, of profile (without plate flange)
= $c_3 \frac{h_w t_w^3}{3}$ for flat bars (slabs)
= $c_3 \frac{1}{3}\left[h_w t_w^3 + b_f t_f^3\left(1 - 0.63\frac{t_f}{b_f}\right)\right]$ for flanged profiles
c_3 = 10^{-4}
I_p = polar moment of inertia, of profile about connection of stiffener to plate cm^4
= $c_3 \frac{h_w^3 t_w}{3}$ for flat bars (slabs)

$= c_3\left(\frac{h_w^3 t_w}{3} + h_w^2 b_f t_f\right)$ for flanged profiles

I_w = warping constant, of profile about connection of stiffener to plate cm^6

$= c_4 \frac{h_w^3 t_w^3}{36}$ for flat bars (slabs)

$= c_4\left(\frac{t_f b_f^3 h_w^2}{12}\right)$ for "Tee" profiles

$= c_4 \frac{b_f^3 h_w^2}{12(b_f + h_w)^2}\left[t_f\left(b_f^2 + 2b_f h_w + 4h_w^2\right) + 3t_w b_f h_w\right]$ for angles and bulb profiles

c_4 = 10^{-6}

h_w = web height mm

t_w = web thickness mm

b_f = flange width mm

t_f = flange thickness mm

l = span of member m

C = spring stiffness exerted by supporting plate panel

$= \frac{k_p E t_p^3}{3s\left(1 + \frac{1.33 k_p h_w t_p^3}{s t_w^3}\right)}$ N

s = spacing of member mm

t_p = plate thickness mm

k_p = $1-\eta_p$, not to be taken less than zero

For flanged profiles k_p need not be taken less than 0.1.

η_p = $\frac{\sigma_a}{\sigma_{Ep}}$

σ_a = calculated compressive stress

For longitudinals, members see 2.4.1(c)(iv) of this Chapter

σ_{Ep} = elastic buckling stress of supporting plate as calculated in 2.3.1(c)(i)(1) of this Chapter

(iii) Critical Buckling Stress

The critical buckling stress in compression, σ_c, is determined as follows:

$\sigma_c = \sigma_E$ when $\sigma_E \leq 0.5\ \sigma_y$

$\sigma_c = \sigma_y\left(1 - \frac{\sigma_y}{4\sigma_E}\right)$ when $\sigma_E > 0.5\ \sigma_y$

where:

σ_y = yield strength of material N/mm^2

Note:

Generally the unwelded yield strength may be used, but due account is to be made for critical or extensive weld zones.

σ_E = ideal elastic buckling stress calculated in 2.4.1(c)(i) of this Chapter

(iv) Calculated Compressive Stress

$\sigma_a = 10^5 \times \frac{M_t y}{I}$ N/mm^2

where:

σ_a = working compressive stress in panel being considered, but generally not less than the following: N/mm^2

$\frac{175}{Q}\frac{SM_R}{SM_A}$ N/mm^2

M_t = maximum total bending moment as given in 2.1.1(a)(ii)(5) of this Chapter kN-m

y = vertical distance, from the neutral axis to the considered location m

I = moment of inertia of the hull girder cm^4

SM_R = hull girder section modulus, as required in 2.1 of this Chapter cm^2-m

SM_A = section modulus of the hull girder at the location being considered cm^2-m
Q = material factor as given in 2.1.1(a) of this Chapter

(v) Design Buckling Stress

The design buckling stress, σ_c, is to be such that:

$$\sigma_c \geq \beta \sigma_a$$

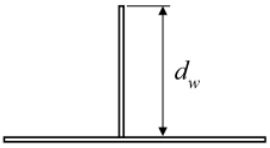
where:
β = 1.10 for the web plating of members
= 1.20 for overall buckling of members

(vi) Web and Flange Buckling

Local buckling is considered satisfactory provided the following proportions are not exceeded.

(1) Flat bars

$$d_w/t_w \leq 0.5(E/\sigma_y)^{1/2} C_2$$



(2) Built-up Sections, Angle Bars and Tee Bars

$$d_w/t_w \leq 1.5(E/\sigma_y)^{1/2} C_2$$

(3) Bulb Plates

$$d_w/t_w \leq 0.85(E/\sigma_y)^{1/2} C_2$$

(4) Outstanding Face Bars and Flanges

$$d_w/t_w \leq 0.5(E/\sigma_y)^{1/2} C_2$$



where:
t_w = total required thickness mm
d_w = depth of the web mm
E = as defined in 2.4.1(b)(ii) of this Chapter
σ_y = yield strength of material N/mm^2
Note:
Generally the unwelded yield strength may be used, but due account is to be made for critical or extensive weld zones.
C_2 = 1 where $\sigma_a > 0.80\sigma_y$
= where $\sigma_a < 0.80\sigma_y$, and σ_a is to be taken not less than $0.55\sigma_y$

For webs and flanges that do not satisfy these limits, a detailed analysis of buckling strength using an acceptable method is to be submitted for review.

(d) Corrugated Panels

(i) Stiffeners

The section modulus, SM, for corrugated bulkhead is to be not less than that obtained by the requirements in 2.4.1(b) of this Chapter with *l* being the distance between supporting members in m, and s is equal to a + b where a and b are as defined in Fig. III 2-15 of this Chapter, in m.

The developed section modulus, SM, may be obtained from the following equation, where a, t, and d are as indicated in Fig. III 2-15 of this Chapter.

$$SM = td^2/6 + (adt/2)$$

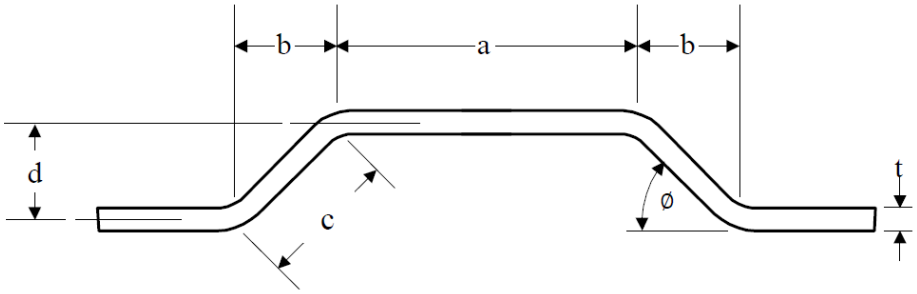


Fig. III 2-15
Corrugated Bulkhead

(ii) End Connections

The structural arrangements and size of welding at the ends of corrugations are to be designed to develop the required strength of corrugation stiffeners. Joints within 10% of the depth of corrugation from the outer surface of corrugation, d_1, are to have double continuous welds with fillet size, w, not less than 0.7 times the thickness of the bulkhead plating or penetration welds of equal strength (Fig. III 2-16 of this Chapter).

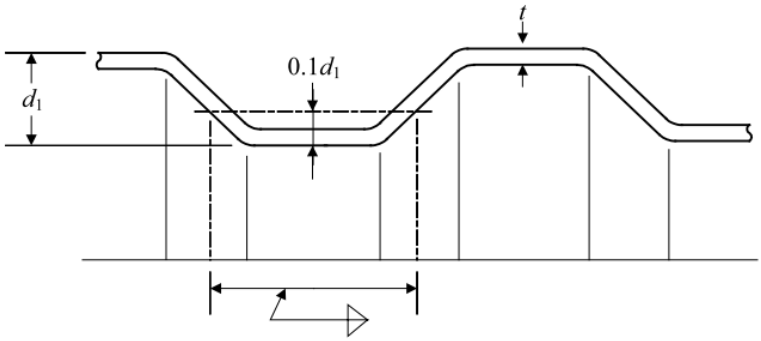


Fig. III 2-16
Corrugated Bulkhead End Connections

(e) Web Thickness

The thickness of the webs of structural members is not to be less than that determined by the following equation:

(i) Webs

$$t = \frac{d_w}{C}\sqrt{\frac{\sigma_y}{\sigma_d}}$$

where:

t_w	=	total required thickness	mm
d_w	=	depth of the web	mm
C	=	70 for steel members	mm
	=	50 for aluminum members	
σ_d	=	235 for steel members	N/mm^2
	=	127.6 for aluminum members	N/mm^2

The web thickness is also not to be less than the following:

$$t = \frac{1000psl}{2d_w\tau_a} \quad \text{mm}$$

where:

t	=	total required thickness	mm
p	=	design pressure, as given in 2.2 of this Chapter	kN/m^2
s	=	width of shell or deck supported by the member	m
l	=	length of member	m
d_w	=	depth of the web	mm
τ_a	=	design shear stress	N/mm^2
	=	$0.5\tau_y$ for steel structure and $0.5\tau_{yw}$ for aluminum structure For bottom primary structure $0.75\tau_y$ or $0.75\tau_{yw}$.	N/mm^2
τ_y	=	minimum shear, unwelded condition	N/mm^2
τ_{yw}	=	minimum shear yield strength, welded condition	N/mm^2

(f) Attachments

(i) Lug Attachments

The lug weld attachment of the longitudinals to the transverse webs are to have total weld throat area not less than the following equations:

$$a_w = \frac{1000psl}{2\tau_a} \quad \text{mm}^2$$

where:

a_w	=	$t_w \times l_w$	
t_w	=	weld throat	mm
l_w	=	total length of weld	mm
p	=	design pressure, as given in 2.2 of this Chapter	kN/m^2
s	=	width of shell or deck supported by the member	m
l	=	length of member	m
τ_a	=	design sheer stress, as defined in 2.4.1(e)(i) of this Chapter	N/mm^2

(ii) End Attachments

The welded end attachments of members, including bracket connections, are to develop the required strength of the member being attached, considering the member as fix ended.

(g) Direct Analysis Methods

Local structure may be designed using advanced analysis techniques such as non-prismatic beam, grillage, and finite element analysis. The requirements for the use of these types of analysis techniques are in 1.3 of this Part.

(h) Decks Exposed to Vehicle Loads

All longitudinals, beams, and girders of decks that are subject to vehicle loads are to be checked under all possible combinations of these loads. The maximum allowable design stress for these members are given in Table III 2-15 of this Chapter.

(i) Tripping Brackets and Stiffeners

Tripping brackets are to be fitted on girders and transverses at a spacing of about 3 m. Stiffeners are to be fitted as may be required.

2.4.2 Fiber Reinforced Plastic

(a) General

The structural arrangements and details are to be in accordance with 2.5 and 2.6 of this Chapter. Laminates may be bi-directional or uni-directional. Bonding angles or tapes are to comply with 2.5 of this Chapter. Laminates of webs, crowns and face bars of stiffeners, transverses and girders may be bi-directional, or multi-axial. Uni-axial caps may be used in the crowns and face bars of these members. In general, the tapes bonding the members, and their secondary bonds, are to develop the strength of the member being attached.

(b) Fiber Reinforcement

The basic laminate given in Part II, Chapter 1, or other approved laminates of glass, aramid, or carbon fiber, in mat, woven roving, cloth, knitted fabric, or non-woven uni-directional reinforcing plies may be used. The plies are in general to be laid-up parallel to the direction of the internal. The strength of the laminate in a direction perpendicular to the direction of the internal is in general not to be less than 25% of the warp strength except for the uni-directional caps of the flange or crown of the internal members. In way of continuous longitudinal members, the required section modulus, shear area and moment of inertia of transverse members are to be maintained by the shell or deck plating and that part of the transverse member that is continuous over the longitudinal member.

Where higher strength or higher modulus plies are used in the flange or crown of the internal, it may be advisable to provide similar higher strength, higher modulus local plies in the shell or deck plating, in the direction parallel to the internal to balance the strength and stiffness of the high strength and high modulus plies in the flange or crown of the internal.

(c) Strength and Stiffness

(i) Section Modulus

The section modulus of each longitudinal, stiffener, transverse web and girder including the plating to which it is attached is to be not less than given by the following equation:

$$\mathrm{SM} = \frac{83.3 \times psl^2}{\sigma_a} \qquad \mathrm{cm}^3$$

where p, s, l and σ_a are defined in 2.4.1(b) of this Chapter.

Where the shell, deck or bulkhead plating, and the webs and flange and crown of the member are of different strength or elastic property plies, consideration is to be given to the effect of the different moduli plies in calculating the moment of inertia and section modulus; the required section modulus is to be considered for each different strength laminate of the member.

(ii) Moment of Inertia

The moment of inertia of each longitudinal, stiffener, transverse web, stringer or girder, including the plating to which it is attached, is to be not less than given by the following equation:

$$I = \frac{260psl^3}{K_4 E} \qquad \mathrm{cm}^4$$

where:

K_4 = for shell and deep tank girders, stringers and transverse webs.
= 0.004 for deck girders and transverses.
= 0.010 for all other members.

E = tensile or compressive modulus representative of the basic value used in the moment of inertia calculation $\mathrm{N/mm}^2$

p, s and l are as given in 2.4.1(b) of this Chapter.

(iii) Shear Area

The web area, A, of the member is to be not less than that given by the following equation:

$$A = \frac{1000psl}{2\tau} \qquad \text{mm}^2$$

where:

A	=	net web area, at location being considered	mm^2
τ	=	design shear stress, to be taken not greater than $0.4\tau_u$	N/mm^2
τ_u	=	lesser of ultimate shear strength, in either warp or fill of the web laminate	N/mm^2

p, s and *l* are as given in 2.4.1(b) of this Chapter.

Consideration will be given to determining the web area using more detailed methods of determining the shear stress in the web at the neutral axis of the member.

(d) Proportions

The thickness of webs and flanges are to be in accordance with 2.6 of this Chapter.

(e) Buckling

(i) Single Skin Laminate

Where single skin laminate members are subject to in-plane compressive loading likely to cause axial overall or local buckling, design calculations are to be submitted to show the margin against buckling failure.

(ii) Sandwich Laminates

Where sandwich laminate members are subject to in-plane compressive loading, likely to cause axial overall or local buckling of the sandwich, or of the sandwich skins, design calculations are to be submitted to show the margin against buckling failure.

2.4.3 Stanchions

(a) General

The structure under stanchions is to be of sufficient strength to distribute the loads effectively. Stanchions between each tier of decks shall be alligned to each other as far as practicable; where this is not practicable, effective means are to be provided for transmitting the loads to the structure below. Stanchions in double bottoms and under the tops of deep tanks are to be metal and solid in cross section. Stanchions are in general not to be used in the bottom or double bottom structures where subject to high impact loads in service.

(b) Stanchion Analysis

The load, W, on a given stanchion is to be developed from the end reaction from the girders that the stanchion supports. These end reactions are to be developed considering the design pressure for the deck in which they are located plus any point loads from stanchions located on the girder. When cascading the stanchion loads through the structure, the analysis is to consider the load from the deck directly above the stanchion plus the loads from all complete decks and one-half the load from all partial or deckhouse decks. The requirement in 2.4.3(c) of this Chapter is given for a simple stanchion that will only need to support the deck directly above. In general, stanchions are to have sectional area not less than 1.015W cm^2 where the stanchions are subject to tension loads.

(c) Stanchion Load

The load on a stanchion is to be obtained from the following equation:

$$W = pbs \qquad \text{kN}$$

where:

W	=	load	kN

b	=	mean breadth, of area supported	m
s	=	mean length, of area supported	m
p	=	design pressure, as given in 2.2 of this Chapter	kN/m^2

(d) Permissible Load

The load a stanchion may carry is to be equal to or greater than the load on the stanchion obtained in 2.4.3(b) of this Chapter. This permissible load is to be obtained from the following equations:

(i) Steel Stanchions

$$W_a = (k - nl/r)A \quad \text{kN}$$

(ii) Aluminum-Alloy Stanchions

$$W_a = (10.00 - 5.82l/r)A\sigma_y/165 \quad \text{kN}$$

where:

W_a	=	permissible load	kN
k	=	12.09 ordinary strength steel	
	=	16.11 HT32 strength steel	
	=	18.12 HT36 strength steel	
n	=	4.44 ordinary strength steel	
	=	7.47 HT32 strength steel	
	=	9.00 HT36 strength steel	
r	=	least radius of gyration of stanchion	cm
A	=	area of stanchion	cm^2
l	=	unsupported length of stanchion	m
σ_y	=	minimum yield strength of welded aluminum under consideration	N/mm^2

The adoption of aluminum test values higher than given in Part II, Chapter 2 will be subject to special consideration.

(e) FRP Stanchions

FRP stanchions will be subject to special consideration.

(f) Support by Bulkheads

Bulkheads supporting girders or bulkheads fitted in lieu of stanchions are to be stiffened to provide support not less effective than required for stanchions.

2.4.4 Internals Subject to Specific Payloads

A first principles analysis is to be performed for all internals that are subject to a military mission load. The maximum stresses in these plates are not to exceed the values as given in Table III 2-16 of this Chapter.

Table III 2-16
Maximum Stresses

		Steel	Aluminum	FRP	
				σ	δ
Human Load		---	---	$0.33\sigma_u$	0.01s
Helicopter Decks	Overall Dist. Loading	$0.6\sigma_y$	$0.6\sigma_{yw}$	See Note (1)	See Note (1)
	Landing Impact Loading Beams	σ_y	σ_{yw}	See Note (1)	See Note (1)
	Landing Impact Loading Girders, Stanchions, or Truss Supports (2)	$0.9\sigma_y$	$0.9\sigma_{yw}$	See Note (1)	See Note (1)
	Stowed helicopter Loading Beams	$0.9\sigma_y$	$0.9\sigma_{yw}$	See Note (1)	See Note (1)
	Stowed helicopter Loading Girders, Stanchions, or Truss Supports (2)	$0.8\sigma_y$	$0.8\sigma_{yw}$	See Note (1)	See Note (1)

σ_y = yield strength of steel N/mm^2
σ_{yw} = welded yield strength of aluminum N/mm^2
s = panel spacing
σ_u = ultimate tensile strength N/mm^2

Notes:

(1) Composites will be specially considered for use in this location.

(2) For members subjected to axial compression, the factor of safety is to be based on the yield stress or critical buckling stress, whichever is less.

2.5 Hull Structural Arrangement

2.5.1 Structural Arrangement – All Materials

(a) Framing, Webs, Girders, and Non-tight Structural Bulkheads

(i) General

The shell, main deck, and the sides and tops of long superstructures are in general to be longitudinally framed; depending on craft length, speed and structural stability, craft may also be transversely framed. On transversely framed craft, it is to be clearly indicated that the structure has a continuous load path that eliminates hard spots on unsupported structure.

Bulkheads, partial bulkheads or web frames are to be arranged in the main hull and in long superstructures or deckhouses to provide effective transverse rigidity. Bulkheads or deep web frames are to be provided in the main hull under the ends of superstructures or deckhouses.

Longitudinals are to be supported by transverse web frames, transverse bulkheads or other transverse structure. For craft over 61 m in length, or on craft where the longitudinals need to be included in the offered longitudinal strength calculation to meet the requirements in 2.1.1 of this Part, the longitudinals are to be continuous in way of transverse supporting members, including transverse bulkheads. All other craft may have longitudinals intercostal to the transverse bulkheads provided that continuity of strength and end fixity are maintained in accordance with 1.2.3(e) of this Part and 2.5.1(a)(ii) of this Chapter. Craft that are under 30.5 m in length, and where the longitudinals do not need to be included in the offered longitudinal strength calculation to meet the requirements in 2.1.1 of this Chapter, may have longitudinal stiffeners that are intercostal to the transverse supporting members and bulkheads providing that continuity of strength and end fixity are maintained in accordance with 1.2.3(e) of this Part and 2.5.1(a)(ii) of this Chapter. For craft with transverse framing, deck and bottom girders are to be provided.

Girders may be intercostal at transverse bulkheads provided continuity of strength is maintained and end fixity is provided in accordance with 1.2.3(e) of this Part and 2.5.1(a)(ii) of this Chapter.

Transverses are to be arranged as continuous web rings and girders are to be aligned with stiffeners at bulkheads. Alternative arrangements that provide fixity at the ends of transverses and girders will be specially considered.

(ii) Attachments and Stiffening

At supporting members, the attachment of all internal structural members is to provide end fixity and effective load transmission. Special consideration will be given to reduced end fixity where the alternative structure has equivalent strength.

The webs of all members are to be effectively attached to the shell, deck or bulkhead plating, to their supporting members and to face bars.

(iii) Engines, Machinery, and other Foundations

The foundations of engines and associated machinery are to be installed to the manufacturer's recommendations. These foundations are to be constructed to withstand the loads imparted by the equipment they support under the worst intended operating conditions. The rigidity of foundations and supporting structure is to be sufficient to prevent misalignment, deflection, or vibration, which would interfere with the operation of the equipment.

Foundations supporting waterjets will be specially considered.

Where main engine girders are part of the longitudinal strength of the craft, there is to be continuity of strength and transition to smaller longitudinals. The flanges of engine girders are to be tripped at each transverse frame. All changes of engine girder web depth are to be gradual. The angle of this transition is not to exceed 45°.

Foundations of auxiliary equipment are to be similar to that of engine foundations. They are to provide for secure attachment of the equipment and are to be effectively attached to the hull structure.

Crane and davit foundations are to be capable of withstanding the axial load and the maximum overturning moments specified by the crane manufacturer.

The foundations for anchor winches or windlasses are to be designed in accordance with the requirements in 5.1.6(b) of this Part.

Structural members of all foundations are not to be punched or drilled for the attachment of equipment or fittings. Brackets, margin plates, special framing, or weld studs are to be attached to the structure and the components mounted on them and not directly on the structure.

All connections that are constructed with the use of a bi-metallic connection are to be in accordance with 2.6.1(a)(vi) and 2.13.2 of this Chapter.

(b) Watertight Bulkheads

(i) General

All vessels having lengths, L, equal to or exceeding 15 m (50 ft) are to be provided with watertight bulkheads in accordance with this section. The plans submitted are to clearly show the location and extent of each watertight bulkhead.

(ii) Openings and Penetrations

The number of openings in watertight subdivisions is to be kept to a minimum, compatible with the design and proper working of the vessel. Where penetrations of watertight bulkheads and internal deck are necessary for access, piping, ventilation, electrical cables, etc., arrangements are to be made to maintain the watertight integrity. Relaxation in the watertightness of openings above the freeboard deck may be considered, provided it is demonstrated that any progressive flooding can be easily controlled and that the safety of the vessel is not impaired.

Ventilation penetrations through watertight subdivision bulkheads are to be avoided. Where penetrations are unavoidable, the ventilation ducting is to satisfy watertight bulkhead requirements or watertight closing appliances are to be installed at the bulkhead penetrations. For ventilation penetrations below the bulkhead deck or below damage equilibrium waterlines, the closing appliances are to be operable from the bridge. Otherwise, local, manual controls may be provided.

(iii) Collision Bulkhead

Craft having a length, as defined in 1.1 of this Part, of or exceeding 15 m are to be provided with a collision bulkhead fitted not less than $0.05L_f$ abaft the stem at the design load waterline. At no point on vessels having 500 or more gross tonnage, except as specially permitted, is it to be further than $0.08L_f$ or $0.05L_f$+3 m, whichever is greater, from the reference point. The bulkhead is to be intact except for approved pipe penetrations, and are to extend to the main weather deck preferably in one plane. In craft having long superstructures at the forward end, the bulkhead is to be extended weathertight to the superstructure deck. Provided the extension is not less than 0.05L abaft the stem at the design load waterline, they need not be fitted directly over the collision bulkhead. In such cases, the part of the deck forming the step is to be weathertight.

On vessels with bow-doors, that part of their sloping loading ramps that form part of the extension of a collision bulkhead and are more than 2.3 m above the freeboard deck may extend forward of the limit below.

Collision bulkhead requirements for passenger vessels are to comply with this section and as indicated in Part II, 14.1 of the Rules for Steel Ships , as well as applicable requirements of Classification.

(iv) Reference Point

The reference point in determining the location of the collision bulkhead is the forward end of L_f except that in the case of vessels having any part of the underwater body, such as the bulbous bow, extending forward of the forward end of L_f, the required distances are to be measured from a reference point located a distance forward of the forward end of L_f. This distance, x, is the lesser of the following (see Fig. III 2-17 of this Chapter):

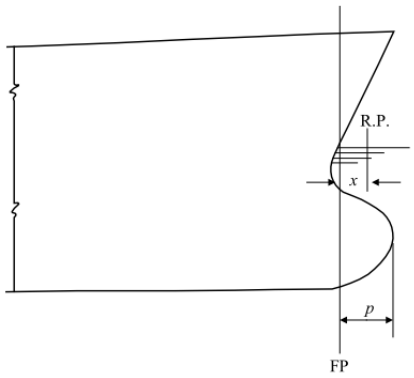


Fig. III 2-17
Reference Point of Vessels with Bulbous Bow

(1) Half the distance between the forward end of L_f and the extreme forward end of the extension, p/2 or

(2) $0.015L_f$

(3) 3 m

where L_f is as defined in 1.1.3 of this Part.

The forward end of L_f is to coincide with the fore side of the stem on the waterline at which L_f is measured.

(v) Engine Room

The engine room is to be enclosed by watertight bulkheads extending to the main weather deck.

(vi) Chain Locker

For craft with length L (as defined in 1.1.2 of this Part) greater than 24 meters, chain lockers and chain pipes are to be made watertight up to the weather deck. The arrangements are to be such that accidental flooding of the chain locker cannot result in damage to auxiliaries or equipment necessary for the proper operation of the craft nor in successive flooding into other spaces. Bulkheads between separate chain lockers not forming a part of subdivision bulkhead (see Fig. III 2-18 of this Chapter), or bulkheads which form a common boundary of chain lockers (see Fig. III 2-19 of this Chapter), need not be watertight.

Where means of access into chain lockers are provided, they are to be closed by a substantial cover secured by closely spaced bolts. Doors are not permitted.

Where a means of access to chain lockers is located below the weather deck, the access cover and its securing arrangements are to be in accordance with recognized standards (such as ISO 5894-1999), or equivalent for watertight manhole covers. Butterfly nuts and/or hinged bolts are prohibited as the securing mechanism for the access cover.

For closure of chain pipes, see 2.9.12(d) of this Chapter.

The arrangements on craft that are not subject to the International Convention on Load Lines or its Protocol may be specially considered.

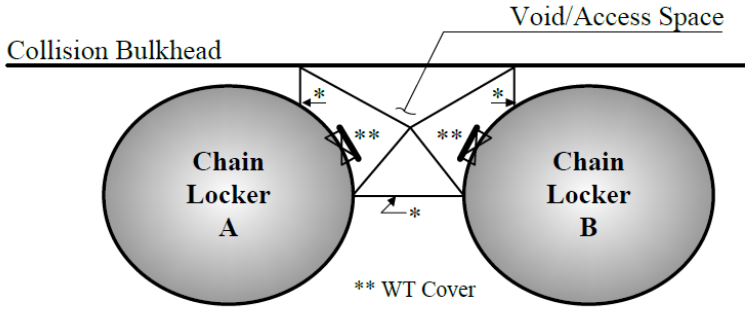


Fig. III 2-18

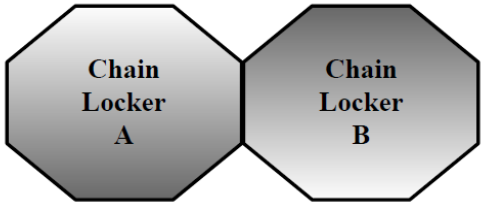


Fig. III 2-19

(c) Tanks

The arrangements of all tanks, their intended service, and the heights of the overflow pipes are to be indicated clearly on the drawings submitted for approval. As a minimum, all gravity fill integral or independent tank structures shall meet the design criteria for plating and framing in 2.3 and 2.4 of this Chapter considering the maximum head pressure imposed on the peripheries.

Where potable water tanks are fitted, water closets are not to be installed on top of the tanks nor are soil lines to run over the tops of the tanks. Pipes containing non-potable liquids are not to be run through the tanks. Attention is directed to the requirements of the national authorities that might govern the location, construction or design of such tanks.

Baffle or swash plates are to be provided. Special consideration may be given for the omission of baffle or swash plates providing the effects of fluid slamming on the plate are considered.

Scantlings of pressurized tanks will be subject to special consideration.

All tanks and void spaces are to be accessible for inspection and repair.

(d) Decks

Where a deck is stepped or has a break, suitable scarphing or brackets are to be provided at the side shell.

Decks passing into superstructures within the 0.5L amidships are to be increased in way of the break. See 2.1.1(d)(iv) of this Chapter.

(e) Means of Escape

All main hull spaces are to have two means of escape to the main weather deck. These escapes are to be located as far apart as practicable and are to be operable from both sides. All escape routes are to be readily accessible and unobstructed.

(f) Double Bottoms

(i) General

Inner bottoms are to be fitted fore and aft between the peaks or as near thereto as practicable in vessels of ordinary design of 500 GT or over. Where, for special reasons, it may be desired to omit the inner bottom, the arrangements are to be clearly indicated on the plans when first submitted for approval. A double bottom need not be fitted in way of deep tanks, provided the safety of the vessel in the event of bottom damage is not thereby impaired. It is recommended that the inner bottom be arranged to protect the bilges as much as possible and that it be extended to the sides of the vessel.

Shell longitudinals and frames in way of deep tanks are to have not less strength than is required for stiffeners on deep tank bulkheads.

(ii) Passenger Craft

For passenger craft that are on international voyages that operate more than four hours at operational speed from a port of refuge are to be fitted with double bottoms in accordance with Part II, Chapter 5 of the Rules for Steel Ships.

(iii) Cargo Craft

Cargo craft that are on international voyages that are more than eight hours at operational speed from a port of refuge are to be fitted with double bottoms. The inner bottoms are to be fitted fore and aft between the peaks or as near thereto as practicable. Where, for special reasons in design, it may be desired to omit the double bottom, the arrangement are to be clearly indicated on the plans when first submitted for approval. A double bottom need not be fitted in way of deep tanks provided the safety of the ship in the event of bottom damage is not thereby impaired. It is recommended that the inner bottom be arranged to protect the bilges as much as possible and that it be extended to the sides of the craft. The scantlings of the double bottom are to be fitted in accordance with 2.2, 2.3 and 2.4 of this Chapter.

(g) Doors, Hatches, Scuttles, and Manhole Covers

All doors, hatches, scuttles, and manhole covers, together with their frames and coamings, are to be in accordance with the same requirements as the structure in which they are installed.

(h) Helicopter Deck

(i) General

Helicopter landing facilities, where provided, are to meet the following safety requirements. The attention of owners, builders and designers is directed to various international and governmental regulations and guides regarding the operational and other design requirements for helicopter landing on craft.

Plans showing the arrangement of the helicopter deck are to be submitted. The arrangement plan is to show the overall size of the helicopter deck and the designated landing area.

If the arrangement provides for the securing of a helicopter or helicopters to the deck, the predetermined position(s) selected to accommodate the secured helicopter, in addition to the locations of deck fittings for securing the helicopter, are to be shown. The type of helicopter to be considered is to be specified and calculations for appropriate loading conditions are to be submitted.

(ii) Safety Net

The unprotected perimeter of the helicopter landing deck is to be provided with safety netting or equivalent.

(iii) Material

In general, the construction of helicopter decks is to be of steel or other material with equivalent ability to retain structural capacity in a fire. If the helicopter deck forms the deckhead of a deckhouse or superstructure, it is to be insulated to A-60 class standard.

Aluminum alloys may be used for helicopter decks integral if they form part of an aluminum deckhouse or superstructure. They may also be of aluminum alloy, fitted above a steel deckhouse or deck structure, provided the following conditions are complied with:

(1) There are to be no openings in the exterior bulkheads directly below the helicopter deck.

(2) All windows in the lower exterior bulkheads are to be fitted with steel shutters.

(iv) Means of Escape and Access

The helicopter deck is to be provided with both a main and an emergency means of escape and access for fire fighting and rescue personnel. These means are to be located as far apart from each other as is practicable and preferably on opposite sides of the helicopter deck.

(i) Compensation

Compensation is to be provided for openings in the shell plating where required to maintain the longitudinal and transverse strength of the hull. All openings are to have well-founded corners. Those in the upper side shell are be located a suitable distance below the deck edge. Cargo and gangway openings are to be kept well clear of other discontinuities in the hull girder. Local provision is to be made to maintain the longitudinal and transverse strength of the hull.

Thick plating and doublers of sufficient breadth to prevent damage from the flukes of stockless anchors are to be fitted around the hawse pipes.

2.5.2 Structural Arrangements – Additional Requirements for Steel and Aluminum Alloys

(a) Shell Plating

The bottom plating is to extend to the chine or upper turn of bilge. In general, the side shell is to be of the same thickness from its lower limit to the gunwale. Increases in thickness and additional stiffening are required in way of skegs, shaft struts, hawse pipes etc. Where a bow thruster tube is fitted, the area in question is to be in accordance with the requirements in 2.3.1(d) of this Chapter.

2.5.3 Structural Arrangements – Additional Requirements for Fiber Reinforced Plastic Hull

(a) Tanks

In fiber reinforced plastic construction, non-integral tanks are to be used whenever possible. When integral tanks are used they are to be of single skin construction; the only exception is the tank top plating can be of sandwich construction. No stiffeners within integral tanks are to penetrate the tank boundaries. No gasoline tanks, or tanks containing petroleum products with flash points less than 61°C are to be fitted integrally. The design and arrangements of oil fuel tanks is to be such that there is no exposed horizontal surface at the bottom that could be exposed to a fire. Other fire protection arrangements for oil fuel tanks will be specially considered. For details of fire protection requirements see 4.1 of this Part.

All internal surfaces of FRP tanks are to be covered with chopped strand mat weighing at least 600 g/m^2. This covering is to be in addition to the scantlings required by the Rules. A suitable coating is to be applied to this covering to prevent the contents of the tank from impregnating the surrounding laminates. The sides, tops, and baffles of integral tanks are to have all connections taped on both sides. Fresh water tanks are to be coated with a non-toxic and non-tainting coat of resin that is recommended by the resin manufacturer for potable water tanks. Where outfit items are to be laminated to the tank surface, the heavy coating of resin is to be applied afterwards and the laminated brackets sealed to prevent the ingress of moisture. The scantlings of integral oil fuel and water tanks are to be in accordance with 2.3 and 2.4 of this Chapter. Integral tanks are to be tested in accordance with Table III 7-1 of this Chapter

2.6 Arrangement, Structural Details and Connections

2.6.1 Structural Details

(a) Aluminum and Steel

(i) General

Structural details are to be designed and constructed to minimize hard spots, notches and other structural discontinuities. Openings in webs, girders and other internal structural members are to be arranged clear of concentrated loads or areas of high stresses; slots in transverses and longitudinals for girders or beams in such locations are to be fitted with collars. Care is to be taken to verify structural continuity; sharp corners and abrupt changes in section are to be avoided; toes of brackets and ends of members are not to terminate on plating without attachment to an adjacent member, unless specially approved.

(ii) Longitudinals

Deck, bottom and inner bottom longitudinals are in general to be continuous unless specially approved otherwise, but in way of bulkheads they may be intercostal provided continuity of strength and end fixity are maintained by the end brackets. The ends of all internal structural members are to provide end-fixity and load transmission to the supporting member. Departures from this may be considered where the alternative structure has equivalent strength. See 2.5.1 of this Chapter.

(iii) Girders and Transverses

Girders and transverses are to have depths not less than twice the depth of slots for beams and longitudinals or other openings. Transverses are to be arranged as continuous web rings, girders are to be aligned with stiffeners at bulkheads, alternative arrangements that provide fixity at the ends of transverses and girders will be specially considered.

(iv) Openings

Access and lightening holes with suitably radiused corners are to be arranged as necessary and clear of areas of load concentration or high stresses. Their depths and lengths are generally not to exceed respectively, 0.5 and 0.75 the depth of the members.

(v) Limber Holes

Drains or limber holes are to be provided in non-tight structure to prevent the accumulation of liquids. Vent pipes are to be arranged to prevent over pressuring of tanks. Holes are to be located to provide complete drainage of all non-tight voids, bays, or pockets formed by structure. The holes are not to be located at points of high stress, such as the intersection of members. Limber holes are to be half round at the edge, or round if not at the edge, of the structure that is to be drained. The diameter of drain or limber hole is not to be greater than 20% of the depth of the member.

(vi) Bi-metallic Connections

In aluminum construction, where bi-metallic connections are unavoidable, suitable insulation, such as gaskets, washers, sleeves, and bushings, are to be provided. The faying surfaces between mechanically fastened metal components, except machinery foundation shims, are to be protected by the use of a bedding compound. Stainless steel fasteners may be joined directly. See also Part II, 2.5.7.

(b) Fiber Reinforced Plastic

(i) General

Structural continuity is to be maintained and where changes in thickness or structural section occur, they are to be gradual to prevent notches, hard spots and other structural discontinuities. The requirements of 2.6.1(b)(iv) and 2.6.1(b)(v), below, and of 2.6.2 and 2.6.3 of this Chapter are for the basic laminate. Special consideration will be given where other laminates or resins are used. The ends of all internal structural members are to provide end-fixity and load transmission to the supporting member. Departures from this may be considered where the alternative structure has equivalent strength.

(ii) Changes in Laminate Thickness

A gradual taper is to be used for all changes in laminate thickness. Where the construction changes from sandwich laminate to a solid laminate, the thickness of the core material is in general, to be reduced by a gradual taper of not less than 2:1.

(iii) Openings, Holes and Raw Edges

Access and lightening holes with suitably radiused corners are to be arranged as necessary and clear of areas of load concentration or high stresses. Their depths and lengths are generally not to exceed, respectively, 0.5 and 0.75 times the depths of the members. Air and limber holes are to be in accordance with 2.6.1(a)(v) of this Chapter.

All exposed edges in way of cuts or holes in FRP single-skin laminates are to be sealed with resin. Edges of sandwich panels and edges of holes in sandwich panels are to be covered with one ply of glass cloth lapped no less than 25 mm onto each face of the laminate. The cloth is to be completely saturated with resin.

Ferrules installed in sandwich panels or stiffeners for drains or wire penetrations are to be set in bedding compound.

All hatch openings are to be supported by a system of transverse and longitudinal stiffeners.

(iv) Piping and Wiring in Foam

Piping or wiring passing through foam-filled spaces is to be installed in PVC tubing. The pipe is to be arranged such that water will not become trapped. The ends of the plastic tubing are to be joined to adjacent structure with resin impregnated mat. See Fig. III 2-20 of this Chapter.

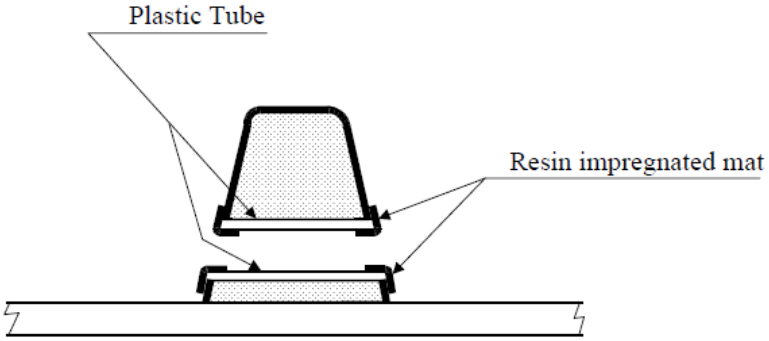


Fig. III 2-20
Piping or Opening through Foam Filled Space

(v) Stiffeners

(1) General
Stiffeners, frames, girders, deck beams, bulkhead stiffeners, etc. used to support FRP panels may be entirely of FRP, FRP laid over nonstructural cores or forms, or composites of FRP or other approved structural materials.

(2) Stiffeners without structural effective Cores or with Nonstructural Cores
Stiffeners without cores or with cores not indicated in 1.1.27(c)(viii) of this Chapter are to conform to Fig. III 2-21, and the thickness of the crown and web of the stiffeners is to be not less than obtained from the following equations:

$$t_1 = w/20 \quad \text{mm}$$

$$t = h/30 \quad \text{mm}$$

where:

t_1	=	thickness of stiffener crown	mm
t	=	thickness of stiffener webs	mm
w	=	width of stiffener crown	mm
h	=	height of stiffener webs	mm

Where the stiffeners are of laminates with properties differing from the basic laminate, the thickness is to be modified by the factor:

$$7.7\sqrt{C/E}$$

where:

E	=	compressive modulus of proposed laminate	kg/cm^2

C = ultimate compressive strength of proposed laminate kg/cm^2

Where polyvinylchloride, balsa, or other approved core material is used, thicknesses less than given above may be accepted provided the buckling stresses of the stiffener skins comply with the buckling stress criteria in 2.3.3(d)(iv) of this Chapter.

Hat-section stiffeners constructed by laying FRP over premolded FRP forms (see Fig. III 2-22 of this Chapter) are to conform with Fig. III 2-21 of this Chapter and the above equations; the premolded forms may be considered structurally effective if their physical properties are at least equal to those of the overlay laminates.

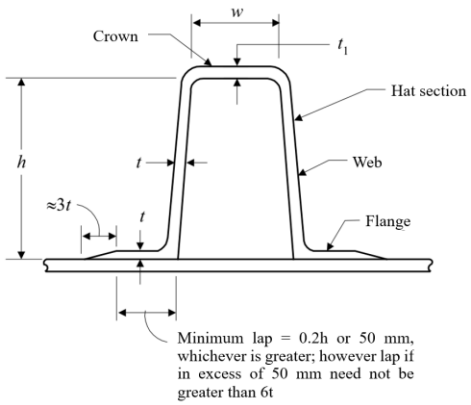


Fig. III 2-21
Proportions of Stiffeners

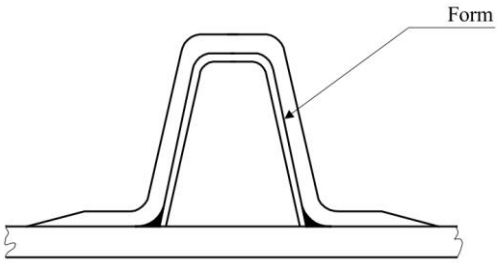


Fig. III 2-22
Premolded FRP Form

Premolded stiffeners bonded to the laminates with FRP angles, flanges or tapes (Fig. III 2-23 of this Chapter) are also to conform to Fig. III 2-21 of this Chapter and the above equations. The thickness of each bonding angle flange or tape is to be not less than the thickness of the webs of the stiffener, and the legs of the bonding angle, flange or tape are to be of equal length in accordance with 2.6.3 of this Chapter. Joints in premolded stiffeners are to be scarphed and spliced or otherwise reinforced to maintain the full strength of the stiffeners.
The thickness may be less than obtained from the above equation if these members are suitably stiffened and provided with adequate lateral stability. The required minimum flange or tape laps onto such members, as shown in Fig. III 2-21 of this Chapter, if greater than 50 mm, need not exceed 10t.

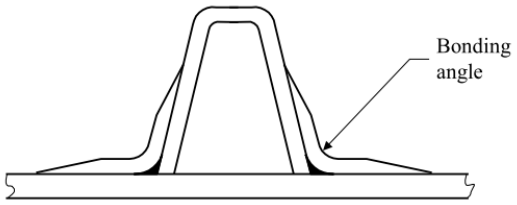


Fig. III 2-23
Premolded Stiffener

(vi) Girders and Longitudinal Frames

Girders and longitudinal frames are to be continuous through floors and web frames. Except in way of integral-tank end bulkheads, girders and longitudinal frames are also to be continuous through transverse bulkheads. Where such members are intercostal, attention is to be given to minimizing structural discontinuities. Where transverse structure is cut out in way of continuous members, the cut out is to be closed as to maintain the required tightness.

An acceptable type of continuous girder and longitudinal-frame FRP connection is shown in Fig. III 2-24 of this Chapter. The laps of the connections onto the supporting structure are to be not less than the overall widths of the structural members including flanges, and the thicknesses of the connections are to be not less than the thicknesses of the structural-member flanges or tapes.

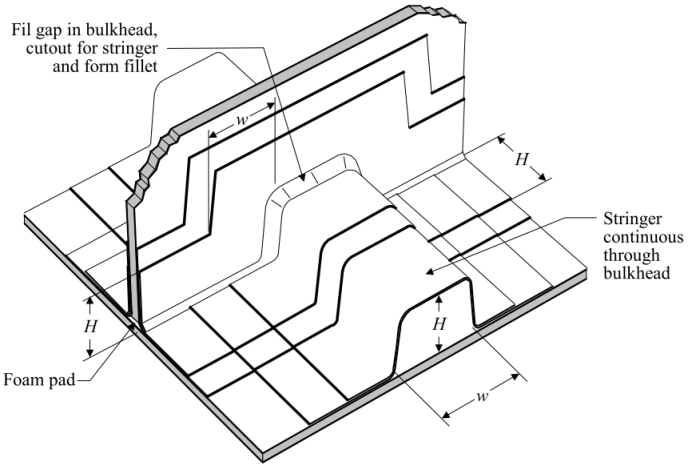


Fig. III 2-24
Connection of Longitudinals to Transverses

(vii) Engine Foundations

Engine bed fittings are to be of thicknesses and widths appropriate to the holding down bolts such that there is a close and accurate fit between the fittings and the engine girder.

Where the engine girders are a non-molded surface, the fittings are to be set in filled resin or mat. On a molded surface where the contours on the girders match the contours on the fitting, the fittings are to be set in a structural adhesive of a filled resin.

The fittings are to be bolted through the webs of the girders. A compression sleeve constructed of stainless steel or FRP is to be fitted in way of the through bolts. The area of the girder that is connected to the fitting is to have a high density insert in way of the faying surfaces. The insert is to extend 25 mm in all directions beyond the connection. If the size of the insert is less than 150 cm^2 a compound consisting of three parts phenolic or glass microballons, two parts resin, and one part milled glass fibers, by volume, may be used. A doubler consisting of one ply of mat and two plies of structural laminates are to be added to each face of the cored laminate. The doubler is to extend no less than 75 mm beyond the high density foam insert.

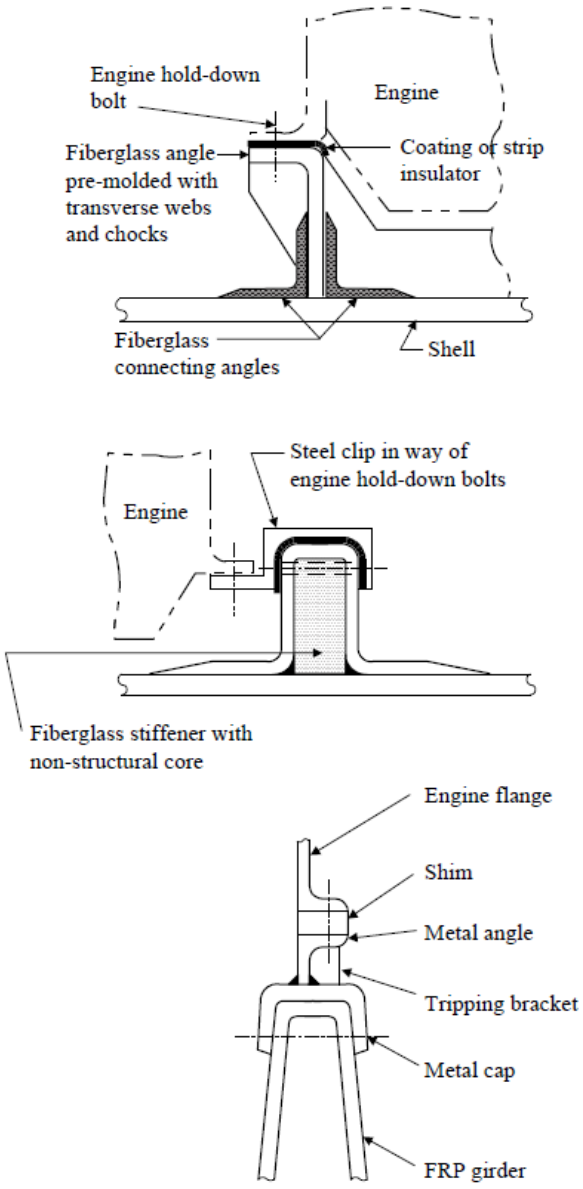


Fig. III 2-25
Engine Foundations

(viii) Deck Fittings

Deck fittings, such as cleats and chocks, are to be bedded in sealing compound, structural adhesive, or gasketed, through-bolted, and supported by either oversize washers or metal, plywood or wood backing plates, as shown in Fig. III 2-26 of this Chapter. Where washers are used, the laminate in way of the fittings is to be increased at least 25% in thickness. In no case is the fitting to impair the strength or tightness of the structure.

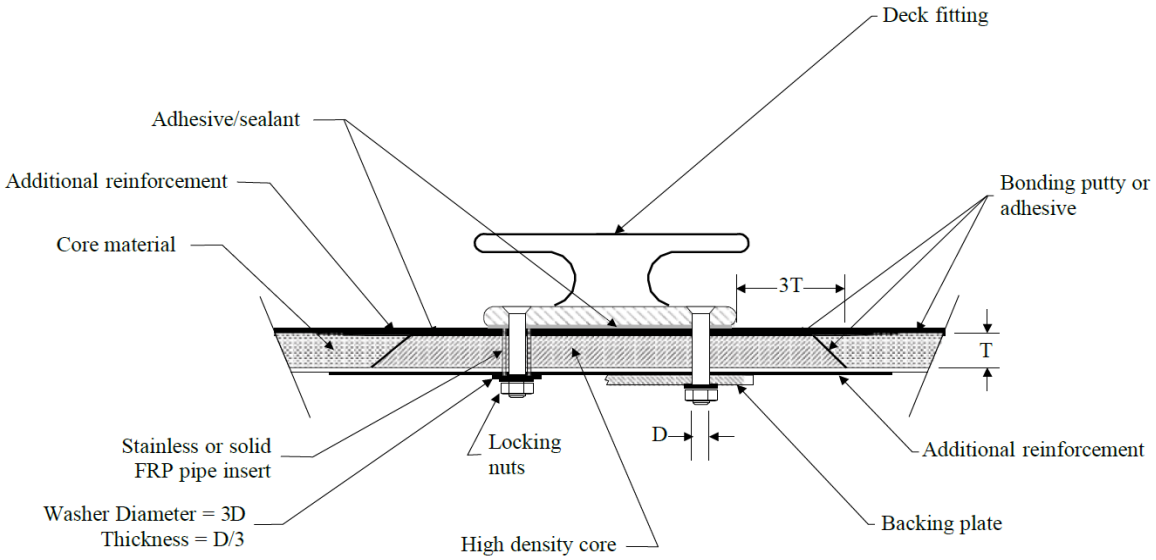


Fig. III 2-26
Deck Fittings

(ix) Through Hull Penetrations

Generally all through hull penetrations below the deepest draft design waterline are to be formed by solid FRP laminates, as shown in Fig. III 2-27 of this Chapter. When sandwich construction is used for the hull, the core material is to be completely sealed off from the through hull penetration, as shown in Fig. III 2-28 of this Chapter. All through hull penetrations are to be taped on both sides of the penetration. The penetration is to be set in a bedding compound.

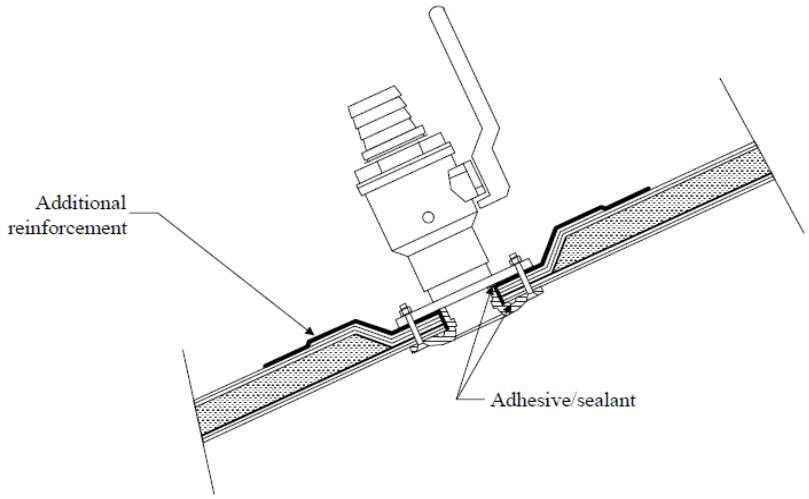


Fig. III 2-27
Through Hull Penetration – Solid Laminate

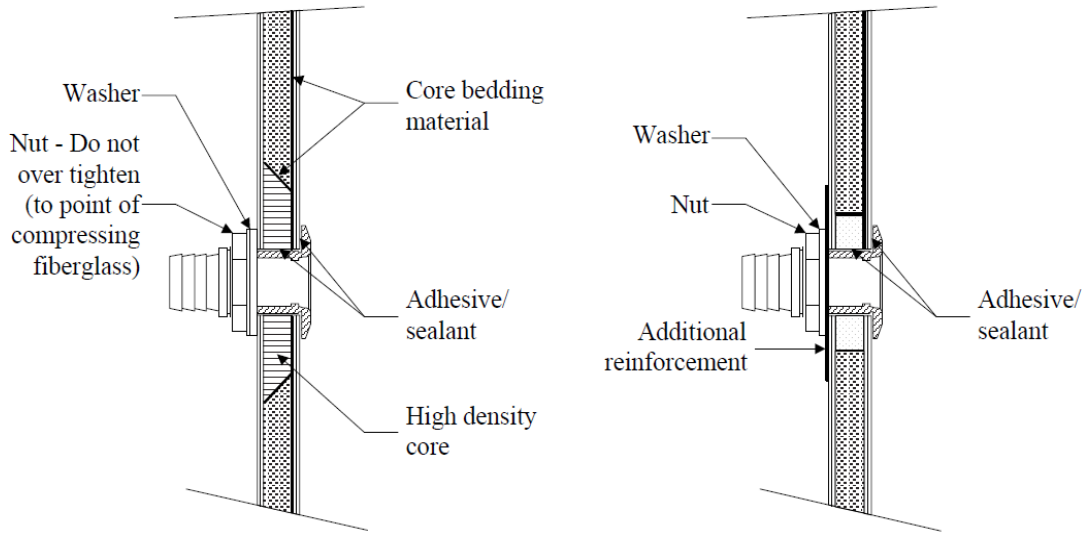


Fig. III 2-28
Through Hull Penetration – Sandwich Laminate

(x) Boundary Angles, Flanges or Tapes

(1) FRP to FRP
Secondary bonding of FRP components by means of double boundary angles, flanges or tapes is to be in accordance with Part II, Chapter 1. Typical boundary angles for FRP components are shown in Fig. III 2-29 of this Chapter. At the end connections of sandwich laminates, the core shear strength is to be effectively developed. The bulkheads are to be set into a foam insert, slow curing polyester putty, a microballon mixture or other approved material. The thickness of each boundary angle, flange or tape having similar strength to the members being connected is to be not less than the one obtained from the following:

(2) Single-skin to Single-skin
One-half the thickness of the thinner of the two laminates being joined.

(3) Sandwich to Sandwich
The greater of the mean thicknesses of the skins of the sandwich panels being attached.

(4) Sandwich to Single Skin
Either one-half the thickness of the single-skin laminate or the mean thickness of the skins of the sandwich panel being attached, whichever is less.
The thickness of each FRP-to-FRP boundary angle also is to be not less than obtained from the following equation:

$$t = 0.105L + 1.11 \quad \text{mm}$$

where:
L = length, as defined in 1.1.2 of this Part, need not be taken as more than 46.6 m m
The width of each flange, not including end taper, is to be not less than 10 times the thickness given above, including the end taper, 13 times the thickness given above, and in general not less than 50 mm.

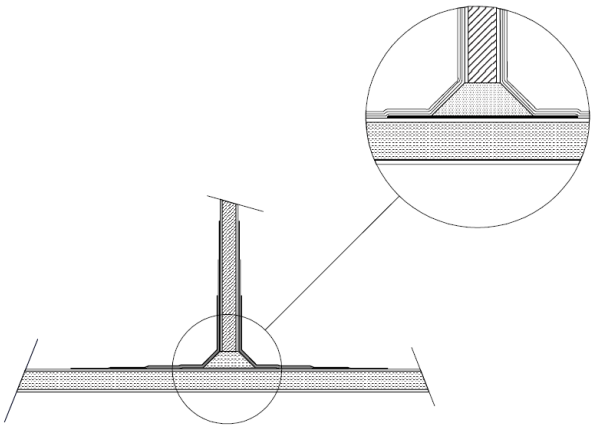


Fig. III 2-29
Boundary Angles for FRP Components

2.6.2 Welded and Mechanical Connections

(a) Steel and Aluminum

(i) General

Components may be fastened by either welding or rivets. For welding, see Part II, Chapter 2.

(ii) Expanding Rivets

Rivets of the expanding type (blind or "pop" rivets) may be used for lightly loaded connections where accessibility is unpracticable so as to prohibit the use of through fastenings. Such rivets are not to be used for joining components having a total thickness exceeding 12.5 mm, and are not to be used for joining decks to hulls except as temporary or unstressed fastenings installed for the sake of convenience or speed during assembly.

(iii) Conventional Rivets

Conventional rivets, where used, are to be subject to special consideration, and are to be of the cold-driven type. Washers, essentially of the same material as the rivets, are to be installed under both the heads and the points.

(b) Fiber Reinforced Plastic

(i) General

Components may be fastened with bolts, machine screws, or self-tapping screws. Where machine screws or self-tapping screws are used, they are not to have countersunk heads. Shanks of all threaded fastenings are to be long enough to pass through the joints, by at least one thread or plastic locking element. Excessive protrusion is to be avoided, and where the threaded end of the fastener is accessible, and the excess length can constitute a hazard, the excess length is to be removed. Washers are not to be used for the sole purpose of lessening thread protrusion. When it is necessary to reduce the length of thread protrusion, excess length is to be removed without damaging the threads and the bolts dressed to remove rough edges. Where watertight joints are required, suitable sealants or bedding compounds are to be used in addition to the fastenings. All threaded fasteners are to be stainless steel. Sizes and specifications are to be indicated on the submitted plans. The diameter of a fastening is not to be less than the thickness of the thinner component being fastened, with a minimum diameter of 8 mm. Where hardware is predrilled for fastener sizes that are less than specified above, the size of the fastener used is to match the size of the predrilled holes.

(ii) Bolts and Machine Screws

Bolts or machine screws are to be used where accessibility permits. The diameter of each fastener is to be at least equal to the thickness of the thinner component being fastened. Bolts and machine screws

less than 8 mm in diameter are not to be used. Where d is the fastener diameter, fastener centers are to be spaced at a minimum of 3d apart and are to be set in from edges of laminates a minimum of 3d.

Generally in fiber reinforced plastic construction, all bolted connections are to be made through solid fiber reinforced plastic inserts. Where this is not possible, all low density core material is to be replaced with a structurally effective insert. Diameters of fastening holes are not to exceed fastening diameters by more than 0.5 mm for bolts less than or equal to 18 mm in diameter and 1 mm for bolts greater than 18 mm in diameter. Elongated and oversize holes are permitted where necessary for adjustment or alignment.

Washers or backing plates are to be installed under all fastening heads and nuts that otherwise would bear on laminates. Washers are to measure not less than 2.25d in outside diameter and 0.1d in thickness. Nuts are to be either of the self-locking type, or other effective means to be provided to prevent backing off. Mechanical thread locking devices and methods such as lockwashers, either spring, tooth, or tab type, peening wiring, or thread upset after assembly are not to be used.

Bolted connections are, in general, to be bonded along all mating surfaces to insure the tightness of the structure using an accepted structural adhesive, and applied in accordance with the manufacturer's requirements.

In general, all structural, bolted connections are to use threads of bolts in accordance with the requirements in the following Table:

Location	Pitch(1)
Watertight connections below design waterline	10d
Connections in hull above design waterline to deck	15d
Hull to deck connections, bonded with approved structural adhesive	15d
Connections in deckhouses	20d
Deckhouse to deck connection, bonded with approved structural adhesive	15d
Minimum distance between reeled lines of bolts	3d

Notes:

(1) d is the diameter of the bolt.

(2) Internal boundary sealing angle is to be provided for all locations.

All structural, single line, bolted connections without adhesive bonding are to be in accordance with the requirements in the following Table:

Location	Pitch(1)
Manhole covers to fuel tanks	6d
Manhole covers to water tanks	8d
Covers to void tanks/cofferdams	10d
Bolted access hatches in decks	10d
Bolted watertight door frames	8d
Window frames	8d

Notes:

(1) d is the diameter of the bolt.

Bolt holes are to be drilled, without undue pressure at breakthrough, having a diametric tolerance of two percent of the bolt diameter. Where bolted connections are to be made watertight, the hole is to be sealed with resin and allowed to cure before the bolt is inserted. In areas of high stress or where unusual bolting configurations, on the basis of equivalence with the above requirements, are proposed, testing may be required.

(iii) Self-tapping Screws

In general, no self-tapping screws are to be used in fiber reinforced plastic construction. Self-tapping screws having straight shanks may be used for non-structural connections where accessibility is

unpracticable so as to prohibit the use of through fastenings. Where used, self-tapping screws are to have coarse threads.

(c) Backing Bars and Tapping Plates

The requirements for backing plates and bars will be individually considered, on the basis of the loading imposed, details of which are to be indicated on the submitted plans. Metal plates and bars are to be suitably protected against corrosion. Tapping plates may be encapsulated within the laminate, laminated to or bolted to the structure. Tapping plate edges or corners are to be suitably rounded.

2.6.3 FRP Deck-to-Hull Joints

(a) Weather Joints

The connection is to develop the strength of the deck and shell laminate, whichever is stronger, by either a bolted or bonded connection.

Where flanges are used, the hull flanges are to be equal in thickness and strength to the hull laminates and the deck flanges are to be equal in strength and thickness to the deck laminates. Where bolts are used to develop the required strength of the connection, the faying surfaces are to be set in bedding compound, polyester putty, or other approved material. Minimum widths of overlaps, minimum bolt diameters, and maximum bolt spacing are to be in accordance with Table III 2-17 of this Chapter. Intermediate values may be obtained by interpolation.

FRP bonding angles, where used, are to have flanges of the same strength and of at least one-half the thickness of single skin hull or deck laminate. On sandwich laminates, they are to have the same strength and thickness as the skin of a sandwich laminate, based on the thicker of the two laminates being connected. The widths of the flanges are to be in accordance with the widths of overlaps in Table III 2-17 of this Chapter.

Calculations supporting the geometry of the deck-to-hull joint are to be submitted for craft over 61 m in length.

Each joint is to be protected by a guard, molding, fender, or rail cap of metal, wood, rubber, plastic, or other approved material. The size and ruggedness of this protective strip are to be consistent with the severity of the service for which the craft is intended. The strip is to be installed in such a manner that it may be removed for repair or replacement without endangering the integrity of the deck-to-hull joint.

(b) Interior Joints

Interior decks are to be connected to the hull by shelves, stringers, or other structural members on both sides by FRP tapes. The connection is to effectively develop the strength of the interior deck. The fit-up between the parts are typically not to exceed 5 mm. The interior deck is to be bedded in syntactic foam or filled resin during assembly and prior to tabbing.

Table III 2-17
Deck-to-Hull Joints

Length of Craft L, m	Minimum Width of Overlap, mm	Minimum Bolt Diameter, mm	Bolt Spacing, mm
9	63.5	6.50	155
12	75.0	7.75	165
15	87.5	9.00	180
18	100.0	10.25	190
21	112.5	11.50	205
24	125.0	12.75	215
27	137.5	14.00	230
30	150.0	15.25	240
33	162.5	16.50	255
36	175.0	17.75	265
39	187.5	19.00	280
42	200.0	20.25	295
45	212.5	21.50	310
48	225.0	22.75	325
51	237.5	23.00	340
54	250.0	24.25	355
57	262.5	25.50	370
60	275.0	26.75	385

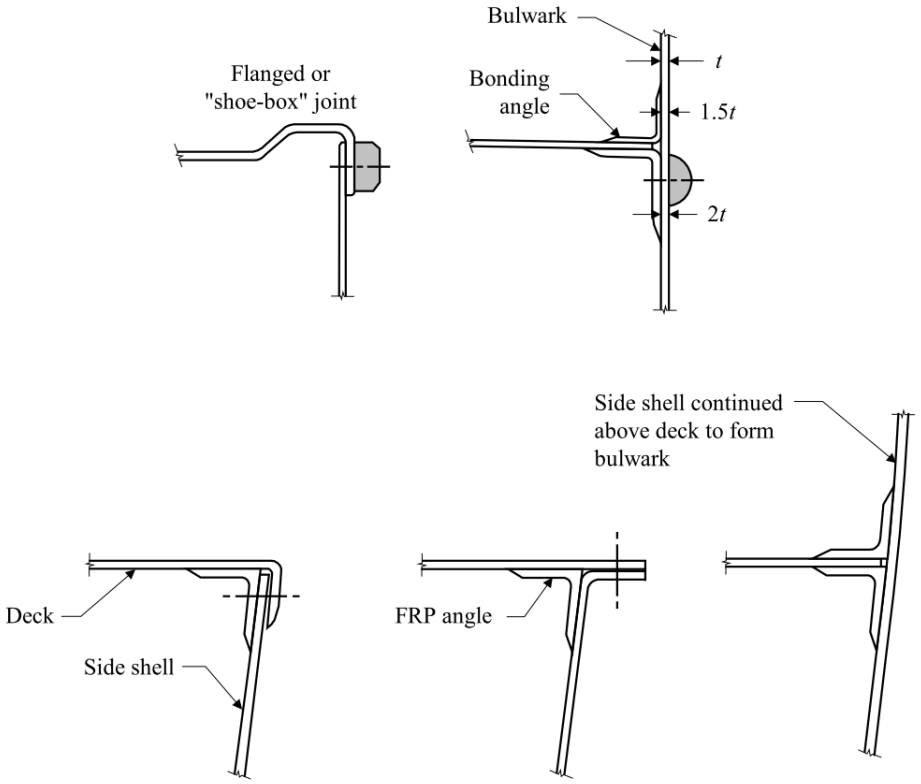


Fig. III 2-30
Examples of Deck-to-Hull Weather Joints

2.6.4 Shell Details

(a) Keels

Plate keels are to be not less than shown in Fig. III 2-31 and Fig. III 2-32, and vertical keels or skegs are to be not less than shown in Fig. III 2-33. Keels or skegs are to be adequate for docking loads, which are to be provided by the designer.

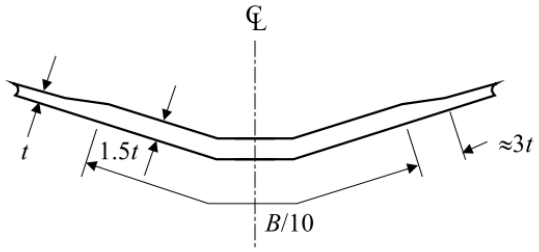


Fig. III 2-31
Plate Keel in One-piece Hull

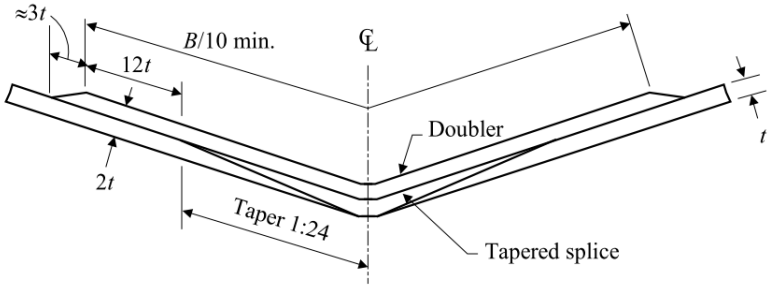


Fig. III 2-32
Plate Keel in Hull Molded in Halves

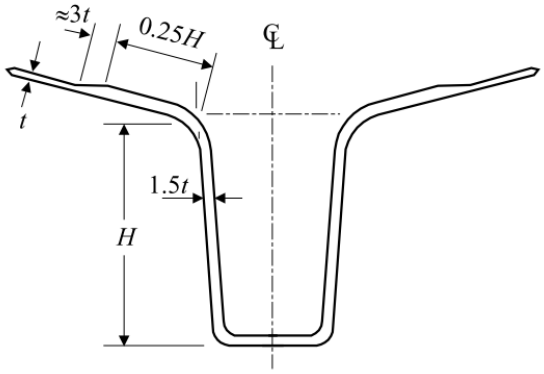


Fig. III 2-33
Vertical Keel or Skeg

(b) Chines and Transoms

Chines and transoms are to be not less than shown in Fig. III 2-34 through Fig. III 2-37.

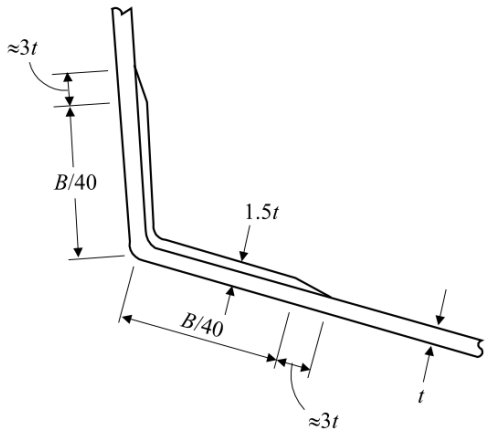


Fig. III 2-34
Chine or Transom – Single Skin Construction

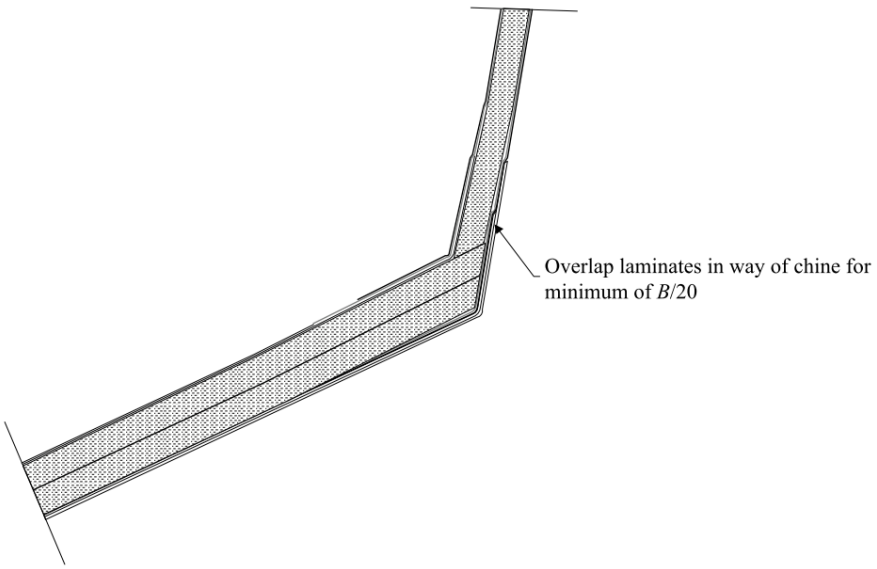


Fig. III 2-35
Chine or Transom – Sandwich Construction

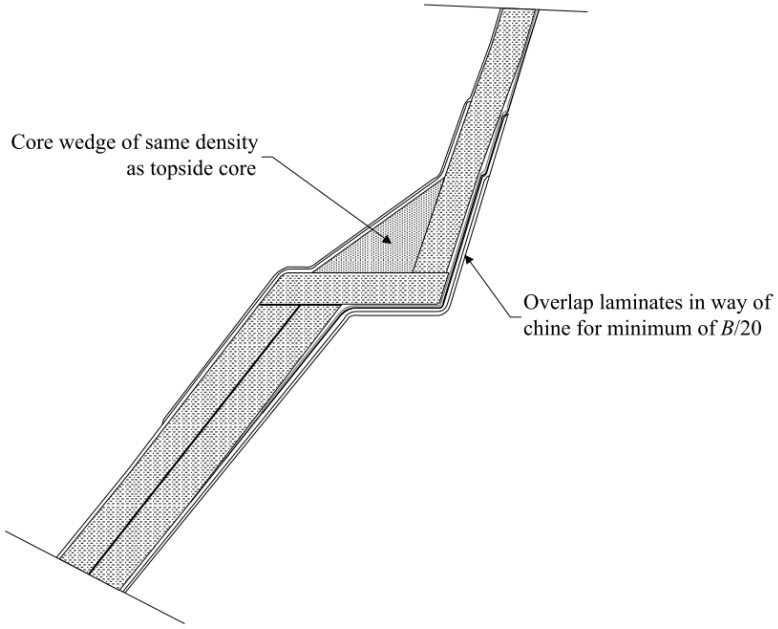


Fig. III 2-36
Stepped Chine – Foam Wedge Option

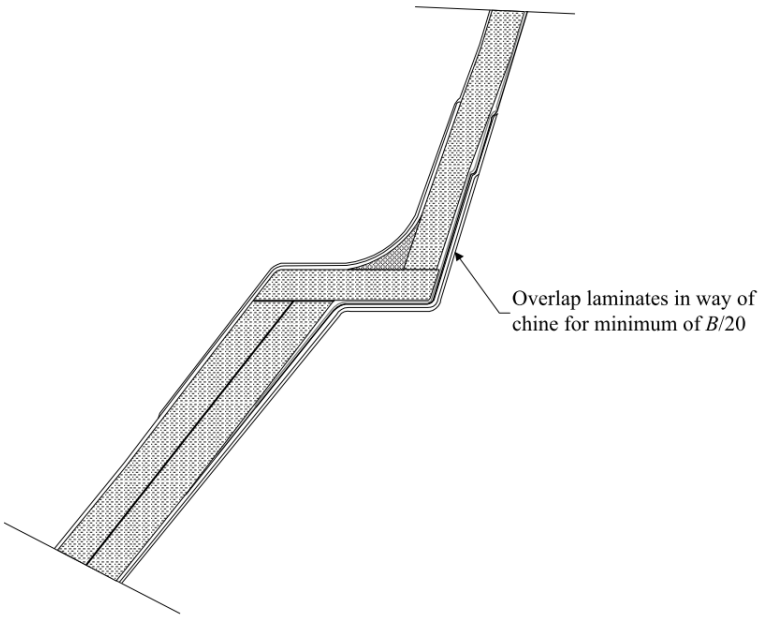


Fig. III 2-37
Stepped Chine – Putty Radius

2.7 Keels, Stems, Shaft Struts, and Propeller Nozzles

2.7.1 Materials

(a) Ordinary Strength Steels

The requirements in the following subsections are based upon ordinary strength steel. For higher strength steels and aluminum alloys, see 2.7.1(b) of this Chapter.

(b) High Strength Steels and Aluminum Alloys

Unless otherwise specified, the required section modulus and moment of inertia for high strength steels and aluminum alloys are as follows:

$$SM = SM_s Q$$

$$I = I_s E_s / E_o$$

where:

SM, I	=	required section modulus and inertia. Unless specifically stated otherwise, the properties about the minor axis (axis perpendicular to h or w) are to be used.	
SM_s, I_s	=	section modulus and inertia obtained from the dimensions given for ordinary strength steel.	
Q	=	as defined in 2.1.1(a)(i) of this Chapter	
E_s	=	2.06×10^5	N/mm^2
E_o	=	modulus of the material being considered	N/mm^2

Use of materials other than steel or aluminum will be specially considered.

(c) Fiber Reinforced Plastic

For fiber reinforced plastic hulls, keels and skegs are to have proportions as indicated in Fig. III 2-30 to 2-32 of this Chapter.

2.7.2 Keels

(a) Bar Keels

Where bar keels are fitted the thickness and depth is not to be less than that obtained from the following equations:

$$t = 0.625L + 12.5 \quad \text{mm}$$

$$h = 1.46L + 100 \quad \text{mm}$$

where:

t	=	thickness	mm
h	=	depth	mm
L	=	length of craft, as defined in 1.1.2 of this Part	m

Thicknesses and depths other than given above are acceptable provided the section moduli and moments of inertia about the transverse horizontal axis are not less than given above.

(b) Plate Keels

The thickness of the steel plate keel throughout the length of the craft is to be not less than the bottom shell required in 2.3 of this Chapter.

2.7.3 Stems

(a) Bar Stems

Where bar stems are fitted the thickness and width is not to be less than obtained from the following equations:

$$t = 0.625L + 6.35 \quad \text{mm}$$

$$w = 1.25L + 90 \quad \text{mm}$$

Where:

t	=	thickness	mm
w	=	width	mm
L	=	length of craft, as defined in 1.1.2 of this Part	m

This thickness and width is to be maintained between the keel and design load waterline. Above the designed load waterline they may be gradually reduced until the area at the head is 70% of that obtained from the equations.

Thicknesses and widths other than given above are acceptable provided the section moduli and moments of inertia about the longitudinal axis are not less than given above. The thickness of the bar stem in general should also not be less than twice the shell thickness.

(b) Plate Stems

Where plate stems are used, they are not to be less in thickness than the bottom shell plating required in 2.3.1 and 2.3.2 of this Chapter, where s is the frame spacing, or 610 mm (24 in.) if greater. Plate stems are to be suitably stiffened.

2.7.4 Stern Frames

Craft that are fitted with stern frames, shoe pieces, rudder horns, and rudder gudgeons are to meet the applicable requirements in Part II, Chapter 2 of the Rules for Steel Ships.

2.7.5 Shaft Struts

(a) General

Tail-shaft (propeller-shaft) struts where provided may be of the V or I type. The following equations are for solid struts having streamline cross-sectional shapes. For struts other than ordinary strength steel see above 2.7.1(b). For hollow section and non-streamlined struts, the equivalent cross sectional area, moment of inertia, and section modulus (major axis) are to be maintained. For a streamlined cross-section strut, the moment of inertia about the longitudinal axis is $wt^3/25$ and the section modulus about the same axis is $wt^2/12.5$. Generally each leg of a "V" strut are to have similar cross section. Alternative methods for the determination of "V" strut requirements can be found in Appendix 3 of this Part.

(b) V Strut

(i) Width

The width of each strut arm is not to be less than obtained from the following equation:

$$w = 2.27D$$

where:

w	=	width of strut (major axis)	mm

D = required diameter of ASTM A668, Class B tail shaft (see Part IV, 2.6) mm

(ii) Thickness

The thickness of the strut is not to be less than obtained from the following equation:

$$t = 0.365D$$

where:

t = thickness of strut (minor axis) mm
D = required diameter of ASTM A668, Class B tail shaft mm

Where the included angle is less than 45 degrees, the foregoing scantlings are to be specially considered.

(c) I Strut

(i) Width

The width of the strut arm is not to be less than obtained from the following equation:

$$w_1 = 3.22D$$

where

w_1 = width of strut (major axis) mm
D = diameter of tail shaft mm

(ii) Thickness

The thickness of the strut is not to be less than obtained from the following equation:

$$t_1 = 0.515D$$

where:

t = thickness of strut (minor axis) mm
D = diameter of tail shaft mm

(d) Strut Length

The length of the longer leg of a V strut or the leg of an I strut, measured from the outside perimeter of the strut barrel or boss to the outside of the shell plating, is not to exceed 10.6 times the diameter of the tail shaft. Where this length is exceeded, the width and thickness of the strut are to be increased, and the strut design will be given special consideration. Where strut length is less than 10.6 times required tailshaft diameter, the section modulus of the strut may be reduced in proportion to the reduced length, provided the section modulus is not less than 0.85 times Rule required section modulus.

(e) Strut Barrel

The thickness of the strut barrel or boss is to be at least one-fifth the diameter of the tail shaft. The length of the strut barrel or boss is to be adequate to accommodate the required length of propeller-end bearings. Strut barrels constructed of aluminum are not subject to the corrections required by 2.7.1(b) of this Chapter.

2.7.6 Skegs and Other Hull Appendages

Craft fitted with skegs and other permanent hull appendages are to comply with the following:

(a) The anticipated operational loadings under all craft operations (docking loads, hydrodynamic forces, and etc., as applicable) are to be submitted for CR review.

(b) All skegs and other permanent hull appendages are to be attached to the shell plate by means of double continuous fillet welds in accordance with 2.5.3 of Part II using a weld factor C = 0.5 DC. Appendage structure is to be aligned or reinforced with internal hull structural members.

(c) Thickness of shell plating in way of an appendage is to be increased in accordance with 2.3.1(a) of this Chapter.

(d) Where a closing plate prohibits the inspection of a void space or joint that is integral to the shell plating, access ports and drain plugs are to be provided in way of this space.

(e) In the case of large continuous skegs or other similar hull appendages, direct analysis may be requested by CR in order to validate stress interaction effects with the hull girder.

(f) Where the appendages designed to shear off in the event of impact, calculations for the appendage are to be submitted and subject to special consideration.

2.7.7 Propeller Nozzles

(a) Application

The requirements in this subsection are applicable for propeller nozzles with inner diameter d of 5 meters or less. Nozzles of larger inner diameter are subject to special consideration with all supporting documents and calculations submitted for review.

(b) Design Pressure

The design pressure of the nozzle is to be obtained from the following:

$$p_d = 10^{-6} \cdot c \cdot \varepsilon \cdot \left(\frac{N}{A_P}\right) \qquad \text{N/mm}^2$$

where:

c	=	coefficient as indicated in Table III 2-18 of this Chapter	
ε	=	coefficient as indicated in Table III 2-19 of this Chapter, but not to be taken less than 10	
N	=	maximum shaft power	kW
A_P	=	propeller disc area	
	=	$D^2 \frac{\pi}{4}$	m^2
D	=	propeller diameter	m

Table III 2-18
Coefficient c

Propeller Zone (see Fig. III 2-38 of this Chapter)	c
	p_d in N/mm^2
2	10.0
1 & 3	5.0
4	3.5

Table III 2-19
Coefficient ε

	p_d in N/mm^2
ε	$21 - 2 \times 10^{-2}\left(\frac{N}{A_p}\right)$

(c) Nozzle Cylinder

(i) Shell Plate Thickness

The thickness of the nozzle shell plating, in mm, is not to be less than:

$t = t_o + t_c$, but not to be taken less than 7.5 mm

where:

t_o = thickness obtained from the following formula:
$0.158 \cdot S_P \cdot \sqrt{p_d} K_n$ mm
S_P = spacing of ring webs mm
P_d = nozzle design pressure N/mm^2
t_c = corrosion allowance determined by Table III 2-20 of this Chapter
K_n = nozzle material factor as defined in 2.8.1(b) of this Chapter

Table III 2-20
Corrosion Allowance t_c

Value of t_o	t_c mm
If $t_o \leq 10.0$	1.5
If $t_o > 10.0$	the lesser of b_1, b_2
where $b_1 = 3.0$ mm $b_2 = \left(\frac{t_o}{\sqrt{1/K_n}} + 5\right) \times 10^{-1}$ mm	

(ii) Internal Diaphragm Thickness

Thickness of nozzle internal ring web is not to be less than the required nozzle shell plating for Zone 3.

(d) Nozzle Section Modulus

The minimum requirement for nozzle section modulus is obtained from the following formula:

$SM = d^2 b V_d^2 Q n$ cm^3

where

d = nozzle inner diameter m
b = nozzle length m
V_d = design speed in ahead condition, as defined in 2.8.2(a) of this Chapter knots
Q = reduction factor conditional on material type
= 1.0 for ordinary strength steel
= 0.78 for H32 strength steel
= 0.72 for H36 strength steel
= 0.68 for H40 strength steel
Q factor for steel having yield strength other than above is to be specially considered
n = nozzle type coefficient taken equal to 0.7 for fixed nozzles

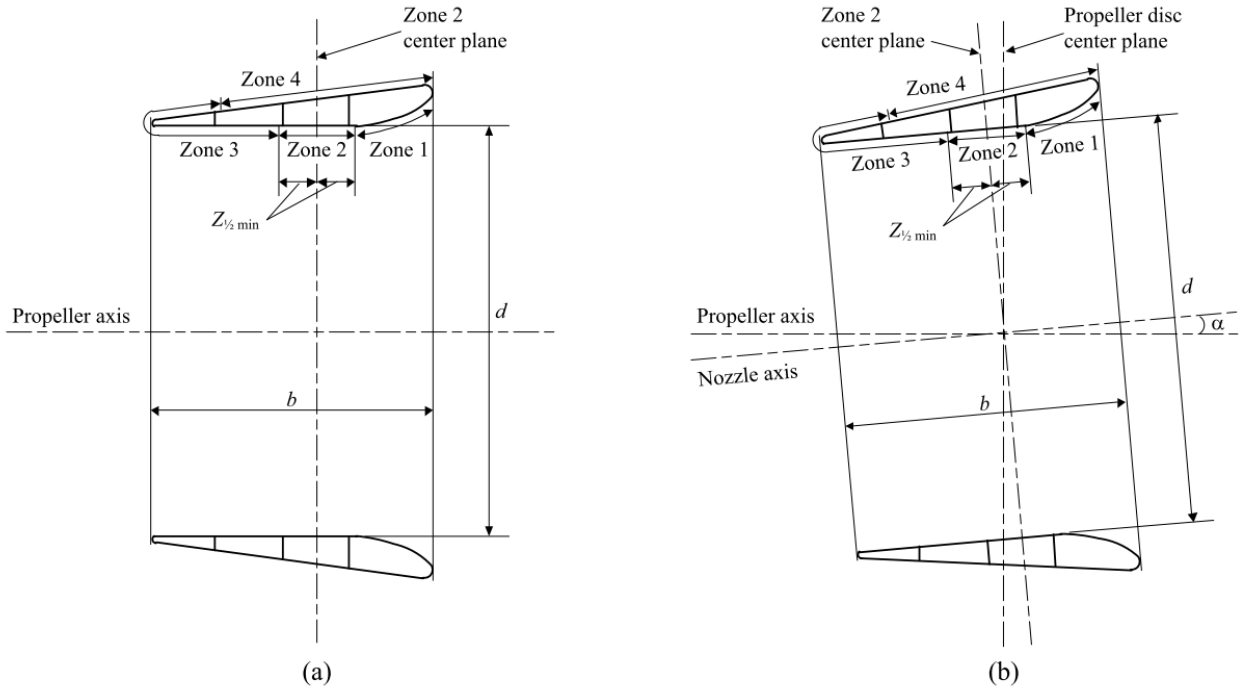


Fig. III 2-38
Propeller Nozzle Section View

b	=	nozzle length
d	=	nozzle inner diameter
Zone 1		zone of nozzle inner skin from nozzle leading edge to the fore end of Zone 2
Zone 2		zone of nozzle inner skin in way of propeller tips with two ring webs within the zone
$z_{1/2min}$	=	The minimum length on each side of Zone 2 center plane is to be:
	= $\frac{b}{8}$	where Zone 2 center plane and propeller disc center plane coincide as shown in Fig. III 2-38(a) of this Chapter;
	= $\frac{b}{8}cos\alpha + \frac{d}{2}tan\alpha$	where α is the tilt angle between the Zone 2 and propeller disc center planes, as shown in Fig. III 2-38(b) of this Chapter;
Zone 3		zone of nozzle inner and outer skin covering the tail vicinity, from aft end of Zones 2 to the aft end of Zone 4
Zone 2		zone of nozzle outer skin from the leading edge to the fore end of Zone 3

(e) Welding Requirement

The inner and outer nozzle shell plating is to be welded to the internal stiffening ring webs with double continuous welds as far as practicable. Plug/slot welding is prohibited for the inner shell, but may be accepted for the outer shell plating, provided that the nozzle ring web spacing is not greater than 350 mm.

2.7.8 Propulsion Improvement Devices (PID) as Hull Appendages

(a) Application Scope

The requirements in this Subsection are applicable for Propulsion Improvement Devices (PID) hull appendages including wake equalizing and flow separation alleviating devices (such as spoilers, wake equalizer, stern tunnels, pre-swirl fins, stators, and pre-swirl ducts) and post swirl devices (such as rudder thrust fins, post swirl stators, and rudder bulbs) that are permanently affixed to the hull structure.

(b) Plans and Documentation

The following plans, details and calculations are to be submitted for approval:

(i) Drawings and plans covering the detailed design of the structural components, including the end connections and attachment to the hull structure;

(ii) Information on material properties and welding details, such as scantlings of the welded connection and welding detail and size;

(iii) Calculations to validate the design of the PID and the supporting foundations interior to the craft. The calculations are to consider strength, fatigue and vibration in both the ahead and astern conditions.

(c) Design and Arrangement

The following requirements are to be complied with for the propulsion improvement devices as outlined in 2.7.8(a) of this Chapter. Devices of novel concept are to be specially considered with all the related drawings and documents submitted:

(i) The structural materials are to be compatible with the mechanical and chemical properties of the hull strake to which it is attached. Examples of such design considerations are to have adequate structural strength for load bearing/transferring and acceptable galvanic potential between materials to reduce the risk of galvanic corrosion.

(ii) PID end connections are to have a suitable transition for the particular application and to be effectively terminated in way of internal stiffening members.

(d) Structural End Connection

Welded end connections of device structural component to the hull are to be designed and constructed in accordance with the following:

(i) Welding at the connection is to be full penetration and is to be in accordance with Part XII of the Rules for Steel Ships and Part II, Chapter 2 of the Rules, as applicable.

(ii) Nondestructive volumetric and surface examinations are to be performed on the welds of the connection plates and the shell penetration. 100% Magnetic Testing (MT) and at least 10% Ultrasonic Testing (UT) is to be carried out on the welds of the connection plates and the shell penetration.

2.8 Rudders and Steering Equipment

2.8.1 General

(a) Application

Requirements specified in this Section are applicable to:

(i) Ordinary profile rudders described in Table III 2-21 of this Chapter with rudder operating angle range from –35° to +35°.

(ii) High-lift rudders described in Table III 2-22 of this Chapter, the rudder operating angle of which might be exceeding 35° on each side at maximum design speed.

(iii) Other steering equipment other than rudders identified in this Section.

Rudders not covered in Table III 2-21 nor Table III 2-22 of this Chapter are subject to special consideration, provided that all the required calculations are prepared and submitted for review in full compliance with the requirements in this Section. Where direct analyses adopted to justify an alternative design are to take into consideration all relevant modes of failure, on a case by case basis. These failure modes may include, amongst others: yielding, fatigue, buckling and fracture. Possible damages caused by cavitation are also to be considered. Validation by laboratory tests or full scale tests may be required for alternative design approaches.

Special consideration will be given to aluminum rudder stocks and fiber reinforced plastic rudders and rudder stocks. Material specifications are to be listed on the plans.

(b) Materials for Rudder, Rudder Stock and Steering Equipment

Rudder stocks, pintles, coupling bolts, keys and other steering equipment components described in this Section are to be made from material in accordance with the requirements of Part XI of the Rules for Steel Ships and Table III 1-2 of this Part, and particularly:

(i) The Surveyor need not witness material tests for coupling bolts and keys.

(ii) The surfaces of rudder stocks in way of exposed bearings are to be of noncorrosive material.

(iii) Material properties of dissimilar parts and components in direct contact with each other are to be submitted for review of compatibilities, such as galvanic potential.

(iv) Material factors of castings and forgings used for the shoe piece (K_g), horn (K_h), stock (K_s), bolts (K_b), coupling flange (K_f), pintles (K_p), and nozzles (K_n) are to be obtained for their respective material from the following equation:

$$K = (235/\sigma_F)^e$$

where

σ_F	=	yield strength of material used, but is not to be taken as greater than $0.7\sigma_T$ or 450, whichever is smaller	N/mm^2
σ_T	=	tensile strength of material used	N/mm^2
e	=	0.75 for $\sigma_F > 235$	N/mm^2
e	=	1.0 for $\sigma_F \leq 235$	N/mm^2

For craft intended to operate in the various seastates exceeding the design significant wave heights , σ_F may be specially considered.

(c) Expected Torque

The torque considered necessary to operate the rudder in accordance with Part IV, 2.4.4(c) is to be indicated on the submitted rudder or steering gear plan. See Part IV, 2.4.2 and 2.8.3(d) of this Chapter.

Note that this expected torque is not the design torque for rudder scantlings.

(d) Rudder Stops

Strong and effective structural rudder stops are to be fitted. Where adequate positive mechanical stops are provided within the steering gear in accordance with Part IV, 2.4.5(a), structural stops will not be required.

2.8.2 Rudder Design Force

Rudder force, C_R, upon which rudder scantlings are to be based, is to be obtained from equation described either in 2.8.2(a) or 2.8.2(b) of this Chapter as applicable. Where for the ordinary rudders the rudder angle, ϕ, exceeds 35°, the rudder force, C_R, is to be increased by a factor of 1.74 sin (ϕ).

(a) Rudder Blades without Cutouts

Where the rudder profile can be defined by a single quadrilateral, the rudder force is to be obtained from the following equation.

$$C_R = 0.132 k_R k_c k_l A V_R^2 \quad \text{kN}$$

where

k_R	=	$(b^2/A_t + 2)/3$ but not taken more than 1.33	
b	=	mean height of rudder area, as determined from Table III 2-21 of this Chapter	m
A_t	=	sum of rudder blade area, A, and the area of rudder post or rudder horn within the extension of rudder profile	m^2
A	=	total projected area of rudder as illustrated in Table III 2-21 of this Chapter	m^2

For steering nozzles, A is not to be taken less than 1.35 times the projected area of the nozzle.

k_c = coefficient depending on rudder cross section (profile type) as indicated in Table III 2-21 and 2-23 of this Chapter. For profile types differing from those in Table III 2-21 and 2-23 of this Chapter, k_c is subject to special consideration.

k_l = coefficient as specified in Table III 2-23 of this Chapter

V_R = craft speed knots

= for ahead condition V_R equals V_d or V_{min}, whichever is greater

= for astern condition V_R equals V_a or $0.5V_d$, or $0.5V_{min}$, whichever is greater

V_d = design speed with the craft running ahead at the maximum continuous rated shaft rpm and at the summer load waterline knots

V_a = maximum astern speed knots

V_{min} = $(V_d+20)/3$

Where there are any appendages such as rudder bulb fitted on the rudder, its effective areas are to be included in the area of the rudder blade if significant.

(b) Rudder Blades with Cutouts

This paragraph applies to rudders with cutouts (semi-spade rudders), such that the whole blade area cannot be adequately defined by a single quadrilateral. See Fig. III 2-40 of this Chapter. Equations derived in this paragraph are based on a cutout blade with two quadrilaterals. Where more quadrilaterals are needed to define the rudder shape, similar rules apply.

The total rudder force described in 2.8.2(a) of this Chapter is applicable for rudders with cutout(s), with A being the summation of sub-quadrilaterals that make up the whole area of the rudder blade. Rudder force distribution over each quadrilateral is to be obtained from the following equations:

$$C_{R1} = C_R A_1/A \quad \text{kN}$$

$$C_{R2} = C_R A_2/A \quad \text{kN}$$

where

C_R and A are as defined in 2.8.2(a) of this Chapter

A_1 and A_2 are as described in Fig. III 2-40 of this Chapter

(c) Rudders Blades with Twisted Leading-Edge

This kind of rudder has the leading edge twisted horizontally on the top and bottom of the section that is an extension of the center of the propeller shaft. For the purpose of calculating design force, twisted rudders may be distinguished in four categories:

Category	Description
1	The projected leading edge of twisted upper and lower blades not lineup to each other
2	The projected leading edge of twisted upper and lower blades form a straight line
3	Rudder with twisted leading edge combined with tail edge flap or fins
4	The twisted leading edge has a smooth continuous wavy contour (no deflector) or the rudder has multiple section profile types

Design force for rudder with twisted leading edge is obtained according to the following criteria:

(i) For Category 1 rudders as indicated in the above table, design force over upper and lower rudder blades are obtained from the following equations respectively:

$C_{R1} = 0.132k_R k_c k_l A_1 V_R^2$ kN for twisted upper rudder blade;

$C_{R2} = 0.132k_R k_c k_l A_2 V_R^2$ kN for twisted lower rudder blade;

$C_R = C_{R1} + C_{R2}$ kN overall design force;

(ii) For Categories 2, 3, and 4, rudder design force indicated in 2.8.2(a) of this Chapter is applicable, that is:

$C_R = 0.132k_R k_c k_l A V_R^2$ kN

where

k_R, k_c, k_l, A, and V_R are as defined in 2.8.2(a) of this Chapter, (for rudder has multiple section profile types, A is the whole projected areas).

A_1 and A_2 are the projected areas of upper and lower blades separated at the deflector cross section, respectively. Where the effective projected area of rudder bulb (if present) forward of rudder leading edge is significant and needs to be counted, the proportioned bulb effective areas are added to A_1 and A_2 accordingly.

Values of k_c for ahead and astern conditions are determined from one of the methods below as applicable, if the type of basic rudder profile is not provided:

(1) k_c is taken from Table III 2-21 of this Chapter for twisted rudders of Categories 1 & 2;

(2) k_c is taken from Table III 2-22 of this Chapter for twisted rudders of Category 3;

(3) k_c is subjected to special considerations for twisted rudders of Category 4;

(4) Shipyard/rudder manufacturers' submitted k_c obtained from testing data or calculations may be accepted subject to the Society's review of all the supporting documents;

Table III 2-21
Coefficient k_c for Ordinary Rudders

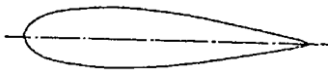
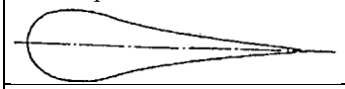
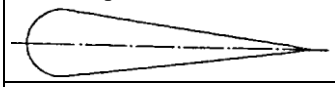
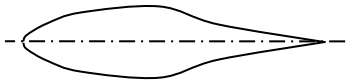
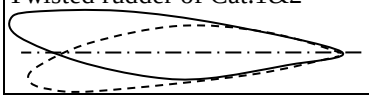
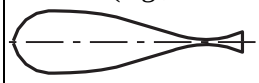
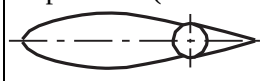
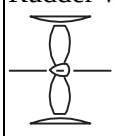
Profile type	k_c	
	Ahead condition	Astern condition
Single plate 	1.0	1.0
NACA-00 Göttingen profile 	1.1	0.80
Hollow profile 	1.35	0.90
Flat side profile 	1.1	0.90
Mixed (e.g., HSVA) 	1.21	0.90
Twisted rudder of Cat.1&2 	1.21 (if not provided)	0.90 (if not provided)

Table III 2-22
Factor of k_c for High-Lift/Performance Rudders

Profile type	k_c	
	Ahead condition	Astern condition
Fish tail (e.g., Schilling high-lift rudder) 	1.4	0.8
Flap rudder (or Twisted rudder of Cat. 3) 	1.7	1.3
Rudder with steering nozzle 	1.9	1.5

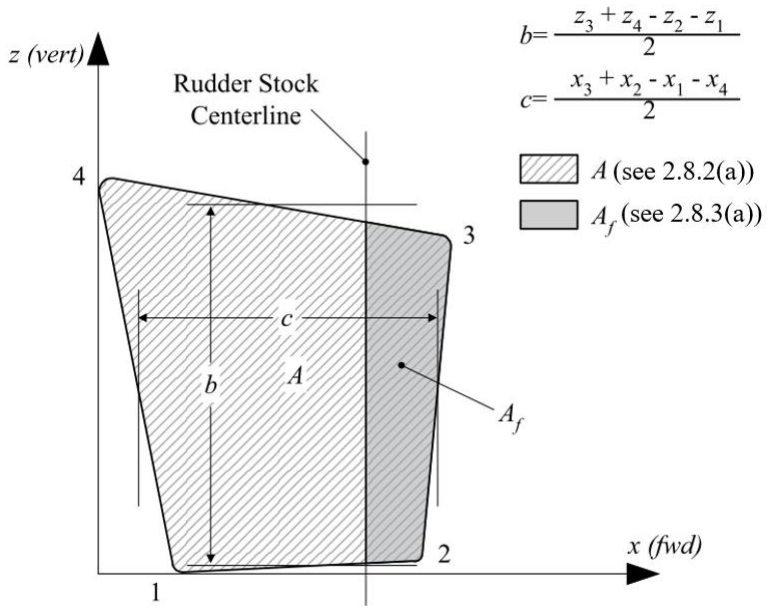


Fig. III 2-39
Rudder Blade without Cutout

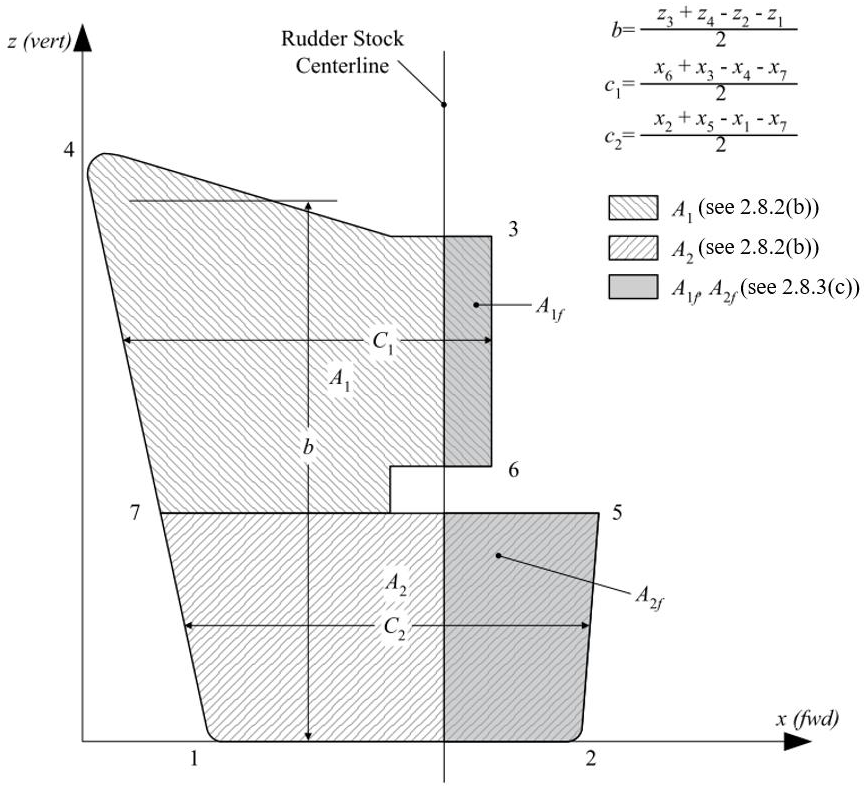


Fig. III 2-40
Rudder Blade without Cutout

2.8.3 Rudder Design Torque

(a) General

The rudder design torque, Q_R, for rudder scantling calculations is to be in accordance with 2.8.3(b) or 2.8.3(c) of this Chapter as applicable.

(b) Rudder Blades without Cutouts

Rudder torque, Q_R, is to be determined from the following equation for both ahead and astern conditions.

$$Q_R = C_R r \quad \text{kN-m}$$

where

C_R = rudder force as calculated in 2.8.2(a) of this Chapter kN

r = c(α− k) (but not less than 0.1c for ahead condition) m

c = mean breadth of rudder area, as shown in Fig. III 2-39 of this Chapter m

α = coefficient as indicated in Table III 2-24 of this Chapter

k = A_f/A

A_f = area of rudder blade situated forward of the centerline of the rudder stock, as shown in Fig. III 2-39 of this Chapter m^2

A = whole rudder area as described in 2.8.2(a) of this Chapter m^2

Where there are any appendages such as rudder bulb fitted on the rudder, effective areas are to be included in the area of the rudder blade if significant.

Table III 2-23
Coefficient k_l

Rudder/Propeller Layout	k_l
Rudders outside propeller jet	0.8
Rudders behind a fixed propeller nozzle	1.15
All others	1.0

Table III 2-24
Coefficient α

Rudder Position or High-lift	α		
	Ahead Condition	Astern Condition	
Located behind a fixed structure, such as a rudder horn	0.25	0.55	
Located where no fixed structure forward of it	0.33	0.75 (hollow profile)	0.66 (non-hollow)
High-Lift Rudders (see Table III 2-22 of this Chapter)	Special consideration (0.40 if unknown)	Special consideration	

(c) Rudders Blades with Cutouts

This paragraph refers to rudder blades with cutouts (semi-spade rudders) as defined in 2.8.2(b) of this Chapter. Equations derived in this paragraph are based on a cutout blade with two quadrilaterals. Where more quadrilaterals are needed to define the rudder shape, similar rules apply.

Rudder torque, Q_R, in ahead and astern conditions is to be obtained from the following equation:

$$Q_R = C_{R1} r_1 + C_{R2} r_2 \quad \text{kN-m}$$

but not to be taken less than Q_{Rmin} in the ahead condition

where

Q_{Rmin} = $0.1C_R(A_1c_1+A_2c_2)/A$

r_1 = $c_1(\alpha - k_1)$ m

r_2 = $c_2(\alpha - k_2)$ m

c_1, c_2 = mean breadth of partial area A_1, A_2 from Fig. III 2-40 of this Chapter m

α = coefficient as indicated in Table III 2-24 of this Chapter

k_1, k_2 = A_{1f}/A_1, A_{2f}/A_2 where A_{1f}, A_{2f} = area of rudder blade situated forward of the centerline of the rudder stock for each part of the rudder, as shown in Fig. III 2-40 of this Chapter

C_R, C_{R1}, C_{R2}, A_1, A_2 are as defined in 2.8.2(b) of this Chapter

(d) Rudders with Twisted Leading Edge

In general, rudder torque, Q_R, indicated in 2.8.3(b) of this Chapter is applicable for rudders with twisted leading edge, where C_R is obtained from 2.8.2(c) of this Chapter.

(e) Trial Conditions

The above equations for Q_R are intended for the design of rudders and should not be directly compared with the torques expected during the trial (see 2.8.1(c) of this Chapter) or the rated torque of steering gear (see Part IV, 2.4.4(c)).

2.8.4 Rudder Stocks

(a) Upper Rudder Stocks

The upper rudder stock is that part of the rudder stock above the neck bearing or above the top pintle, as applicable.

$$S = 42\sqrt[3]{Q_R K_s} \quad \text{mm}$$

where

Q_R = rudder torque, as defined in 2.8.3 of this Chapter kN-m

K_s = material factor for upper rudder stock, as defined in 2.8.1(b) of this Chapter

(b) Lower Rudder Stocks

In determining lower rudder stock scantlings, values of rudder design force and torque calculated in 2.8.2 and 2.8.3 of this Chapter are to be used. Bending moments, shear forces, as well as the reaction forces are to be determined from 2.8.4(d) and 2.8.7(d) of this Chapter, and are to be submitted for review. For rudders supported by shoe pieces or rudder horns, these structures are to be included in the calculation model to account for support of the rudder body. Guidance for calculation of these values is given in Appendix 1 of this Part.

The lower rudder stock diameter is not to be less than obtained from the following equation:

$$S_l = S\sqrt[6]{1 + \left(\frac{4}{3}\right)\left(\frac{M}{Q_R}\right)^2} \quad \text{mm}$$

where

S	=	upper stock required diameter from 2.8.4(a) of this Chapter	mm
S_l	=	lower stock required diameter	
M	=	bending moment at the section of the rudder stock considered	kN-m
Q_R	=	rudder torque from 2.8.3 of this Chapter	kN-m

Above the neck bearing a gradual transition is to be provided where there is a change in the diameter of the rudder stock.

The equivalent stress of bending and torsion, σ_c to be assessed from the aforementioned direct calculation in the transition is not to exceed 118/K, N/mm^2.

$$\sigma_c = \sqrt{\sigma_b^2 + 3\tau^2} \qquad \text{N/mm}^2$$

where

K	=	material factor for upper rudder stock, as defined in 2.8.1(b) of this Chapter
σ_b	=	$10.2\times10^6 M/S_l^3$
τ	=	$5.1\times10^6 Q_R/S_l^3$

(c) Rudder Trunk and Rudder Stock Sealing

(i) In rudder trunks which are open to the sea, a seal or stuffing box is to be fitted above the deepest load waterline, to prevent water from entering the steering gear compartment and the lubricant from being washed away from the rudder carrier.

(ii) Where the top of the rudder trunk is below the deepest waterline two separate stuffing boxes are to be provided.

(iii) Materials. The steel used for the rudder trunk is to be of weldable quality, with a carbon content not exceeding 0.23% on ladle analysis and a carbon equivalent (Ceq) not exceeding 0.41. Plating materials for rudder trunks are in general not to be of lower grades than corresponding to class II as defined in Table III 1-1 of this Chapter. Rudder trunks comprising of materials other than steel are to be specially considered.

(iv) Scantlings. Where the rudder stock is arranged in a trunk in such a way that the trunk is stressed by forces due to rudder action, the scantlings of the trunk are to be such that the equivalent stress due to bending and shear does not exceed $0.35\sigma_F$, and the bending stress on welded rudder trunk is to be in compliance with the following formula:

$$\sigma \le 80/k \qquad \text{N/mm}^2$$

where

σ	=	bending stress in the rudder trunk	
k	=	K as defined in 2.8.1(b) of this Chapter	for castings
	=	1.0	for ordinary strength hull steel plate
	=	Q as defined in 2.1.1(a)(i) of this Chapter	for higher strength steel plate
		k is not to be taken less than 0.7	
σ_F	=	specified minimum yield strength of the material used	N/mm^2

For calculation of bending stress, the span to be considered is the distance between the mid-height of the lower rudder stock bearing and the point where the trunk is clamped into the shell or the bottom of the skeg.

(v) Welding at the Connection to the Hull. The weld at the connection between the rudder trunk and the shell or the bottom of the skeg is to be full penetration and fillet shoulder is to be applied in way of the weld. The fillet shoulder radius r, in mm (in.) (see Fig. III 2-41 of this Chapter) is to be as large as practicable and to comply with the following:

r	=	60 mm	when $\sigma \ge 40/k$
	=	$0.1S_l$, without being less than 30 mm	when $\sigma < 40/k$

where

S_l = rudder stock diameter axis defined in 2.8.4(b) of this Chapter

σ = bending stress in the rudder trunk N/mm^2

k = material factor as defined in 2.8.4(c)(iv) of this Chapter

The radius may be obtained by grinding. If disk grinding is carried out, score marks are to be avoided in the direction of the weld. The radius is to be checked with a template for accuracy. Four profiles at least are to be checked. A report is to be submitted to the Surveyor.

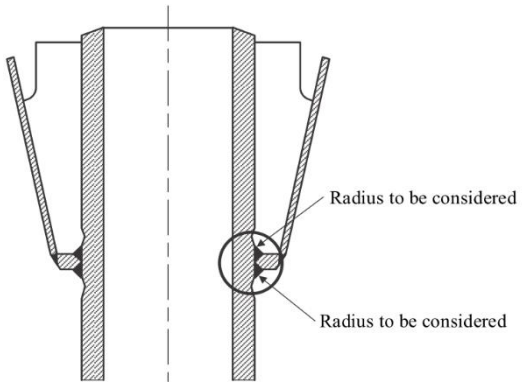


Fig. III 2-41
Fillet Shoulder Radius

(d) Bending Moments

The bending moment on the rudder and rudder stock may be determined in accordance with Appendix 1 of this Part or in accordance with the following equations:

(i) Spade Rudders

$$M_n = C_R l_n \quad \text{kN-m}$$

$$M_s = C_R \frac{A_1}{A} l_c \quad \text{kN-m}$$

where

M_n = bending moment at neck bearing

M_s = bending moment at section under consideration

l_n = distance from center of neck bearing to the centroid of rudder area m

l_c = distance from section under consideration to the centroid of rudder area, A_1 m

A_1 = area below section under consideration m^2

C_R and A are defined in 2.8.2 of this Chapter.

(ii) Balanced Rudders with Shoepiece Support

The bending moment at the neck bearing may be taken as indicated below. Bending moments at other locations are to be determined by direct calculation and are to be submitted. See Appendix 1 of this Part for guidance in calculating bending moments.

$$M_n = NC_R l_b \quad \text{kN-m}$$

where

M_n = bending moment at neck bearing

l_b = distance between center of neck bearing and center of shoepiece pintle bearing m

$$N = \left[\frac{0.5 + \frac{\alpha_1}{8}}{1 + \alpha_1(1 + \frac{l_u}{l_b}\frac{I_b}{I_u})}\right]$$

$$\alpha_1 = \frac{l_b^3}{l_s^3}\frac{I_d}{I_b}$$

I_d = mean moment of inertia of shoepiece about the vertical axis cm^4

l_s = distance between center of shoepiece pintle bearing and the effective support point of the shoepiece in the hull m

I_b = mean moment of inertia of the rudder, considering a width of rudder plating twice the athwartship dimension of the rudder and excluding welded or bolted cover plates for access to pintles, inc. cm^4

l_u distance between center of the neck bearing and the center of the rudder carrier bearing m

I_u = mean moment of inertia of rudder stock, between neck bearing and rudder carrier bearing cm^4

C_R is as defined in 2.8.2 of this Chapter.

2.8.5 Flange Couplings

(a) General

Rudder flange couplings are to comply with the following requirements:

(i) Couplings are to be supported by an ample body of metal worked out from the rudder stock.

(ii) The smallest distance from the edge of the bolt holes to the edge of the flange is not to be less than two-thirds of the bolt diameter.

(iii) Coupling bolts are to be fitted bolts.

(iv) Suitable means are to be provided for locking the nuts in place.

In addition to the above, rudder flange couplings are to meet the type-specific requirements in 2.8.5(b) of this Chapter (horizontal couplings) or 2.8.5(c) of this Chapter (vertical couplings) as applicable.

(b) Horizontal Couplings

(i) Coupling Bolts

There are to be at least six coupling bolts in horizontal couplings, and the diameter, d_b, of each bolt is not to be less than obtained by the following equation:

$$d_b = 0.62\sqrt{d_s^3 K_b/(nrK_s)} \quad \text{mm}$$

where

d_s = required rudder stock diameter, S (2.8.4(a)) or S_1 (2.8.4(b)) of this Chapter as applicable, in way of the coupling

n = total number of bolts in the horizontal coupling

r = mean distance, in mm, of the bolt axes from the center of the bolt system

K_b = material factor for bolts, as defined in 2.8.1(b) of this Chapter

K_s = material factor for stock, as defined in 2.8.1(b) of this Chapter

(ii) Coupling Flange

Coupling flange thickness is not to be less than the greater of the following equations:

$$t_f = d_{bt}\sqrt{K_f/(K_b)} \quad \text{mm}$$

$$t_f = 0.9 d_{bt} \quad \text{mm}$$

where

d_{bt} = calculated bolt diameter as per 2.8.5(b)(i) of this Chapter based on a number of bolts not exceeding 8

K_f = material factor for bolts, as defined in 2.8.1(b) of this Chapter

K_b = material factor for bolts, as defined in 2.8.1(b) of this Chapter

(iii) Joint between Rudder Stock and Coupling Flange

The welded joint between the rudder stock and the flange is to be made in accordance with Fig. III 2-42 of this Chapter or equivalent.

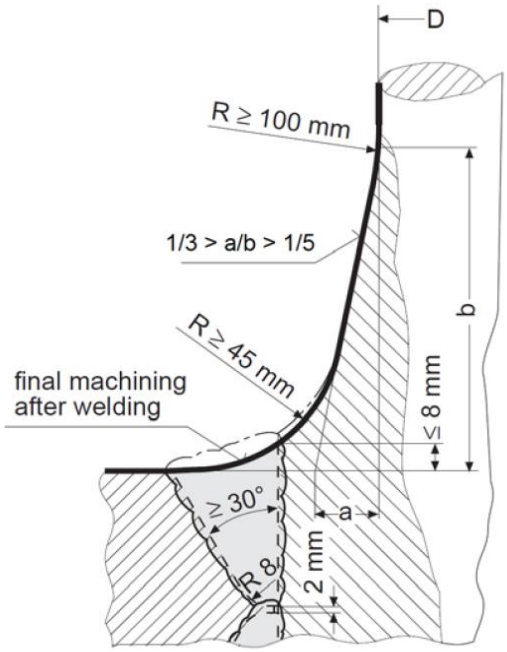


Fig. III 2-42
Welded Joint between Rudder Stock and Coupling Flange

(c) Vertical Couplings

(i) Coupling Bolts

There are to be at least eight coupling bolts in vertical couplings, and the diameter, d_b, of each bolt is not to be less than obtained by the following equation:

$$d_b = 0.81 d_s \sqrt{K_b/(nK_s)} \quad \text{mm}$$

where

n = total number of bolts in the vertical coupling, which is not to be less than 8

d_s, K_b, K_s are as defined in 2.8.5(b) of this Chapter.

In addition, the first moment of area, m, of the bolts about the center of the coupling is not to be less than given by the following equation:

$$m = 0.00043 d_s^3 \quad \text{mm}^3$$

where

d_s = diameter as defined in 2.8.5(b) of this Chapter

(ii) Coupling Flange

Coupling flange thickness,t_f, is not to be less than d_b, as defined in 2.8.5(c)(i) of this Chapter.

(iii) Joint between Rudder Stock and Coupling Flange

The welded joint between the rudder stock and the flange is to be made in accordance with Fig. III 2-42 of this Chapter or equivalent.

2.8.6 Tapered Stock Couplings

(a) Coupling Taper

Tapered stock couplings are to comply with the following general requirements in addition to type-specific requirements given in 2.8.6(b) or 2.8.6(c) of this Chapter as applicable:

(i) Tapered stocks, as shown in Fig. III 2-43 of this Chapter, are to be effectively secured to the rudder casting by a nut on the end.

(ii) The cone shapes are to fit exactly.

(iii) Taper length (l) in the casting is generally not to be less than 1.5 times the stock diameter (d_o) as shown in Fig. III 2-43 of this Chapter.

(iv) The taper on diameter (c) is to be 1/12 to 1/8 for keyed taper couplings and 1/20 to 1/12 for couplings with hydraulic mounting/dismounting arrangements, as shown in the following table.

(v) Where mounting with an oil injection and hydraulic nut, the push-up oil pressure and the push-up length are to be specially considered upon submission of calculations.

(vi) Means of effective sealing are to be provided against sea water ingress.

Type of Coupling Assembly	$c = \frac{d_o - d_u}{l}$
Without hydraulic mounting/dismounting	$1/12 \le c \le 1/8$
With hydraulic mounting/dismounting	$1/20 \le c \le 1/12$

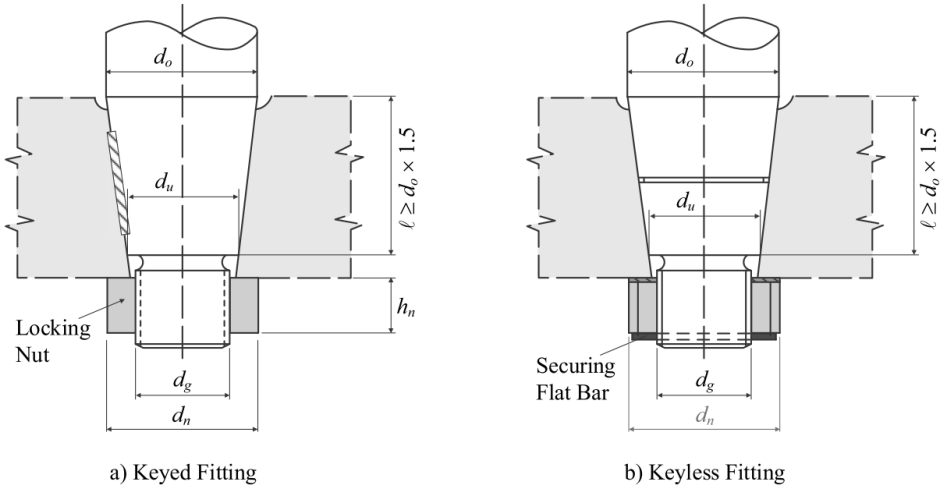


Fig. III 2-43
Tapered Couplings

(b) Keyed Fitting

Where the stock, it is to be fitted in accordance with the following:

(i) The top of the keyway is to be located well below the top of the rudder.

(ii) Torsional strength of the key equivalent to that of the required upper stock is to be provided.

(iii) For the couplings between stock and rudder the shear area* of the key is not to be less than:

$$a_s = \frac{17.55 Q_F}{d_k \sigma_{F1}} \qquad \text{cm}^2$$

where

Q_F = design yield moment of rudder stock N-m
= $0.02664\ d_t^3/K$

*Note: The effective area is to be the gross area reduced by any area removed by saw cuts, set screw holes, chamfer, etc., and is to exclude the portion of the key in way of spooning of the key way.

Where the actual diameter d_{ta} is greater than the calculated diameter d_t , the diameter d_{ta} is to be used. However, d_{ta} applied to the above formula need not be taken greater than $1.145\ d_t$.

d_t = stock diameter, in mm, according to 2.8.4(a) of this Chapter

K = material factor for stock as given in 2.8.1(b) of this Chapter

d_k = mean diameter of the conical part of the rudder stock, in mm, at the key

σ_{F1} = minimum yield stress of the key material, in N/mm^2

The effective surface area, in cm^2, of the key (without rounded edges) between key and rudder stock or cone coupling is not to be less than:

$$a_k = \frac{5 Q_F}{d_k \sigma_{F2}} \qquad \text{cm}^2$$

where:

σ_{F2} = minimum yield stress of the key, stock or coupling material, whichever is less. N/mm^2

(iv) In general, the key material is to be at least of equal strength to the keyway material. For keys of higher strength materials, shear and bearing areas of keys and keyways may be based on the respective material properties of the keys and the keyways, provided that compatibilities in mechanical properties of both components are fully considered. In no case, is the bearing stress of the key on the keyway to exceed 90% of the specified minimum yield strength of the keyway material.

(v) Push up. It is to be proved that 50% of the design yield moment is solely transmitted by friction in the cone couplings. This can be done by calculating the required push-up pressure and push-up length according to 2.8.6(c)(v) and 2.8.6(c)(vi) of this Chapter for a torsional moment $Q'_F = 0.5Q_F$.

Notwithstanding the requirements in 2.8.6(c)(iii) and 2.8.6(c)(v) of this Chapter, where a key is fitted to the coupling between stock and rudder and it is considered that the entire rudder torque is transmitted by the key at the couplings.

(c) Keyless Fitting

Hydraulic and shrink fit keyless couplings are to be fitted in accordance with the following:

(i) Detailed preloading stress calculations and fitting instructions are to be submitted;

(ii) Preload stress is not to exceed 70% of the minimum yield strength of either the stock or the bore;

(iii) Prior to applying hydraulic pressure, at least 75% of theoretical contact area of rudder stock and rudder bore is to be achieved in an evenly distributed manner;

(iv) The upper edge of the upper main piece bore is to have a slight radius;

(v) Push-up Pressure. The push-up pressure is not to be less than the greater of the two following values:

$$p_{req1} = \frac{2 Q_F}{d_m^2 l \pi \mu_o} 10^3 \qquad \text{N/mm}^2$$

$$p_{req2} = \frac{6 M_b}{l^2 d_m} 10^3 \qquad \text{N/mm}^2$$

where

Q_F = design yield moment of rudder stock,as defined in 2.8.6(b)(iii) of this Chapter N-m

d_m = mean cone diameter mm
l = cone length mm
μ_0 = frictional coefficient, equal to 0.15
M_b = bending moment in the cone coupling (e.g. in case of spade rudders) N-m

It has to be proved by the designer that the push-up pressure does not exceed the permissible surface pressure in the cone. The permissible surface pressure is to be determined by the following formula:

$$p_{perm} = \frac{0.8R_{eH}(1-\alpha^2)}{\sqrt{3+\alpha^4}} \quad \text{N/mm}^2$$

where:

R_{eH} = minimum yield stress of the material of the gudgeon N/mm^2
α = d_m / d_a
d_m = mean cone diameter mm
d_a = outer diameter of the gudgeon to be not less than 1.5 d_m mm

(vi) Push-up Length. The push-up length Δl, in mm, Δl is to comply with the following formula:

$$\Delta l_1 \leq \Delta l \leq \Delta l_2$$

where

$$\Delta l_1 = \frac{p_{req} d_m}{E\left(\frac{1-\alpha^2}{2}\right)c} + \frac{0.8R_{tm}}{c} \quad \text{mm}$$

$$\Delta l_2 = \frac{1.6R_{eH}d_m}{Ec\sqrt{3+\alpha^4}} + \frac{0.8R_{tm}}{c} \quad \text{mm}$$

R_{tm} = mean roughness, taken equal to 0.01 mm
c = taper on diameter according to 2.8.6(a)(iv)
R_{eH} = minimum yield stress of the material of the gudgeon N/mm^2
E = Young's modulus of the material of the gudgeon N/mm^2

R_{eh}, α, and d_m are as defined in 2.8.6(c)(v).

Notwithstanding the above, the push up length is not to be less than 2 mm.

Note: In case of hydraulic pressure connections the required push-up force P_e for the cone may be determined by the following formula:

$$P_e = p_{req} d_m \pi l \left(\frac{c}{2} + 0.02\right) \quad \text{N}$$

The value 0.02 is a reference for the friction coefficient using oil pressure. It varies and depends on the mechanical treatment and roughness of the details to be fixed. Where due to the fitting procedure a partial push-up effect caused by the rudder weight is given, this may be taken into account when fixing the required push-up length, subject to approval by the Society.

(vii) Couplings with Special Arrangements for Mounting and Dismounting the Couplings. Where the stock diameter exceeds 200 mm, the press fit is recommended to be effected by a hydraulic pressure connection. In such cases the cone is to be more slender, c ≈1:12 to ≈1:20. In case of hydraulic pressure connections the nut is to be effectively secured against the rudder stock or the pintle. For the safe transmission of the torsional moment by the coupling between rudder stock and rudder body the push-up pressure and the push-up length are to be determined according to 2.8.6(c)(v) and 2.8.6(c)(vi) of this Chapter, respectively.

(viii) The locking nut is to be fitted in accordance with 2.8.6(d) of this Chapter.

(d) Locking Nut

Dimensions of the securing nut, as shown in Fig. III 2-43 of this Chapter, are to be proportioned in accordance with the following and the nut is to be fitted with an effective locking device.

Height	$h_n \geq 0.6\ d_g$
Outer diameter of nut	$d_n \geq 1.2\ d_u$ or $1.5d_g$, whichever is greater
External thread diameter	$d_g \geq 0.65\ d_o$

In the case of a hydraulic pressure secured nut, a securing device such as a securing flat bar is to be provided. Calculations proving the effectiveness of the securing device are to be submitted.

2.8.7 Pintles

(a) General

Pintles are to have a conical attachment to the gudgeons with a taper on diameter of:

1/12 to 1/8 for keyed and other manually assembled pintles with locking nut.

1/20 to 1/12 for pintle mounted with oil injection and hydraulic nut.

(b) Diameter

$$d_p = 11.1\sqrt{BK_p} \qquad \text{mm}$$

where

B = bearing force, in N, from 2.8.7(d) of this Chapter but not to be taken less than B_{min} as specified in Table III 2-25 of this Chapter — kN

K_p = material factor for the pintle, as defined in 2.8.1(b) of this Chapter

For rudders on horns with two pintles, as shown in Fig. III 2-40 of this Chapter, calculations are to include pintle bearing forces with the craft running ahead at the maximum continuous rated shaft rpm and at the lightest operating draft.

Threads and nuts are to be in accordance with 2.8.6(d) of this Chapter.

The pintle and pintle boss are to comply with the following requirements:

(i) The depth of the pintle boss is not to be less than the pintle diameter, d_p.

(ii) The bearing length of the pintle is to be between 1.0 and 1.2 times the pintle diameter, where d_p is measured on the outside of the liner.

(iii) The bearing pressure is to be in accordance with 2.8.8(a) of this Chapter.

(iv) The thickness of the pintle housing is not to be less than 25% of the pintle diameter.

Table III 2-25
Minimum Bearing Force B_{min}

Pintle Type		B_{min}
Conventional two pintle rudder		$0.5C_R$
Fig. III A1-4 of this Part	lower pintle	$0.5C_R$
Fig. III A1-4 of this Part	main pintle	$C_R l_a/l_p$*
Fig. III A1-3 of this Part	main pintle	$C_R l_a/l_p$*
	upper pintle	$0.25C_R$

* $B_{min} = C_R$ where $l_a/l_p \geq 1$

l_a/l_p as described in Fig. III 2-44 of this Chapter

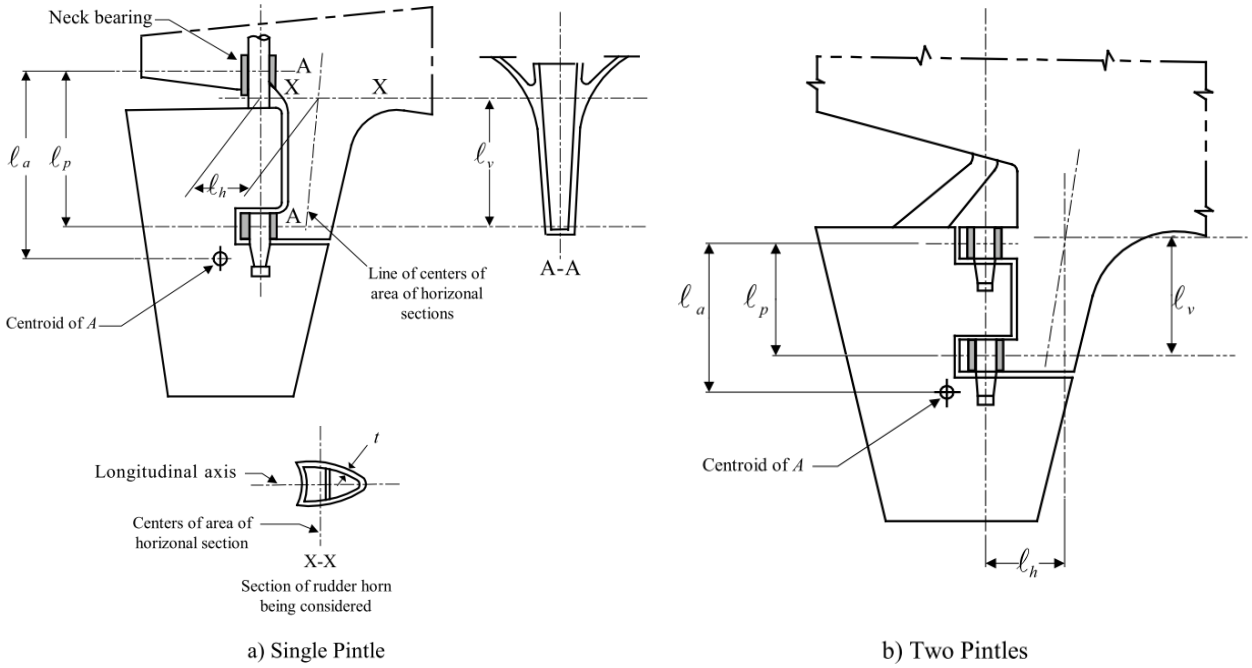


Fig. III 2-44
Rudder Horn

(c) Push-up Pressure and Push-up Length

The required push-up pressure preq for pintle bearings, in N/mm², is to be determined by the following formula:

$$p_{req} = 0.4\frac{B_1 d_o}{d_m^2 l} \qquad \text{N/mm}^2$$

where:

B_1	=	supporting force in the pintle bearing	N
d_0	=	actual pintle diameter excluding the liner	mm
d_m	=	mean cone diameter	mm
l	=	cone length	mm

The push up length is to be calculated similarly as in 2.8.6(c)(vi) of this Chapter, using required push-up pressure and properties for the pintle bearing.

(d) Shear and Bearing Forces

The shear and bearing forces may be determined in accordance with Appendix 1 of this Part, or by the equations given below.

(i) Spade Rudder

Bearing force at rudder carrier: $P_u = \frac{M_n}{l_u}$ kN

Bearing force at neck bearing: $P_n = C_R + P_u$ kN

Shear force at neck bearing: $F_n = C_R$ kN

where C_R is as defined in 2.8.3 and M_n, l_u are as defined in 2.8.4(d) of this Chapter.

(ii) Balanced Rudder with Shoepiece Support

Bearing force at rudder carrier: $P_u = \frac{M_n}{l_u}$ kN

Bearing force at neck bearing: $P_n = P_u\left(1 + \frac{l_u}{l_b}\right) + \frac{C_R}{l_b}\left(\frac{l_R}{2} + l_p\right)$ kN

where

l_b = distance between the center of neck bearing support and the center of shoepiece support, as shown in Fig. III A1-2 of this Part

= $l_p + l_r + l_l$

l_p = distance between bottom of rudder blade and center of support of neck bearing

l_l = distance between top of rudder blade and center of support of neck bearing

Bearing force at shoepiece: $P_p = C_R + P_u - P_n$ kN

Shear force at neck bearing: $F_n = P_n - P_u$ kN

where C_R is as defined in 2.8.2 of this Chapter.

2.8.8 Supporting and Anti-Lifting Arrangements

(a) Bearings

(i) Bearing Surfaces

Bearing surfaces for rudder stocks, shafts and pintles are to meet the following requirements:

(1) The length/diameter ratio (l_b/d_l) of the of bearing surface is not to be greater than 1.2*

(2) The projected area of the bearing surface ($A_b=d_l\, l_b$) is not to be less than A_{bmin},

where

d_l = outer diameter of the liner mm

l_b = bearing length mm

A_{bmin} = $1000\frac{P}{p_a}$ mm^2

P = bearing reaction force, as determined from Table III 2-26 of this Chapter kN

p_a = allowable surface pressure, as indicated in Table III 2-27 of this Chapter depending on bearing material N/mm^2

* Request for bearing arrangement of length/diameter ratio greater than 1.2 is subject to special consideration provided that calculations are submitted to show acceptable clearance at both ends of the bearing.

(ii) Bearing Clearance

(1) The clearance for metal bearings is not to be less than $d_i/1000+1.0$ mm on the diameter, where d_i is the inner diameter of the bushing, in mm.

(2) The clearance for non-metallic bearings is to be specially determined considering the material's swelling and thermal expansion properties. This clearance in general is not to be taken less than 1.5 mm on diameter*.

* Request of clearance less than 1.5 mm for non-metallic bearings is subject to special considerations provided that documented evidence, such as manufacturer's recommendation on acceptable clearance, expansion allowance and satisfactory service history with reduced clearances, are submitted for review.

For spade rudders with a rudder stock diameter of 400 mm or less, the clearances on the diameter are not to be less than given below:

Stock Diameter, mm	Metallic Bushing, mm	Synthetic Bushing(1), mm
400	1.15	1.15+E(2)
300	0.85	0.85+E
200	0.78	0.78+E
100	0.75	0.75+E

Notes:

(1) The bushing manufacturer's recommended running clearance may be used as an alternative to these clearances.

(2) E = expansion allowance provided by bushing manufacturer, mm.

(iii) Bearing Pressure

Bearing pressure is to be accordance with Table III 2-27 of this Chapter.

(iv) Bearing Material

Where stainless steel or wear-resistant steel is used for liners or bearings, the material properties including chemical composition of both components are to be submitted for review for an approved combination.

(v) Liners and Bushes

(1) Rudder Stock Bearings. Liners and bushes are to be fitted in way of bearings. The minimum thickness of liners and bushes is to be equal to:

t_{min} = 8 mm for metallic materials and synthetic material

t_{min} = 22 mm for lignum material

(2) Pintle Bearings

a) The thickness of any liner or bush is neither to be less than:

$$t = 0.01\sqrt{B} \quad \text{mm}$$

where

B = bearing force N

nor than the minimum thickness defined in 2.8.8(a)(v)(1) of this Chapter.

b) The bearing length L_P of the pintle is to be in accordance with 2.8.8(a)(i) of this Chapter.

Table III 2-26
Bearing Reaction Force

Bearing Type	P, Bearing Reaction Force, kN
Pintle bearings	P = B as defined in 2.8.7
Other bearings	Calculation of P is to be submitted. Guidelines for calculation can be found in Appendix 1 of this Part

Table III 2-27
Allowable Bearing Surface Pressure

Bearing Material	p_a, N/mm^2
lignum vitae	2.5
white metal, oil lubricated	4.5
synthetic material with hardness between 60 and 70 Shore D(1)	5.5(2)
steel (3) and bronze and hot-pressed bronze-graphite materials	7.0

Notes:

(1) Indentation hardness test at 23°C and with 50% moisture, according to a recognized standard. Synthetic bearing materials to be of approved type.

(2) Higher values than given in the table may be taken if they are verified by tests, but in no case more than 10 N/mm^2.

(3) Stainless and wear-resistant steel in an approved combination with stock liner.

(b) Rudder Carrier

(i) The weight of the rudder assembly is to be supported by a rudder carrier mounted on the hull structure designed for that purpose.

(ii) At least half of the rudder carrier's holding-down bolts are to be fitted bolts. Alternative means of preventing horizontal movement of the rudder carrier may be considered.

(iii) The bearing part is to be well lubricated by dripping oil, automatic grease feeding, or a similar method.

(iv) Hull structures in way of the rudder carrier are to be suitably strengthened.

(c) Anti Lifting Devices

Means are to be provided to prevent accidental unshipping or undue movement of the rudder which may cause damage to the steering gear. There are to be at least two bolts in the joint of the anti-lifting ring.

2.8.9 Double Plate Rudder

(a) Strength

The section modulus and web area of the rudder mainpiece are to be such that the stresses indicated in the following Subparagraphs are not exceeded.

In calculating the section modulus of the rudder, the effective width of side plating is to be taken as not greater than twice the athwartship dimension of the rudder. Bolted cover plates on access openings to pintles are not to be considered effective in determining the section modulus of the rudder. In order for a cover plate to be considered effective, it is to be closed using a full penetration weld and confirmed suitable by non-destructive testing method. Generous radii are to be provided at abrupt changes in section where there are stress concentrations, including in way of openings and cover plates. When inspection windows are located in the panel below the rudder hub, the stress is to be as permitted in way of cutouts.

Moments, shear forces and reaction forces are to be as given in 2.8.4(d) and 2.8.7(d) of this Chapter.

For spade rudders and rudders with horns, the section modulus at the bottom of the rudder is not to be less than one-third the required section modulus of the rudder at the top of the rudder or at the center of the lowest pintle.

Special attention is to be paid in design and construction of rudders with slender foil sections in the vicinity of their trailing edge (e.g., hollow foil sections, fishtail foil sections). Where the width of the rudder blade at the aftermost vertical diaphragm, w, is equal or less than 1/6 of the trailing edge length measured between the diaphragm and the trailing edge, *l*, finite element vibration analysis of the rudder blade is also to be submitted for review. See Fig. III 2-45 of this Chapter.

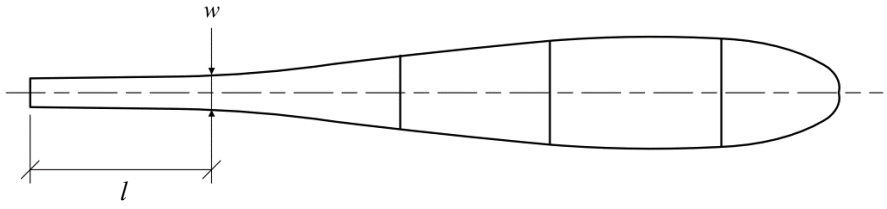


Fig. III 2-45

Spade rudders with an embedded rudder trunk are to have a trailing edge with dimensions that satisfy the following requirements:

- For a rudder trailing edge having a monotonous transition to a rounded end with a finite thickness or diameter (see Fig. III 2-46 of this Chapter), the vortex shedding frequency calculated using the equation given below is to be higher than 35 Hz.

$$f_s = \frac{S_1 U}{\beta_D D + \beta_T T}$$

where

f_s	=	vortex shedding frequency	Hz
U	=	flow velocity, which is taken as craft's design speed with craft running ahead at the maximum continuous rated shaft rpm and at the summer load waterline	m/s
S_t	=	nominal Strouhal number	
	=	0.18	
β_D	=	0.27	
C	=	minimal chord length of rudder cross section profile	m
D	=	nominal boundary layer thickness at trailing edge	
	=	0.01C	
β_T	=	0.77	
T	=	thickness or diameter of rounded end	

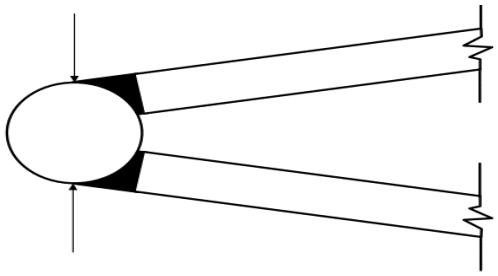


Fig. III 2-46
Thickness or Diameter of Rounded End

- For a rudder trailing edge with a flat insert plate (see Fig. III 2-47 of this Chapter), the insert plate thickness, t_0, is to be no larger than $1.5V_d$ in mm, where V_d is the design speed in ahead condition, in knots, as defined in 2.8.2(a) of this Chapter. The extension beyond the weld to rudder plate, *l*, is to satisfy the following Fig. III 2-47 of this Chapter and with consideration of possible local vibratory bending of the insert plate.

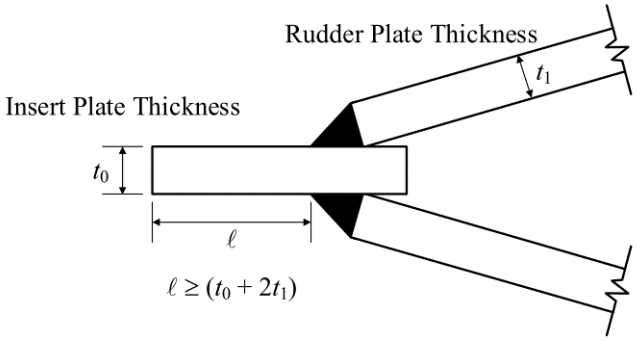


Fig. III 2-47

Alternatively, a vibration analysis is to be carried out to confirm that the natural frequency of the rudder is to be at least ±20% away from the vortex shedding frequency preferably determined using either a detailed

numerical analysis method such as CFD or testing for ballast and full draft at 85% and 100% V_d as defined in 2.8.2(a) of this Chapter.

(i) Clear of Cut-outs

Bending stress	$\sigma_b = 110/Q$	N/mm^2
Shear stress	$\tau = 50/Q$	N/mm^2
Equivalent stress	$\sigma_e = \sqrt{\sigma_b^2 + 3\tau^2} = 120/Q$	N/mm^2

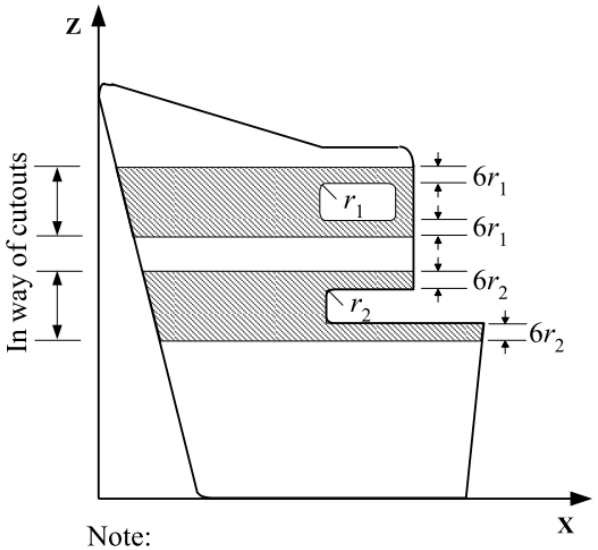
Q = as defined in 2.1.1(a)(i) of this Chapter

(ii) In way of Cut-outs

Allowable stresses for determning the rudder strength in way of cutouts (see Fig. III 2-48 of this Chapter) are as follows:

Bending stress	$\sigma_b = 75/Q$	N/mm^2
Shear stress	$\tau = 50/Q$	N/mm^2
Equivalent stress	$\sigma_e = \sqrt{\sigma_b^2 + 3\tau^2} = 100/Q$	N/mm^2

Q = as defined in 2.1.1(a)(i) of this Chapter



Note:
r_1 = corner radius of rudder plate in way of portable bolted inspection hole
r_2 = corner radius of rudder plate

Fig. III 2-48

The mainpiece of the rudder is to be formed by the rudder side plating (but not more than the effective width indicated above) and vertical diaphragms extending the length of the rudder or the extension of the rudder stock or a combination of both.

(b) Side, Top and Bottom Plating

The plating thickness is not to be less than obtained from the following equation:

$$t = 0.0055s\beta\sqrt{d + (\frac{0.1C_R}{A}) \times \sqrt{Q}} + 2.5 \qquad \text{mm}$$

where

d	=	summer loadline draft of the craft	m
C_R	=	rudder force according to 2.8.2 of this Chapter	kN
A	=	rudder area	m^2
s	=	smaller unsupported dimension of plating	mm
b	=	greater unsupported dimension of plating	mm
β	=	$\sqrt{1.1 - 0.5(s/b)^2}$; maximum 1.0 for b/s ≥ 2.5	
Q	=	material factor for rudder plating, as defined in 2.1.1(a)(i) of this Chapter	mm

The thickness of the rudder side or bottom plating is to be at least 2 mm greater than that required by 2.3.1(b) of this Chapter with p obtained from 2.2.5(a) of this Chapter, for which h is measured from the lower edge of the plate to the design load waterline in displacement mode.

The rudder side plating in way of the solid part is to be of increased thickness per 2.8.9(d) of this Chapter.

(c) Diaphragm Plates

Vertical and horizontal diaphragms are to be fitted within the rudder, effectively attached to each other and to the side plating. Vertical diaphragms are to be spaced approximately 1.5 times the spacing of horizontal diaphragms. Openings are in general not to be more than 0.5 times the depth of the web.

The thickness of diaphragm plates is not to be less than 70% of the required rudder side plate thickness or 8 mm, whichever is greater. Openings in diaphragms are to have generous radii and the effects of openings are to be considered in the strength assessment as required in 2.8.9(a) of this Chapter.

The diaphragm plating in way of the solid part is to be of increased thickness for vertical and horizontal diaphragm plates per 2.8.9(d) of this Chapter.

(d) Connections of Rudder Blade Structure with Solid Parts

Solid parts in forged or cast steel, which house the rudder stock or the pintle, are normally to be provided with protrusions.

These protrusions are not required when the diaphragm plate thickness is less than:

- 10 mm for diaphragm plates welded to the solid part on which the lower pintle of a semi-spade rudder is housed and for vertical diaphragm plates welded to the solid part of the rudder stock coupling of spade rudders.
- 20 mm for other diaphragm plates.

The solid parts are in general to be connected to the rudder structure by means of two horizontal diaphragm plates and two vertical diaphragm plates.

Minimum section modulus of the connection with the rudder stock housing.

The section modulus of the cross-section of the structure of the rudder blade formed by vertical diaphragm plates and rudder plating, which is connected with the solid part where the rudder stock is housed is to be not less than:

$$w_s = c_s S_l^3 \left(\frac{H_E - H_X}{H_E}\right)\frac{Q}{K_s}10^{-4} \qquad \text{cm}^3$$

where

c_s	=	coefficient, to be taken equal to:	
	=	1.0	if there is no opening in the rudder plating or if such openings are closed by a full penetration welded plate
	=	1.5	if there is an opening in the considered cross-section of the rudder

S_l = rudder stock diameter mm

H_E = vertical distance between the lower edge of the rudder blade and the upper edge of the solid part m

H_X = vertical distance between the considered cross-section and the upper edge of the solid part as indicated in Fig. III 2-49 of this Chapter m

Q = material factor for the rudder blade plating as given in 2.8.9(a) of this Chapter

K_s = material factor for the rudder stock as given in 2.8.1(b) of this Chapter

The actual section modulus of the cross-section of the structure of the rudder blade is to be calculated with respect to the symmetrical axis of the rudder.

The breadth of the rudder plating to be considered for the calculation of section modulus is to be not greater than:

$$b = s_v + 2H_X/3 \quad \text{m}$$

where

s_v = spacing between the two vertical diaphragm (see Fig. III 2-49 of this Chapter) m

Where openings for access to the rudder stock nut are not closed by a full penetration welded plate, they are to be deducted.

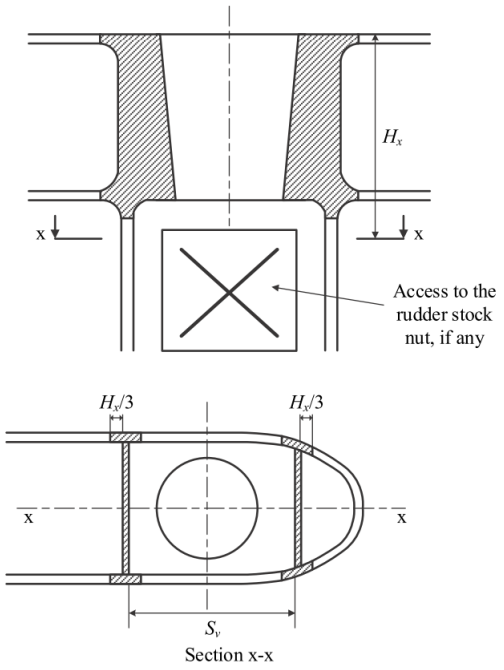


Fig. III 2-49
Cross-section of the Connection Between Rudder Blade Structure and Rudder Stock Housing

The thickness of the horizontal diaphragm plates connected to the solid parts, in mm (in.), as well as that of the rudder blade plating between these diaphragms, is to be not less than the greater of the following values:

$$t_H = 1.2t \quad \text{mm}$$

$$t_H = 0.0045d_s^2/s_H \quad \text{mm}$$

where

t = defined in 2.8.9(b)

d_s = diameter, to be taken equal to: mm

= S_l as per 2.8.4(b), for the solid part housing the rudder stock

= d_p as per 2.8.7(a), for the solid part housing the pintle

s_H = spacing between the two horizontal diaphragm plates mm

The increased thickness of the horizontal diaphragms is to extend fore and aft of the solid part at least to the next vertical diaphragm.

The thickness of the vertical diaphragm plates welded to the solid part where the rudder stock is housed as well as the thickness of the rudder side plating under this solid part is to be not less than the values obtained, in mm, from Table III 2-28 of this Chapter.

The increased thickness of vertical diaphragm plates is to extend below the solid piece at least to the next horizontal diaphragm.

Table III 2-28
Thickness of Side Plating and Vertical Diaphragm Plates

Type of Rudder	Thickness of Vertical Diaphragm Plates, in mm		Thickness of Rudder Plating, in mm	
	Rudder Blade without Opening	Rudder Blade with Opening	Rudder Blade without Opening	Area with Opening
Rudder supported by sole piece	1.2t	1.6t	1.2t	1.4t
Semi-spade and spade rudders	1.4t	2.0t	1.3t	1.6t

t = thickness of the rudder plating, in mm, as defined in 2.8.9(b) of this Chapter

(e) Welding and Design Details

(i) Slot-welding is to be limited as far as possible. Slot welding is not to be used in areas with large in-plane stresses transversely to the slots or in way of cut-out areas of semi-spade rudders.

(ii) When slot welding is applied, the length of slots is to be minimum 75 mm with breadth of 2t, where t is the rudder plate thickness, in mm. The distance between ends of slots is not to be more than 125 mm. The slots are to be fillet welded around the edges and filled with a suitable compound (e.g., epoxy putty). Slots are not to be filled with weld.

(iii) Grove welds with structural backing/backing bar (continuous type slot weld) may be used for double-plate rudder welding. In that case, the root gap is to be between 6 to 10 mm and the bevel angle is to be at least 15°.

(iv) In way of the rudder horn recess of semi-spade rudders the radii in the rudder plating are not to be less than 5 times the plate thickness, but in no case less than 100 mm. Welding in side plate are to be avoided in or at the end of the radii. Edges of side plate and weld adjacent to radii are to be ground smooth.

(v) Welds between plates and heavy pieces (solid parts in forged or cast steel or very thick plating) are to be made as full penetration welds. In way of highly stressed areas (e.g., cut-out of semi-spade rudder and upper part of spade rudder), cast or welding on ribs is to be arranged. Two sided full penetration welding is normally to be arranged. Where back welding is impossible welding is to be performed against ceramic backing bars or equivalent. Steel backing bars may be used and are to be continuously welded on one side to the heavy piece.

(f) Watertightness

The rudder is to be watertight and is to be tested in accordance with 7.1 of this Part.

2.8.10 Single Plate Rudder

(a) Mainpiece Diameter

The mainpiece diameter is calculated according to 2.8.4(b) of this Chapter. For spade rudders, the lower third may be tapered down to 0.75 times stock diameter at the bottom of the rudder.

(b) Blade Thickness

The blade thickness is not to be less than obtained from the following equation:

$$t_b = 0.0015sV_R + 2.5 \quad \text{mm}$$

where

s	=	spacing of stiffening arms, not to exceed 1000 mm	mm
V_R	=	speed, as defined in 2.8.2(a) of this Chapter	

(c) Arms

The thickness of the arms is not to be less than the blade thickness obtained in 2.8.10(b) of this Chapter. The section modulus of each set of arms about the axis of the rudder stock is not to be less than obtained from the following equation:

$$SM = 0.0005sC_1^2V^2 \quad \text{cm}^3$$

where

C_1	=	horizontal distance from the aft edge of the rudder to the centerline of the rudder stock	m
Q	=	as defined in 2.1.1(a)(i) of this Chapter	

s, V_R are defined in 2.8.10(b) of this Chapter.

2.8.11 Shelled Rudder Blades

Rudder blades that are constructed out of cast resilient polymers or filled FRP shells are to have a solid metallic core that complies with the requirements for single plate rudders, see 2.8.10 of this Chapter.

2.9 Protection of Deck Openings

2.9.1 General

All openings in decks are to be framed to provide efficient support and attachment for the ends of the deck beams. The proposed arrangement and details for all hatchways are to be submitted for approval.

2.9.2 Position of Deck Openings

For the purpose of these Rules, two positions of deck openings are defined as follows:

(a) Position 1

Upon exposed main and raised quarter decks, and upon exposed superstructure decks situated forward of a point located a quarter of the craft length from the forward perpendicular.

(b) Position 2

Upon exposed superstructure decks situated abaft a quarter of the craft length from the forward perpendicularand located at least one standard height of superstructure above the freeboard deck.

Upon exposed superstructure decks situated forward of a point located a quarter of the ship's length from the forward perpendicular and located at least two standard height of superstructure above the freeboard deck.

2.9.3 Hatchway Coamings, Companionway Sills and Access Sills

(a) Coaming and Sill Heights

The heights above deck of the coamings, the sills of companionways and access openings, are to be not less than given in Table III 2-29 of this Chapter. Where hatch covers are substantially constructed and made tight by means of gaskets and clamping devices, these heights may be reduced, or the coamings omitted entirely, provided that the safety of the craft is not thereby impaired in any sea conditions. Sealing arrangements are to be weathertight if coaming is fitted, and watertight for flush covers.

Table III 2-29
Coamings and Sill Heights

L equal to or over 24 meters in length		
	Position 1	Position 2
Hatch Coamings	600 mm	450 mm
Companionway Sills	600 mm	380 mm
Access Sills	380 mm	380 mm
L under 24 meters in length		
	Position 1	Position 2
Hatch Coamings and Companionways	450 mm	300 mm
Access Sills	380 mm	300 mm

Note:
For craft with L < 24 m, the coaming/sill height is to be as indicated above.

2.9.4 Enclosed Superstructures

To be considered enclosed, superstructures are to meet the following requirements. Superstructures with openings which do not fully comply with these requirements are to be considered as open superstructures. See also 2.11.2(d) of this Chapter.

(a) Closing Appliances

All openings in the bulkheads of enclosed superstructures are to be provided with efficient means of closing, so that in any sea conditions water will not penetrate the craft. Opening and closing appliances are to be framed and stiffened so that the whole structure, when closed, is equivalent to the unpierced bulkhead.

Doors for access openings into enclosed superstructures are to be of steel or other approved material, permanently and strongly attached to the bulkhead. The doors are to be provided with gaskets and clamping devices, or other equivalent arrangements, permanently attached to the bulkhead or to the doors themselves, and the doors are to be so arranged that they can be operated from both sides of the bulkhead. The construction of the doors is to be as required in 2.5.1(g) of this Chapter.

Portlights and windows in the end bulkheads of enclosed superstructures are to be of substantial construction and provided with efficient inside deadlights, as required in 2.11.3 of this Chapter.

The location and means of the closing appliances for windows are to be in accordance with 2.11.4 of this Chapter.

(b) Sills of Access Openings

Except as otherwise provided in these Rules, the height of the sills of access openings in bulkheads at the ends of enclosed superstructures is to be at least 380 mm above the deck. See Table III 2-29 of this Chapter for required sill heights.

(c) Means of Access

Superstructures are not to be regarded as enclosed unless access is provided for the crew to reach machinery and other working spaces inside these superstructures by alternate means which are available at all times when bulkhead openings are closed.

2.9.5 Hatchways Closed by Covers of Steel and Fitted with Gaskets and Clamping Devices

(a) Strength of Covers

The maximum allowable stress and deflection under design load, w, and the minimum top plate thickness are as follows:

Maximum allowable stress	$0.235\sigma_u$
Maximum allowable deflection	0.0028s
Top plate thickness	0.01s, but not less than, 6.0 mm

Position 1

$w = 0.097L + 7.45$ kN/m^2

Position 2

$w = 0.0709L + 5.65$ kN/m^2

where:

w	=	design load	kN/m^2
L	=	length of craft, as defined in 1.1 of this Part, but is not to be taken less than 24 m.	m
s	=	stiffener spacing	mm
σ_u	=	minimum ultimate tensile strength	N/mm^2

(b) Means for Securing Weathertightness

The means for securing and maintaining weathertightness is to be such that the tightness can be maintained in any sea condition. The covers are to be hose tested in position under a water pressure of at least 2.1 bar at the time of installation.

(c) Flush Hatch Covers

Where flush hatch covers are fitted on the freeboard deck within the forward one-fourth length, and the craft is operating with low freeboard (e.g., assigned a freeboard less than Type-B under the International Convention on Load Lines 1966), the assumed loads on flush hatch covers are to be increased 15% over that indicated in 2.9.5(a) of this Chapter.

2.9.6 Hatchways Closed by Portable Covers in Lower Decks or within Fully Enclosed Superstructures

(a) General

The following scantlings are intended for conventional type covers. Those for covers of special types are to be specially considered.

(b) Steel Covers

The thickness of the plating for steel covers is not to be less than that required for lower decks as obtained from 2.3.1 of this Chapter. A stiffening bar is to be fitted around the edges as required to provide the necessary rigidity to permit the covers being handled without deformation. The effective depth of the framework is normally to be not less than 4% of its unsupported length. The stiffeners, in association with the plating to which they are attached, are to have section modulus, SM, as determined by the following equation:

$$SM = 7.8hsl^2 \quad \text{cm}^3$$

where:

h	=	tween-deck height	m
s	=	spacing of the stiffeners	m
l	=	length of the stiffener	m

(c) Wheel Loading

Where provision is to be made for the operation and stowage of vehicles having rubber tires, the thickness of the hatch cover plating is to be in accordance with 2.3.1(e) of this Chapter.

2.9.7 Hatchways Closed by Covers of Materials Other Than Steel

Hatch covers constructed of materials other than steel will be specially considered.

2.9.8 Small Hatches on the Exposed Fore Deck

(a) Application

This subsection is applicable to craft with length L (as defined in 1.1.2 of this Part) not less than 80 meters.

The requirements of this subsection apply to all small hatches [opening normally 2.5 square meters or less] located on the exposed fore deck within the forward 0.25L, where the deck in way of the hatch is less than 0.1L or 2.2 m above the summer load line, whichever is less.

Hatches designed for emergency escape need not comply with 2.9.8(c)(i), 2.9.8(c)(ii), the third paragraph of 2.9.8(d) and 2.9.8(e) of this Chapter.

(b) Strength

For small rectangular steel hatch covers, the plate thickness, stiffener arrangement and scantlings are to be in accordance with Table III 2-30 and Fig. III 2-50 of this Chapter. Stiffeners, where fitted, are to be aligned with the metal-to-metal contact points as required in 2.9.8(d) of this Chapter. See also Fig. III 2-50 of this Chapter. Primary stiffeners are to be continuous. All stiffeners are to be welded to the inner edge stiffener, see Fig. III 2-51 of this Chapter.

The upper edge of the hatchway coaming is to be suitably reinforced by a horizontal section, normally not more than 170 to 190 mm from the upper edge of the coaming.

For small hatch covers of circular or similar shape, the cover plate thickness and reinforcement is to provide strength and stiffness equivalent to the requirements for small rectangular hatches.

For small hatch covers constructed of materials other than steel, the required scantlings are to provide strength and stiffness equivalent to 235 N/mm^2 yield strength steel.

(c) Primary Securing Devices

The primary securing devices are to be such that their hatch covers can be secured in place and made weathertight by means of a mechanism employing any one of the following methods:

(i) Butterfly nuts tightening onto forks (clamps), or

(ii) Quick acting cleats, or

(iii) A central locking device.

Dogs (twist tightening handles) with wedges are not acceptable.

(d) Requirements for Primary Securing

The hatch cover is to be fitted with a gasket of elastic material. This is to be designed to allow a metal-to-metal contact at a designed compression and to prevent over compression of the gasket by green sea forces that may cause the securing devices to be loosened or dislodged. The metal-to-metal contacts are to be

arranged close to each securing device in accordance with Fig. III 2-50 of this Chapter, and of sufficient capacity to withstand the bearing force.

The primary securing method is to be designed and manufactured such that the designed compression pressure is achieved by one person without the need of any tools.

For a primary securing method using butterfly nuts, the forks (clamps) are to be of robust design. They are to be designed to minimize the risk of butterfly nuts being dislodged while in use; by means of curving the forks upward and a raised surface on the free end, or a similar method. The plate thickness of unstiffened steel forks is not to be less than 16 mm. An example arrangement is shown in Fig. III 2-51 of this Chapter.

For small hatch covers located on the exposed deck forward of the fore-most cargo hatch, the hinges are to be fitted such that the predominant direction of green sea will cause the cover to close, which means that the hinges are normally to be located on the fore edge.

On small hatches located between the main hatches, for example between Nos. 1 and 2, the hinges are to be placed on the fore edge or outboard edge, whichever is practicable for protection from green water in beam sea and bow quartering conditions.

(e) Secondary Securing Devices

Small hatches on the fore deck are to be fitted with an independent secondary securing device e.g., by means of a sliding bolt, a hasp or a backing bar of slack fit, which is capable of keeping the hatch cover in place, even in the event that the primary securing device became loosened or dislodged. It is to be fitted on the side opposite to the hatch cover hinges.

Table III 2-30
Scantlings for Small Steel Hatch Covers on the Fore Deck

Nominal Size (mm×mm)	Cover Plate Thickness (mm)	Primary Stiffeners	Secondary Stiffeners
		Flat Bar (mm×mm); number	
630×630	8	---	---
630×830	8	100×8; 1	---
830×630	8	100×8; 1	---
830×830	8	100×10; 1	---
1030×1030	8	120×12; 1	80×8; 2
1330×1330	8	150×12; 2	100×10; 2

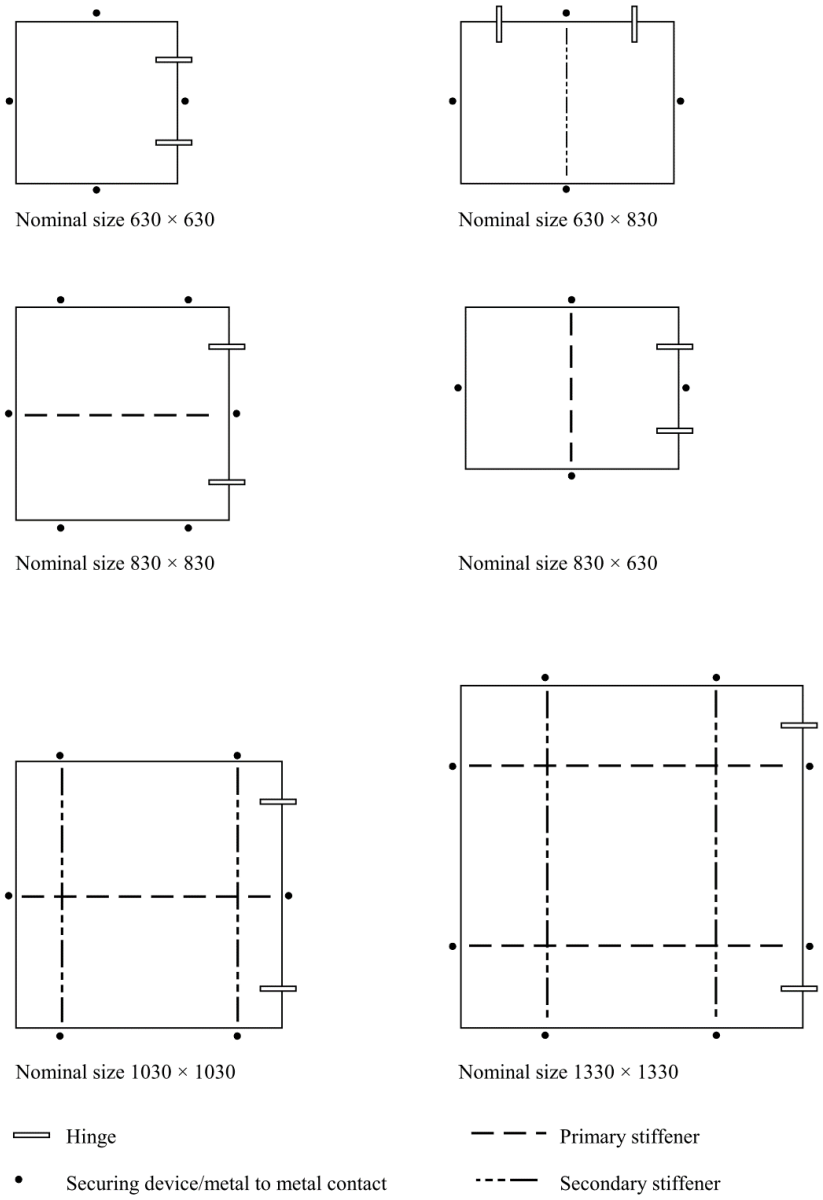
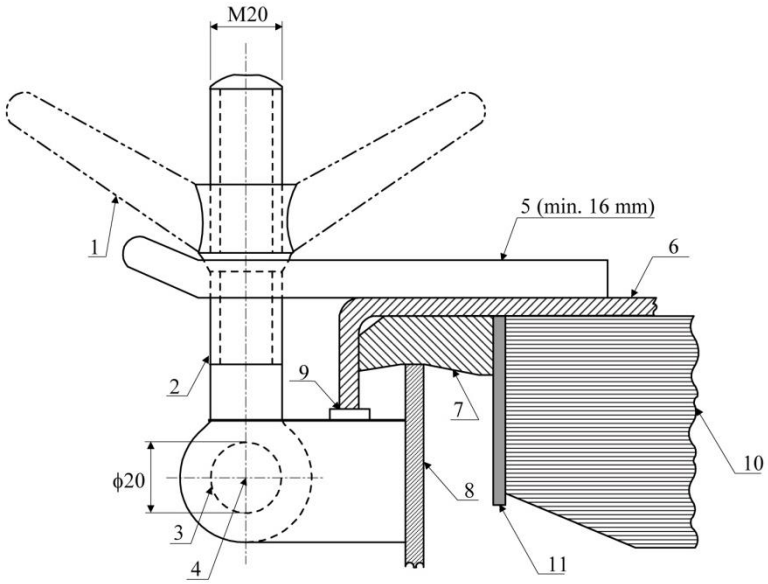


Fig. III 2-50
Arrangement of Stiffeners



Note: Dimensions in mm

1	butterfly nut	7	gasket
2	bolt	8	hatch coaming
3	pin	9	bearing pad welded on the bracket of a bolt for metal to metal contact
4	center of pin	10	stiffener
5	fork (clamp)plate	11	inner edge stiffener
6	hatch cover		

Fig. III 2-51
Example of Primary Securing Method

2.9.9 Hatchways within Open Superstructures

Hatchways within open superstructures are to be considered as exposed to weather.

2.9.10 Hatchways within Deckhouses

Hatchways within deckhouses are to have coamings and closing arrangements as required in relation to the protection afforded by the deckhouse from the standpoint of its construction and the means provided for the closing of all openings into the house.

2.9.11 Machinery Casings

(a) Arrangement

Machinery-space openings in Position 1 or 2 are to be framed and efficiently enclosed by casings of ample strength, and wherever practicable, those in main decks are to be placed within superstructures or deckhouses. Casings are to be of material similar to that of the surrounding structure. Openings in exposed casings are to be fitted with doors complying with the requirements of 2.9.4(a) of this Chapter; the sills are to be in accordance with 2.9.3(a) of this Chapter for companionways. Other openings in such casings are to be fitted with equivalent covers, permanently attached. Stiffeners are to be spaced at not more than 760 mm.

(b) Scantlings

The scantlings of exposed casings are to be similar to those obtained for superstructures and deckhouses in accordance with the applicable requirements of 2.2, 2.3 and 2.4 of this Chapter.

The scantlings of casings within enclosed superstructures or deckhouses will be specially considered.

2.9.12 Miscellaneous Openings in Freeboard and Superstructure Decks

(a) Manholes and Scuttles

Manholes and flush scuttles in Position 1 or 2 within superstructures other than enclosed superstructures are to be closed by substantial covers capable of being made watertight. Unless secured by closely spaced bolts, the covers are to be permanently attached.

(b) Other Openings

Openings in freeboard decks other than hatchways, machinery-space openings, manholes and flush scuttles are to be protected by an enclosed superstructure, or by a deckhouse or companionway of equivalent strength and weathertightness. Any such opening in an exposed superstructure deck or in the top of a deckhouse on the main deck which gives access to a space below the main deck or a space within an enclosed superstructure is to be protected by an efficient deckhouse or companionway. Doorways in such deckhouses or companionways are to be fitted with doors complying with the requirements given in 2.9.4(a) of this Chapter.

(c) Escape Openings

(i) The closing appliances of escape openings are to be of a type that is operable from each side.

(ii) The maximum force needed to open the closing appliances is not to exceed 150 N.

(iii) The use of a spring equalizing, counterbalance or other suitable device on the hinge side to reduce the force needed for opening is acceptable.

(d) Chain Pipe Opening

For craft with length L (as defined in 1.1.2 of this Part) greater than 24 meters, chain pipes through which anchor cables are led are to be provided with permanently attached closing appliances to minimize ingress of water. A canvas cover with appropriate lashing arrangement will be acceptable* for this purpose. Cement and wire mesh arrangement is not permitted.

The arrangement on craft that are not subject to the International Convention on Load Lines or its Protocol may be specially considered.

*Note:

Examples of acceptable arrangements are such as:

(i) Steel plates with cutouts to accommodate chain links, or

(ii) Canvas hoods with a lashing arrangement that maintains the cover in the secured position.

2.10 Protection of Shell Openings

2.10.1 Cargo, Gangway, or Fueling Ports

(a) Construction

Cargo, gangway, or fueling ports in the sides of craft are to be strongly constructed and capable of being made thoroughly watertight. Where frames are cut in way of such ports, web frames are to be fitted on the sides of the openings, and suitable arrangements are to be provided for the support of the beams over the openings. Thick shell plates or doublers are to be fitted as required to compensate for the openings. The corners of the openings are to be well rounded. Waterway angles and scuppers are to be provided on the decks in way of ports in cargo spaces below the freeboard deck or in cargo spaces within enclosed superstructures to prevent the spread of any leakage water over the decks.

Indicators showing whether the ports in the side shell below the freeboard or superstructure deck are secured closed or open are to be provided on the navigation bridge.

(b) Location

The lower edges of cargo, gangway, or fueling-port openings are not to be below a line parallel to the main deck at side having as its lowest point the designed load waterline or upper edge of the uppermost load line.

2.10.2 Bow Doors, Inner Doors, Side Shell Doors and Stern Doors

(a) General

Where steel bow doors of the visor or side-opening type are fitted leading to complete or long forward enclosed superstructure, bow doors and inner doors are to meet the requirements of this subsection. Hull supporting structure in way of the bow doors is to be able to withstand the loads imposed by the bow doors securing and supporting devices without exceeding the allowable stresses for those devices, both given in this subsection. Special consideration will be given to bow doors constructed of materials other than steel.

(b) Arrangement

(i) General

As far as practicable, bow doors and inner doors are to be arranged so as to preclude the possibility of the bow door causing structural damage to the inner door or to the collision bulkhead in the case of damage to or detachment of the bow door.

(ii) Bow Doors

Bow doors are to be situated above the main deck except that where a watertight recess fitted for arrangement of ramps or other related mechanical devices is located forward of the collision bulkhead and above the deepest waterline, the bow doors may be situated above the recess.

(iii) Inner Doors

An inner door is to be fitted in the extension of the collision bulkhead required by 2.5.1(b) of this Chapter. A vehicle ramp made watertight and conforming to 2.5.1(b) of this Chapter in the closed position may be accepted for this purpose.

(iv) Side Shell and Stern Doors

Stern doors for passenger craft are to be situated above the freeboard deck. Stern doors for ro-ro cargo craft and all side shell doors need not be situated above the freeboard deck.

2.10.3 Securing, Locking and Supporting of Doors

(a) Definitions

(i) Securing Device

A device used to keep the door closed by preventing it from rotating about its hinges or its pivoted attachments to the craft.

(ii) Supporitng Device

A device used to transmit external or internal loads from the door to a securing device and from the securing device to the craft’s structure, or a device other than a securing device, such as a hinge, stopper or other fixed device, that transmits loads from the door to the craft’s structure.

(iii) Locking Device

A device that locks a securing device in the closed position.

2.10.4 Securing and Supporting Devices

(a) General

Securing and supporting devices are to be arranged in accordance with this subsection, and are to have scantlings as required by 2.10.7(e), 2.10.8(c) or 2.10.9(e) of this Chapter, as appropriate.

(b) Bow Doors

Means are to be provided to prevent lateral or vertical movement of the bow doors when closed. Means are also to be provided for mechanically fixing the door in the open position.

Means of securing and supporting the door are to maintain equivalent strength and stiffness of the adjacent structure.

(i) Clearance and Packing

The maximum design clearance between the door and securing/supporting devices is not to exceed 3 mm. Where packing is fitted, it is to be of a comparatively soft type and the supporting forces are to be carried by the steel structure only.

(ii) Visor Door Arrangement.

The pivot arrangement is to be such that the visor is self-closing under external loads. The closing moment, M_y, as defined in 2.10.10(c)(i) of this Chapter is not to be less than M_{yo} as given by the following equation:

$$M_{yo} = Wc + 0.1\sqrt{a^2 + b^2}\sqrt{F_x^2 + F_z^2}$$

where W, a, b, c, F_x and F_z are as defined in 2.10.10 of this Chapter

In addition, the arrangement of the door is to be such that the reaction forces of pin or wedge supports at the base of the door does not act in the forward direction when the door is loaded in accordance with 2.10.10(c)(iv) of this Chapter.

(c) Side Shell and Stern Doors

Means are to be provided to prevent lateral or vertical movement of the side shell or stern doors when closed. Means are also to be provided for mechanically fixing the doors in the open position.

Clearance and packing for side shell and stern doors are to be in accordance with 2.10.4(b)(i) of this Chapter.

2.10.5 Securing and Locking Arrangement

(a) General

Securing devices are to be provided with a mechanical locking arrangement (self-locking or separate arrangement), or are to be of the gravity type.

(b) Operation

Securing devices are to be simple to operate and readily accessible. The opening and closing systems as well as the securing and locking devices are to be interlocked in such a way that they can only operate in the proper sequence.

(i) Hydraulic Securing Devices

Where hydraulic securing devices are applied, the system is to be mechanically lockable in the closed position. In the event of a loss of hydraulic fluid, the securing devices are to remain locked.

The hydraulic system for securing and locking devices is to be isolated from other hydraulic circuits when in the closed position.

(ii) Remote Control

Where bow doors and inner doors give access to a vehicle deck, an arrangement for remote control from a position above the freeboard deck is to be provided allowing closing and opening of the doors and associated securing and locking of the securing and locking devices for every door. The operating panels for operation of doors are to be accessible to authorized persons only. A notice plate giving instructions to the effect that all securing devices are to be closed and locked before leaving harbor is to be placed at each operating panel and is to be supplemented by warning indicator lights as indicated in 2.10.5(c)(i) of this Chapter.

(c) Indication/Monitoring

(i) Indicators

The indicator system is to be designed on the fail safe principle and in accordance with the following:

(1) Location and Type
Separate indicator lights are to be provided on the navigation bridge to show that the bow door and inner door are closed and that their locking devices are properly positioned.
The indication panel on the navigation bridge is to be equipped with a mode selection function "harbor/sea voyage", arranged so that an audible and visible alarm is given if in the sea voyage condition, the bow door or inner door is not closed, or any of the securing devices is not in the correct position.
Indication of the open/closed position of every door and every securing and locking device is to be provided at the operating panels.

(2) Indicator lights
Indicator lights are to be designed so that they cannot be manually turned off. The indication panel is to be provided with a lamp test function.

(3) Power Supply
The power supply for the indicator system is to be independent of the power supply for operating and closing the doors.

(4) Protection of Sensors
Sensors are to be protected from water, ice formation and mechanical damage.

(ii) Water Leakage Protection

A drainage system is to be arranged in the area between the bow door and ramp and in the area between the ramp and inner door where fitted. The system is to be equipped with an audible alarm function to the navigation bridge for water level in these areas exceeding 0.5 m above the car deck level.

A water leakage detection system with audible alarm and television surveillance are to be arranged to provide an indication to the navigation bridge and to the engine control room of leakage through the inner door.

(iii) Door Surveillance

Between the bow door and the inner door a television surveillance system is to be fitted with a monitor on the navigation bridge and in the engine control room. The system is to monitor the position of doors and a sufficient number of their securing devices.

2.10.6 Tightness

(a) Bow Doors

Bow doors are to be so fitted as to provide tightness consistent with operational conditions and to give effective protection to the inner doors.

(b) Inner Doors

Inner doors forming part of the extension of the collision bulkhead are to be weathertight over the full height of the cargo space and arranged with fixed sealing supports on the aft side of the doors.

(c) Side Shell and Stern Doors

Side shell doors and stern doors are to be so fitted as to provide watertightness.

2.10.7 Bow Door Scantlings

(a) General

Bow doors are to be framed and stiffened so that the whole structure is equivalent to the unpierced bulkhead when closed.

(b) Primary Structure

Scantlings of primary members are to be designed so that the allowable stresses indicated in 2.10.13(a) of this Chapter are not exceeded when the structure is subjected to the design loads indicated in 2.10.10(a) of this Chapter. Unless the ends of the primary members are effectively fixed-ended, the member is to be considered simply supported.

(c) Secondary Stiffeners

Secondary stiffeners are to be supported by primary members constituting the main stiffening of the door. The section modulus, SM, of secondary stiffeners is to be as required by 2.4.1(b) of this Chapter. In addition, stiffener webs are to have a net sectional area not less than that obtained from the following equation:

$$A = VQ/10 \qquad cm^2$$

where:

V = shear force, in the stiffener calculated using the uniformly distributed external pressure P_{eb} as given in 2.10.10(a) of this Chapter kN

Q = as defined in 2.1.1(a)(i) of this Chapter

(d) Plating

The thickness of bow door plating is to be not less than that required for side shell plating at the same location.

(e) Securing and Supporting Devices

Scantlings of securing and supporting devices are to be designed so that the allowable stresses indicated in 2.10.13(a) of this Chapter are not exceeded when the structure is subjected to the design loads indicated in 2.10.10(b) of this Chapter. All load transmitting elements in the design load path from the door through securing and supporting devices into the craft structure, including welded connections, are to meet the strength standards required for securing and supporting devices. Where fitted, threaded bolts are not to carry support forces, and the maximum tensile stress in way of the threads is not to exceed the allowable stress given in 3-2.10.13(c) of this Chapter.

In determining the required scantlings, the door is to be assumed to be a rigid body. Only those active supporting and securing devices having an effective stiffness in the relevant direction are to be included and considered when calculating the reaction forces on the devices. Small or flexible devices such as cleats intended to provide load compression of the packing material are not to be included in the calculations.

(i) Bearing Pressure

The bearing pressure on steel to steel bearings is to be calculated by dividing the design force by the projected bearing area, and is not to exceed the allowable stress as given in 2.10.13(b) of this Chapter.

(ii) Redundancy

In addition to the above requirements, the arrangement of the securing and supporting devices is to be designed with redundancy such that in the event of failure of any single securing or supporting device, the stresses in the remaining devices do not exceed the allowable stresses as indicated in 2.10.13(a) of this Chapter by more than 20% under the above loads.

(iii) Visor Door Securing and Supporting Devices

Securing and supporting devices, excluding the hinges, are to be capable of resisting the vertical design force given in 2.10.10(c)(iii) of this Chapter without stresses exceeding the allowable stresses in 2.10.13(a) of this Chapter.

Two securing devices are to be provided at the lower part of the door, each capable of providing the full reaction force required to prevent opening of the door without stresses exceeding the allowable stresses indicated in 2.10.13(a) of this Chapter. The opening moment, M_o, to be balanced by this force is as given in 2.10.10(c)(ii) of this Chapter.

(iv) Side-opening Door Thrust Bearing

A thrust bearing is to be provided in way of girder ends at the closing of the two doors, and is to prevent one door from shifting towards the other one under the effect of unsymmetrical pressure. Securing devices are to be fitted to secure sections thrust bearing to one another.

(f) Visor Door Lifting Arms and Supports

Where visor type bow doors are fitted, calculations are to be submitted verifying that lifting arms and their connections to the door and craft structure are adequate to withstand the static and dynamic forces applied during the lifting and lowering operations under a wind pressure of at least 1.5 kN/m^2.

2.10.8 Inner Door Scantlings

(a) General

Scantlings of inner doors are to meet the requirements of this subsection. In addition, where inner doors are used as vehicle ramps, scantlings are not to be less than required for vehicle decks.

(b) Primary Structure

Scantlings of primary members are to be designed so that the allowable stresses indicated in 2.10.13(a) of this Chapter are not exceeded when the structure is subjected to the design loads indicated in 2.10.11(a) of this Chapter.

(c) Securing and Supporting Devices

Scantlings of securing and supporting devices are to be designed so that the allowable stresses indicated in 2.10.13(a) of this Chapter are not exceeded when the structure is subjected to the design loads indicated in 2.10.11 of this Chapter. Where fitted, threaded bolts are not to carry support forces, and the maximum tensile stress in way of the threads is not to exceed the allowable stress as given in 2.10.13(b) of this Chapter.

The bearing pressure on steel to steel bearings is to be calculated by dividing the design force by the projected bearing area, and is not to exceed the allowable stress given in 2.10.13(b) of this Chapter.

2.10.9 Side Shell Door and Stern Door Scantlings

(a) General

Scantlings of side shell doors or stern doors are to meet the requirements of this subsection. The doors are to be framed and stiffened so that the whole structure is equivalent to the intact side or stern structure when closed. In addition, where the doors are used as vehicle ramps, scantlings are not to be less than required for vehicle decks in 2.3 and 2.4 of this Chapter.

(b) Primary Structure

Scantlings of primary members are to be designed so that the allowable stresses indicated in 2.10.13(a) are not exceeded when the structure is subjected to the design loads indicated in 2.10.12. The primary members are to be considered simply supported at their support points unless the end connections are effectively restrained.

(c) Secondary Stiffeners

Secondary stiffeners are to be supported by primary members constituting the main stiffening of the door. The section modulus, SM, of secondary stiffeners is to be not less than required by 2.4 of this Chapter for frames in the same location. In addition, the net sectional area of stiffener webs is to be in accordance with 2.10.7(c), using the external pressure, p_e, given in 2.10.12.

(d) Plating

The thickness of side or stern door plating is to be not less than that required for side shell plating at the same location.

(e) Securing and Supporting Devices

Scantlings of securing and supporting devices are to be designed so that the allowable stresses indicated in 2.10.13(a) of this Chapter are not exceeded when the structure is subjected to the design loads indicated in 2.10.12 of this Chapter. All load-transmitting elements in the design load path from the door through securing and supporting devices into the craft structure, including welded connections, are to meet the strength standards required for securing and supporting devices. Where fitted, threaded bolts are not to carry support forces, and the maximum tensile stress in way of the threads is not to exceed the allowable stress given in 2.10.13(c) of this Chapter.

In determining the required scantlings, the door is to be assumed to be a rigid body. Only those active supporting and securing devices having an effective stiffness in the relevant direction are to be included and considered when calculating the reaction forces on the devices. Small or flexible devices such as cleats intended to provide compression load on the packing material are not to be included in the calculations.

(i) Bearing Pressure

The bearing pressure on steel to steel bearings is to be calculated by dividing the design force by the projected bearing area, and is not to exceed the allowable stress given in 2.10.13(b) of this Chapter.

(ii) Redundancy

In addition to the above requirements, the arrangement of the securing and supporting devices is to be designed with redundancy such that in the event of a failure of any single securing or supporting device, the stresses in the remaining devices do not exceed the allowable stresses indicated in 2.10.13(a) of this Chapter by more than 20% under the above loads.

2.10.10 Bow Door Design Loads

(a) External Pressure

The design external pressure, P_{eb}, is to be taken as indicated by the following equation.

$$P_{eb} = 2.75c(0.22 + 0.15tan\beta)(0.4V_d sin\alpha + 0.6\sqrt{L})^2 \quad \text{kN/m}^2$$

where:

c = 0.0125L L < 80 m for craft having L < 80 m
= 1.0 for other craft

L = length of craft as defined in 1.1.2 of this Part m

β = flare angle at the point to be considered, defined as the angle between a vertical line and the tangent to the side shell plating measured in a vertical plane normal to the horizontal tangent to the shell plating. See Fig. III 2-52 of this Chapter.

α = entry angle at the point to be considered, defined as the angle between a longitudinal line parallel to the centerline and the tangent to the shell plating in a horizontal plane. See Fig. Fig. III 2-52 of this Chapter.

V_d = craft design speed as defined in 2.8.2(a) of this Chapter.

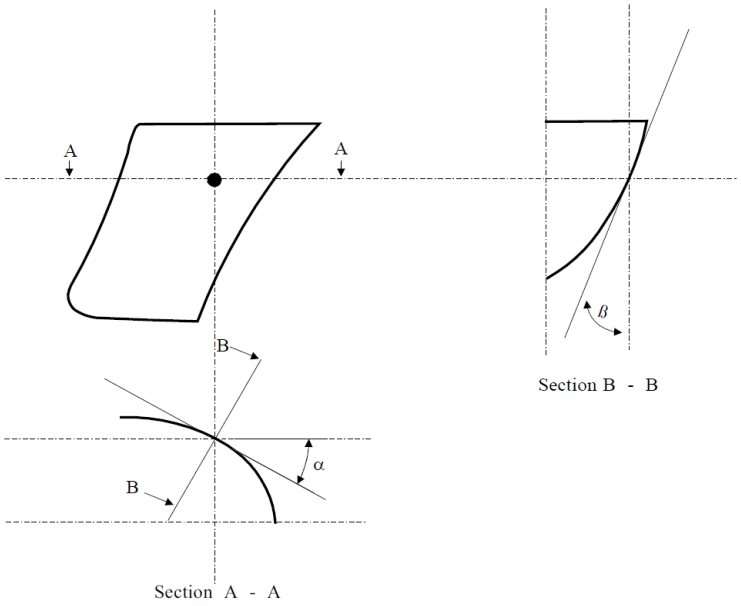


Fig. III 2-52
Entry and Flare Angles

(b) External Forces

The design external forces considered in determining scantlings of securing and supporting devices of bow doors are not to be taken less than those given by the following equations:

$$F_x = P_{em} A_x$$
$$F_y = P_{em} A_y$$
$$F_z = P_{em} A_z$$

where:

F_x = design external force in the longitudinal direction kN
F_y = design external force in the horizontal direction kN
F_z = design external force in the vertical direction kN
A_x = area, of the transverse vertical projection of the door between the levels of the bottom of the door and the upper deck or between the bottom of the door and the top of the door, whichever is less m^2
A_y = area, of the longitudinal vertical projection of the door between the levels of the bottom of the door and the upper deck or between the bottom of the door and the top of the door, whichever is less m^2
A_z = area, of the horizontal projection of the door between the levels of the bottom of the door and the upper deck or between the bottom of the door and the top of the door, whichever is less m^2
P_{em} = bow door pressure, P_{eb}, determined using α_m and β_m in place of α and β
β_m = flare angle measured at a point on the bow door *l*/2 aft of the stem line on a plane h/2 above the bottom of the door, as shown in Fig. III 2-53 of this Chapter
α_m = entry angle measured at the same point as β_m. See Fig. III 2-53 of this Chapter.
h = height, of the door between the levels of the bottom of the door and the upper deck or between the bottom of the door and the top of the door, whichever is less m
l = length, of the door at a height of h/2 above the bottom of the door m

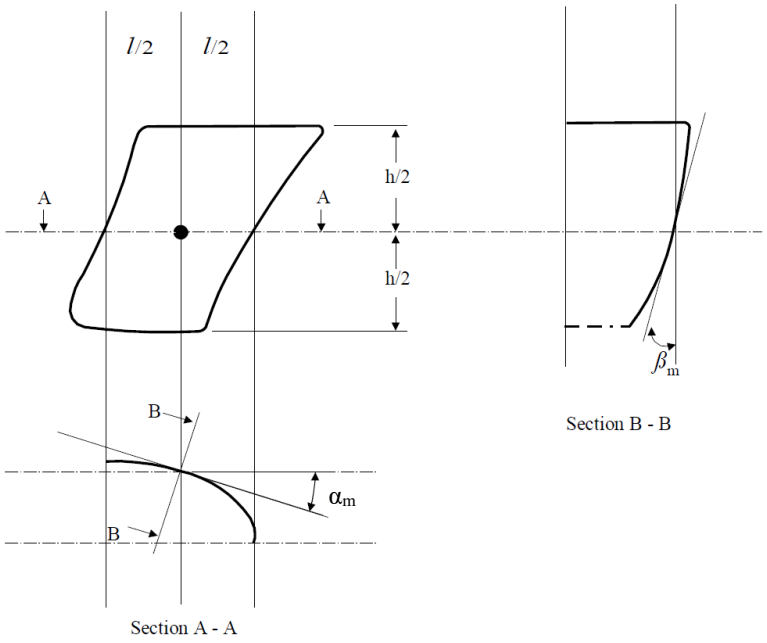


Fig. III 2-53
Definition of α_m and β_m

(c) Visor Door Forces, Moments and Load Cases

(i) Closing Moment

For visor doors, the closing moment, My, is to be taken as indicated by the following equation:

$$M_y = F_x a + Wc - F_z b \qquad \text{kN-m}$$

where:

W = weight of the visor door kN

a = vertical distance, from the visor pivot to the centroid of the transverse vertical projected area of the visor door. See Fig. III 2-54 of this Chapter m

b = horizontal distance, from visor pivot to the centroid of the horizontal projected area of the visor door. See III 2-54 of this Chapter m

c = horizontal distance, from the visor pivot to the center of gravity of the visor door. See Fig. III 2-54 of this Chapter m

F_x and F_z are as defined in 2.10.10(b) of this Chapter.

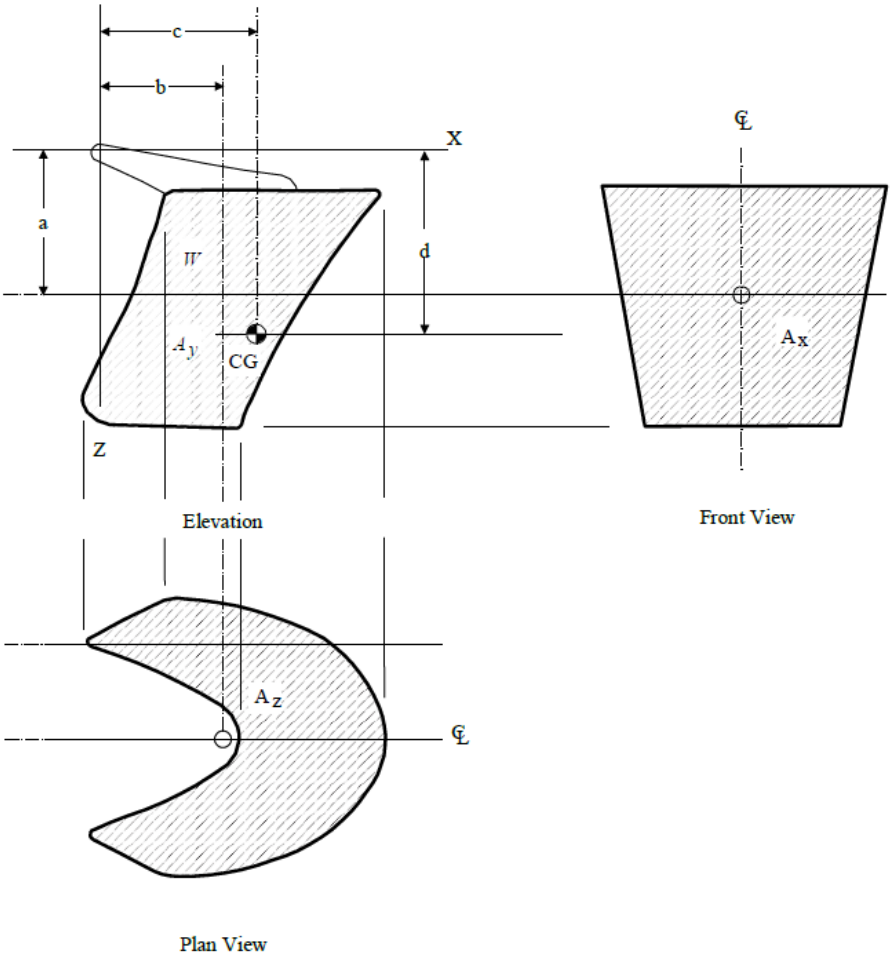


Fig. III 2-54
Visor Type Bow Door

(ii) Opening Moment

The opening moment, M_o, is to be taken as indicated by the following equation:

$$M_o = Wd + 5A_x a \qquad \text{kN-m}$$

where:

d = vertical distance, from the hinge axis to the center of gravity of the door m

W, A_x and a are as indicated above.

(iii) Vertical Design Force

The vertical design force is to be taken as F_z – W, where F_z is as defined in 2.10.10(b) and W is as defined in 2.10.10(c)(i).

(iv) Combined Load Case 1

The visor doors are to be evaluated under a load of F_x, F_z and W acting simultaneously with F_x and F_z acting at the centroid of their respective projected areas.

(v) Combined Load Case 2

The visor doors are to be evaluated under a load of $0.7F_y$ acting on each side separately together with $0.7F_x$, $0.7F_z$ and W. F_x, F_y and F_z are to be taken as acting at the centroid of their respective projected areas.

(d) Side-Opening Door Load Cases

(i) Combined Load Case 1

Side opening doors are to be evaluated under a load of F_x, F_y, F_z and W acting simultaneously with F_x, F_y and F_z acting at the centroid of their respective projected areas.

(ii) Combined Load Case 2

Side opening doors are to be evaluated under a load of $0.7F_x$, $0.7F_z$ and W acting on both doors simultaneously and $0.7F_y$ acting on each door separately.

2.10.11 Inner Door Design Loads

(a) External Pressure

The design external pressure is to be taken as the greater of P_{ei} or P_h as given by the following equations:

$P_{ei} = 0.45L$ kN/m^2

$P_h = 10h$ kN/m^2

where:

L = as defined in 1.1.2 of this Part.

h = the distance, from the load point to the top of the cargo space m

(b) Internal Pressure

The design internal pressure, P_i, is to be taken as not less than 25 kN/m^2.

2.10.12 Side Shell and Stern Doors Design Loads

(a) Design Forces for Primary Members

The design force, in kN, for primary members is to be the greater of the following:

External force: $F_e = Ap_e$

Internal force: $F_i = F_o + W$

(b) Design Forces for Securing or Supporting Devices of Doors Opening Inwards

The design force, in kN, for securing or supporting devices of doors opening inwards is to be the greater of the following:

External force: $F_e = Ap_e + F_p$

Internal force: $F_i = F_o + W$

(c) Design Forces for Securing or Supporting Devices of Doors Opening Outwards

The design force, in kN, for securing or supporting devices of doors opening outwards is to be the greater of the following:

External force: $F_e = Ap_e$

Internal force: $F_i = F_o + W + F_p$

where:

A	=	area, of the door opening m^2	
W	=	weight of the door kN	
F_p	=	total packing force, Packing line pressure is normally not to be taken less than 5.0 N/mm	kN
F_o	=	the greater of F_c and 5A	kN
F_c	=	accidental force, due to loose cargo, etc., to be uniformly distributed over the area A and not to be taken less than 300 kN. For small doors such as bunker doors and pilot doors, the value of F_c may be appropriately reduced. However, the value of F_c may be taken as zero provided an additional structure such as an inner ramp is fitted which is capable of protecting the door from accidental forces due to loose cargoes. kN	
p_e	=	external design pressure, determined at the center of gravity of the door opening and not taken less than:	kN/m^2
			kN/m^2
		$p_e = 25$ for $Z_G \geq d$	
		$p_e = 10\ (d - Z_G) + 25$ for $Z_G < d$	
		Moreover, for craft fitted with bow doors, p_e for stern doors is not to be taken less than: $p_e = 0.605c(0.8 + 0.6\sqrt{L})^2$	
		For craft fitted with bow doors and operating in restricted service, the value of p_e for stern doors will be specially considered.	
d	=	draft, as defined in 1.1.6 of this Part m	
Z_G	=	height of the center of area of the door, above the baseline m	
c	=	0.0125L for L < 80 m	
	=	1 for L ≥ 80 m	
L	=	length of craft, as defined in 1.1.2 of this Part, but need not be taken as greater than 200 m	m

2.10.13 Allowable Stresses

(a) Primary Structure and Securing and Supporting Devices

The following stresses are not to be exceeded under the loads indicated above:

Shear Stress:	$\tau = 80/Q$	N/mm^2
Bending Stress:	$\tau = 120/Q$	N/mm^2
Equivalent Stresses $(\sqrt{\sigma^2 + 3\tau^2})$:	$\sigma_e = 150/Q$	N/mm^2

where Q is as defined in 2.1.1(a)(i) of this Chapter.

(b) Steel Securing and Supporting Devices Bearing Stress

For steel to steel bearings in securing and supporting devices, the nominal bearing pressure is not to exceed $0.8\sigma_f$, where σ_f is the yield stress of the bearing material.

(c) Tensile Stress on Threaded Bolts

The tensile stress in threaded bolts is not to exceed $125/Q\ N/mm^2$.

2.10.14 Operating and Maintenance Manual

The following information is to be submitted for review:

(a) Manual

An operating and maintenance manual for the bow door and inner door is to be provided on board and is to contain at least the following:

(i) Main particulars and design drawings

(ii) Service conditions (e.g., service area)

(iii) Restrictions, acceptable clearances for supports

(iv) Maintenance and function testing

(v) Register of inspections and repairs

(b) Operating Procedures

Documented operating procedures for closing and securing the bow door and inner door are to be kept on board and posted at an appropriate location.

2.11 Bulwarks, Rails, Ports, Portlights, Windows, Ventilators, Tank Vents and Overflows

2.11.1 Bulwarks and Guard Rails

Bulwarks or guard rails or a combination of both, are in general to be provided on periphery of exposed decks, and on exposed tops of superstructures and deckhouses.

Where the flag administration has specific requirements for bulwarks and guardrails they may be accepted provided they are not less effective.

For vessels less than 24 meters in length, may be special considered.

(a) Location and Heights

Bulwarks or guardrails are also to be provided on the exposed side of any platform surface that is greater than 600 mm or higher above the adjacent surface.

The height of bulwarks and guard rails on exposed freeboard and superstructure decks, at the boundary of first tier deckhouses and at the ends of superstructures is to be at least 1 m. Where this height would interfere with the normal service or operation of a craft, a lesser height may be approved if adequate protection is provided. Where approval of a lesser height is requested, justifying information is to be submitted, such as arrangements provided to prevent personnel going over the guard rails or bulwarks.

(b) Strength of Bulwarks

Bulwarks are to be of ample strength for their height and location, suitably stiffened at the top, and if necessary at the bottom, and supported by efficient stays or brackets.

Stays or brackets on the main weather deck are to be spaced not more than 1.83 m.

Openings in bulwarks are to be smooth-edged, with well-rounded corners.

(c) Guard Rails

(i) Fixed, removable or hinged stanchions are to be fitted at approximately 1.5 m apart. Removable or hinged stanchions are to be capable of being locked in the upright position.

(ii) At least every third stanchion is to be supported by a bracket or stay. Dimensions and arrangement of stanchion and stays are to be as shown in Fig. III 2-55 of this Chapter. Where this arrangement would interfere with the safe traffic of persons on board, the following alternative arrangements of stanchions may be acceptable:

(1) At least every third stanchion is to be of increased breadth, $kb_s = 2.9b_s$ at the attachment of stanchion to the deck, or,

(2) At least every second stanchion is to be of increased breadth, $kb_s = 2.4b_s$ at the attachment of stanchion to the deck, or,

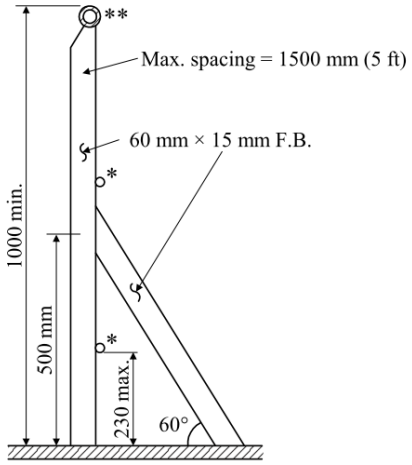
(3) Every stanchion is to be of increased breadth, $kb_s = 1.9b_s$ at the attachment of stanchion to the deck.

where, b_s is not to be taken as less than 60 mm (see Fig. III 2-56 of this Chapter). The thickness of the flat bar stanchions is not to be less than 15 mm.

For any of the above arrangements (1), (3) or (3), the following details are to be complied with:

(4) Flat steel stanchion required by (1), (2) or (3) above is to be aligned with supporting member below the deck unless the deck plating thickness exceeds 20 mm and welded to deck with double continuous fillet weld with minimum leg size of 7.0 mm or as specified by the design standard.

(5) The underdeck supporting member of the stanchion is to be a minimum of 100 × 12 mm flat bar welded to deck by double continuous fillet weld.



Standard stanchion, rail, and stay sizes.
(Stay to be provided at every third stanchion)

* = 20 mm solid round bar or 26.9 mm outside diameter pipe with 2.3 mm minimum wall thickness (or pipes having an equivalent section modulus)

** Top Rail = 42.4 mm outside diameter pipe with 2.6 mm minimum wall thickness (or pipes having an equivalent section modulus)

Fig. III 2-55
Guardrail Stanchion

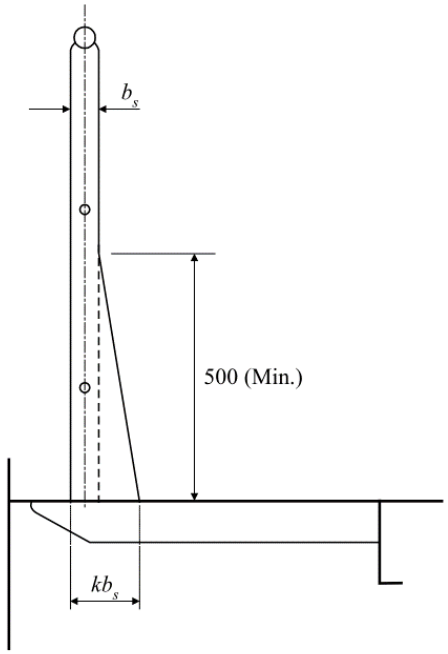


Fig. III 2-56
Guardrail Stanchion

(iii) The clear opening below the lowest course is not to exceed 230 mm. Where a foot-stop is installed at the deck level the clear opening below the lowest course may be measured from the top of the foot-stop. The clear distances between the lowest and the middle courses, as well as the middle and the upper courses are not to exceed 380 mm.

The distance between the lower rail and the top of the sheerstrake is not to exceed 230 mm.

(iv) For vessels with rounded gunwales, stanchions are to be placed on the flat of the deck.

(d) Guard Rail Scantling Correction

When aluminum guard rails are used, calculate an equivalent section modulus to the standard shown in Fig. III 2-55 of this Chapter, using the below formula.

$$SM_{al} = 0.9Q_0 SM_s$$

where:

SM_{al} = minimum section modulus of aluminum guardrail
SM_s = offered section modulus of guardrail as shown in Fig. III 2-55 of this Chapter
Q = material factor, as determined from 2.11.1(d)(i) of this Chapter
Q_0 = material factor, as determined from 2.11.1(d)(i) of this Chapter

(i) Material Factors

The material factor, Q, is obtained from the following equation:

$$Q = 0.9 + (120/Y_{al})$$

but is not to be taken as less than Q_0 below.

The material factor, Q_0, is obtained from the following equation:

$$Q_0 = 635/(\sigma_y + \sigma_u)$$

where

Y_{al}	=	minimum yield strength of the welded aluminum alloy under consideration at 2% offset in a 254 mm gauge length, in accordance with the requirements of the table below	N/mm^2
σ_u	=	minimum ultimate strength of the welded aluminum alloy under consideration, in accordance with the table below	N/mm^2
σ_y	=	minimum yield strength of the welded aluminum alloy under consideration, in accordance with the table below	N/mm^2

(e) Life Lines

Life lines, where fitted, are to be a minimum of 9.5 mm in diameter, 7×19 construction, and made of stainless steel wire rope. They are to have a stainless steel turnbuckle at one end and a stainless steel screw pin shackle at the other.

2.11.2 Freeing Ports

(a) Basic Area for Craft More Than 24 meters in Length

Where bulwarks on freeboard decks form wells, ample provision is to be made for rapidly freeing the decks of water and for draining them. The minimum freeing-port area on each side of the craft for each well 20 m or less in length is to be obtained from the following equation:

$$A = 0.7 + 0.035l \quad \text{m}^2$$

Where the bulwark length exceeds 20 m:

$$A = 0.07l \quad \text{m}^2$$

where:

A	=	freeing-port, area in m^2
l	=	bulwark length, in m, but need not exceed 0.7L

The minimum area for each well on superstructure decks is to be one half of the area obtained from the above equations.

If a bulwark is more than 1.2 m in height, the freeing-port area is to be increased by 0.004 m^2 per meter of length of well for each 0.1 m difference in height. If a bulwark is less than 0.9 m in height, the freeing-port area may be decreased by the same ratio. Where sheer is less than standard, the percentage is to be obtained by interpolation.

(b) Basic Area for Craft Less Than 24 meters in Length

Freeing ports may comply with the requirements of a recognized standard acceptable to CR in lieu of the requirements stated in 2.11.2(a) of this Chapter.

(c) Trunks, Deckhouses and Hatchway Coamings

Where a craft is fitted with a trunk on the freeboard deck, and open rails are not fitted in way of the trunk for at least one-half its length, or where continuous or substantially continuous hatchway side coamings are fitted or long deckhouse exist between detached superstructures, the minimum area of freeing-port openings is to be obtained from the following table:

Breadth of Trunk, Deckhouse or Hatchway in Relation to Breadth of Craft	Area of Freeing Ports in Relation to Total Area of Bulwarks
40% or less	20%
75% or more	10%

The area of freeing ports at intermediate breadths is to be obtained by linear interpolation.

(d) Superstructure Decks

Where bulwarks on superstructure decks form wells, the bulwarks are to comply with 2.11.2(a) of this Chapter except that the minimum freeing-port area on each side of the craft for each well is to be one-half of the area obtained in 2.11.2(a) and 2.11.2(b) of this Chapter.

(e) Open Superstructures

In craft having superstructures that are open at either end or both ends, adequate provisions for freeing the spaces within such superstructures are to be provided; the arrangements will be subject to special approval.

(f) Details of Freeing Ports

The lower edges of freeing ports are to be as near the deck as practicable. Two-thirds of the freeing port area required is to be provided in the half of the well nearest the lowest point of the sheer curve. One third of the freeing port area required is to be evenly spread along the remaining length of the well. With zero or little sheer on the exposed freeboard deck or an exposed superstructure deck the freeing port area is to be evenly spread along the length of the well.

All freeing port openings in the bulwarks are to be protected by rails or bars spaced approximately 230 mm apart. If shutters are fitted to freeing ports, ample clearance is to be provided to prevent jamming. Hinges are to have pins or bearings of non-corrodible material. Shutters are not to be fitted with securing appliances.

2.11.3 Portlights

(a) Location

No portlight is to be fitted in a position with its sill below a line drawn parallel to the freeboard deck at side and having its lowest point less than 2.5% of the craft breadth above the maximum load waterline or 500 mm, whichever is greater. In addition, portlights are not to be fitted in spaces which are used for the carriage of cargo.

(b) Construction

Portlights fitted below the main weather deck or in superstructure and house side plating are to be of substantial construction and provided with steel, aluminum or other approved material inside deadlights, permanently attached and arranged to be capable of being closed and secured watertight. Except in way of the machinery space, portlights may be of the hinged opening type, with hinge pins of noncorrosive material. Where vessels are subject to damaged stability requirements of 3.1.2(b) of this Part, portlights found to be situated below a final damage equilibrium waterline are to be of the non-opening type. Portlight frames are to be of steel or other approved material and are to be attached to the hull by through bolts or equivalent. Lower edges of portlights are not to be below a line parallel to the main weather deck at side having its lowest point at a distance above the design waterline either 2.5% of the craft breadth or 500 mm whichever is greater.

For craft limited in service range and weather conditions and not receiving a Load Line Certificate, consideration will be given to the omission of deadlights depending on the type and thickness of the portlight.

The thickness of portlights of tempered or toughened monolithic safety glass is to be not less than given in Table III 2-31 of this Chapter. Consideration will also be given to laminated glass, acrylic and polycarbonate glazing materials based upon equivalent flexural strength and stiffness. See Table III 2-33 of this Chapter for glazing mechanical properties.

In addition to the above, where the craft is assigned a load line in accordance with the International Convention on Load Lines, 1966 (as amended), portlights and deadlights are to meet the requirements of Regulation 23 of the Convention.

(c) Testing

All portlights are to be hose tested in position under a water pressure of at least 2 bar.

The flexural strength of the glass is to be verified by compliance with the proof load in ISO 614.

Table III 2-31
Thickness of Tempered or Toughened Monolithic Glass Portlights

Location	Rounded Portlights		Rectangular Portlights	
	General	Limited Service Craft	General	Limited Service Craft
Side Shell below main weather deck	0.050d	0.040d	$0.091s\sqrt{k}$	$0.073s\sqrt{k}$
Superstructure or deckhouse on main weather deck	0.033d	0.033d	$0.060s\sqrt{k}$	$0.060s\sqrt{k}$
Deckhouse above main weather deck	0.025d	0.025d	$0.045s\sqrt{k}$	$0.045s\sqrt{k}$

Notes:

(1) d is taken as the diameter between inner edges of the portlight frame in mm.

(2) For calculations of required thickness on limited service craft, d is not to be taken less than 250 mm.

(3) k is to be taken from Table III 2-32 of this Chapter; s is the short panel dimension and l is the long window dimension.

2.11.4 Windows

(a) Construction

Windows are defined as being rectangular openings generally, or oval, openings with an area exceeding 0.16 m^2.

Windows to spaces within enclosed superstructure and deckhouses are to be fitted with strong steel, aluminum or other approved material, storm shutters. Windows are not to be fitted below the freeboard deck. Windows are not to be fitted in the first tier end bulkheads or sides of enclosed superstructures. Windows are not to be fitted in first tier deckhouses considered buoyant in the stability calculations or protecting openings leading below. Window frames are to be of steel or other approved material and are to be attached by through bolts or equivalent.

Windows on the second tier above the freeboard deck may not require deadlights depending upon the arrangement of the craft. Window frames are to be metal or other approval material, and effectively secured to the adjacent structure. Windows are to have a minimum of a 1/4 inch radius at all corners. The glazing is to be set into the frames in a suitable, approved packing or compound. Special consideration to be given to angled house fronts.

For externally fitted storm covers an arrangement for safe and easy access is to be provided.

For craft limited in service range and weather conditions and not receiving a Load Line Certificate, consideration will be given to the omission of deadlights depending on the location, type and thickness of the windows.

In addition to the above, where the craft is assigned a load line in accordance with the International Convention on Load Lines, 1966 (as amended), windows and storm shutters are to meet the requirements of Regulation 23 of the Convention.

The thickness of the window is not to be less than that obtained from 2.11.4(a)(i), 2.11.4(a)(ii) or 2.11.4(a)(iii) below, whichever is greater.

(i)

$$t = s\left(\sqrt{\frac{pk}{1000\sigma_a}}\right) \quad \text{mm}$$

(ii)

$$t = s\left(\sqrt[3]{\frac{pk_1}{20E}}\right) \quad \text{mm}$$

(iii) Minimum Tempered Monolithic Glass Thicknesses:

t = 9.5 mm for front windows

t = 6.5 mm for side and end windows

where

t = required window thickness, in mm (in.)

s = lesser dimension of window, in mm (in.)

p = pressure head for window location as determined by 2.2.4

k = factor given in Table III 2-32 of this Chapter

k_1 = factor given in Table III 2-32 of this Chapter

σ_a = $0.30\sigma_f$

σ_f = material flexural strength; see Table III 2-33 of this Chapter

E = material flexural modulus; see Table III 2-33 of this Chapter

Table III 2-32

l/s	k	k_1
>5	0.750	0.142
5	0.748	0.142
4	0.741	0.140
3	0.713	0.134
2	0.610	0.111
1.8	0.569	0.102
1.6	0.517	0.091
1.4	0.435	0.077
1.2	0.376	0.062
1	0.287	0.044

Note: *s* = lesser dimension of window panel, in mm
l = greater dimension of window panel, in mm

Intermediate values may be determined by linear interpolation.

Table III 2-33

Glazing	Flexural Strength	Flexural Modulus
Tempered Monolithic	119 MPa	73,000 MPa
Laminated Glass	69 MPa	2,620 MPa
Polycarbonate*	93 MPa	2,345 MPa
Acrylic (PMMA)*	110 MPa	3,000 MPa

* Special considerations will be made with regards to design, manufacture and testing of glass specimens.

(b) Testing

All windows are to be hose tested in position under a water pressure of at least 2 bar.

The flexural strength of the glass is to be verified by compliance with the proof load in ISO 614.

2.11.5 Ventilators, Tank Vents and Overflows

(a) General

Ventilators are to comply with the requirements of 2.11.5(b) below. Tank vents and overflows are to comply with the requirements in 2.11.5(c) below. In addition, for those located on the fore deck of craft with length L (as defined in 1.1.2 of this Part) not less than 80 meters, the requirements given in 2.11.5(d) below are to be complied with.

(b) Ventilators

(i) Coaming Construction

Ventilators on exposed freeboard decks, superstructure decks, or deckhouses are to have coamings of steel or equivalent material. Coaming plate thicknesses for steel are to be obtained from the following equation:

$$t = 0.01\mathrm{d} + 5.5 \qquad \text{mm}$$

where:

t = thickness of coaming, in mm

d = diameter of ventilator, in mm, but not less than 200 mm

The maximum steel coaming plate thickness required is 10 mm. The coamings are to be effectively secured to the deck. Coamings which are more than 900 mm high and which are not supported by adjacent structures are to have additional strength and attachment. Ventilators passing through superstructures other than enclosed superstructures are to have substantially constructed coamings of steel or equivalent material at the freeboard deck. Where a fire damper is located within a ventilation coaming, an inspection port or opening at least 150 mm in diameter is to be provided in the coaming to facilitate survey of the damper without disassembling the coaming or the ventilator. The closure provided for the inspection port or opening is to maintain the watertight integrity of the coaming and, if appropriate, the fire integrity of the coaming.

Coaming plate thickness of material other than steel will be specially considered.

(ii) Coaming Height

Ventilators in Position 1 are to have coamings at least 900 mm high. Ventilators in Position 2 are to have coamings at least 760 mm high. For definitions of Position 1 and Position 2, see 2.9.2 of this Chapter.

(iii) Means for Closing Ventilators

Except as provided below, ventilator openings are to be provided with efficient, permanently attached closing appliances. In craft measuring 24 m or more in length (as defined in the International Convention on Load Lines, 1966), ventilators in Position 1, the coamings of which extend to more than 4.5 m above the deck and in Position 2, the coamings of which extend to more than 2.3 m above the deck, need not be fitted with closing arrangements.

These coaming height requirements may be modified in craft measuring less than 24 m in length.

(c) Tank Vents and Overflows

Tank vents and overflows are to be in accordance with the following requirements and, where applicable, the requirements given below in 2.11.5(d) of this Chapter.

(i) Vent Pipes

Except for comparatively small compartments that are not fitted with a fixed means of drainage, vent pipes are to be fitted to all tanks, cofferdams, voids, tunnels and compartments which are not fitted with other ventilation arrangements. In all craft, the structural arrangement in double- bottom and other tanks

is to be such as to permit the free passage of air and gases from all parts of the tanks to the vent pipes. Each tank is to be fitted with at least one vent pipe which is to be located at the highest part of the tank. Vent pipes are to be arranged to provide adequate drainage under normal conditions. No shutoff valve or closing device that can prevent the venting from a tank is to be installed in vent piping.

(ii) Overflow Pipes

(1) General Requirements
Overflow pipes discharging through the craft's side are to be located as far above the deepest load line as practicable and are to be provided with nonreturn valves located on the craft's side. Where the overflow does not extend above the freeboard deck, there is to be provided, in addition, an efficient and accessible means for preventing water from passing inboard. Such means may consist of another nonreturn valve located in an accessible position above the deepest load line. Where it is impracticable to locate the inner valve in an accessible position, one nonreturn valve with positive means for closing from an accessible position above the freeboard or bulkhead deck will be acceptable, provided there are suitable arrangements to insure the valve not being closed by unauthorized persons and provided a notice is posted in a conspicuous place at the operating station to the effect that the valve is never to be closed, except as may be required in an emergency.

(2) Overflows from Combustible and Flammable Liquid Tanks
Overflow pipes from combustible and flammable liquid tanks are to be led to an overflow tank or to a storage tank with sufficient excess capacity (normally 5 minutes at transfer pump capacity) to accommodate the overflow. An alarm device is to be provided to give warning when the liquid reaches a predetermined level in the overflow tank. If a sight flow glass is also provided in the overflow pipe, then such sight glasses are to be fitted only in vertical sections of overflow pipes and be in readily visible positions.
For craft in which the overflow of fluid from tanks containing combustible and flammable liquids is accomplished via overflow through the tanks vent, there is to spill containment provided at the outlet of the vent with a minimum capacity of 1 / 2 barrel (0.079 m^3, 21 gal.) for each vent.

(3) Overflow Common Header
Where overflows from the tanks in more than one watertight subdivision are connected to a common header below the freeboard or bulkhead deck, the arrangement is to be such as to prevent fore-and-aft flooding of one watertight bulkhead subdivision from another in the event of damage.

(4) Fuel Oil Overflow (2018)
Where a common vent/overflow header is provided for fuel oil storage and day tanks, the vent/overflow header need not be fitted with a separate vent pipe leading directly to atmosphere. The individual tanks and the common vent/overflow header may be vented through the overflow tank vent line to atmosphere, provided the common vent/overflow header arrangement has the following features/conditions:

a) Each vent/overflow line from the tank to the common header, the vent/overflow common headers and the vent line from the overflow tank to the atmosphere are to be sized in order to provide a venting area of at least 125% of the effective fill line area of the shore filling line or onboard transfer line, whichever is greater. Fuel oil tank scantlings are to consider the height of the overflow tank vent.

b) Each storage tank is to be fitted with a high level alarm and a high-high level alarm. Both level alarms are to provide visual and audible indication of the alarm condition at a manned station (such as wheel house, engine control room or an equivalent station) from where filling/transfer operation is controlled.

c) The drop lines from the common headers to the overflow tank are to terminate above the maximum liquid level in the overflow tank (i.e., above the alarm point where the liquid reaches a predetermined level in the overflow tank to give the high level warning).

d) The venting arrangement of the overflow tank is to permit the free passage of air from the individual tanks, the vent/overflow headers and the overflow tank vent to atmosphere under all conditions

e) The storage tanks are not to be filled by using a cascade filling arrangement (i.e., tanks are not to be filled by overflowing from one to another).

f) The fueling station(s) is to be manned at all times during bunkering and/or fuel oil transfer operations.

g) In lieu of items a) through f), the overflow line common header may be vented to the atmosphere in accordance with the requirements below, in addition to the overflow tank being fitted with a dedicated vent pipe.

i) Vent pipes are to have a minimum internal diameter not less than 38 mm and not less than the internal diameter of the fill line. Where tanks are to be filled by pump pressure, the aggregate area of the vents in the tank is to be at least 125% of the effective area of the filling line, except that when overflows are fitted, the area of the overflow is to be at least 125% of the effective area of the filling line and the vents need not exceed the above minimum size.

ii) Notwithstanding the above, the pump capacity and pressure head are to be considered in the sizing of vents and overflows. When high capacity and/or high head pumps are used, calculations demonstrating the adequacy of the vent and overflows are to be submitted.

(d) Ventilators, Tank Vents and Overflows on the Fore Deck

(i) Application

The requirements of this paragraph applies to all ventilators, tank vents and overflows located on the exposed fore deck within the forward 0.25L on craft with length L (as defined in 1.1.2 of this Part) not less than 80 meters and where the height of the exposed deck in way of the item is less than 0.1L or 22 meters above the summer load waterline, whichever is the lesser.

(ii) Applied Loading to the Air Pipes and Ventilators

(1) Pressure. The pressures p, in kN/m^2, acting on air pipes, ventilator pipes and their closing devices, may be calculated from:

$$p = f\rho V^2 C_d C_s C_p \qquad \text{kN/m}^2$$

where:

f = 0.5

ρ = density of sea water, 1.025 t/m^3

V = velocity of water over the fore deck, 13.5 m/sec

C_d = shape coefficient

= 0.5 for pipes

= 1.3 for pipes or ventilator heads in general

= 0.8 for pipes or ventilator heads of cylindrical form with its axis in the vertical direction

C_s = slamming coefficient, 3.2

C_p = protection coefficient:

= 0.7 for pipes and ventilator heads located immediately behind a breakwater or forecastle

= 1.0 elsewhere including immediately behind a bulwark

(2) Force. Forces acting in the horizontal direction on the pipe and its closing device may be calculated from the above pressure using the largest projected area of each component.

(iii) Strength Requirements for Ventilators, Tank Vents and Overflows and their Closing Devices

(1) Bending Moment and Stress. Bending moments and stresses in air pipes and ventilator pipes are to be calculated at critical positions: at penetration pieces, at weld or flange connections, at toes

of supporting brackets. Bending stresses in the net section are not to exceed 0.8Y, where Y is the specified minimum yield stress or 0.2% proof stress of the steel at room temperature. Irrespective of corrosion protection, a corrosion addition to the net section of 2.0 mm is then to be applied.

(2) Tank Vents and Overflows

a) For standard tank vents and overflows of 760 mm height closed by heads of not more than the tabulated projected area, pipe thicknesses and bracket heights are specified in Table III 2-34 of this Chapter. Where brackets are required, three or more radial brackets are to be fitted.

b) Brackets are to be of gross thickness of 8 mm or more, of minimum length of 100 mm, and height according to Table III 2-34 of this Chapter, but need not extend over the joint flange for the head. Bracket toes at the deck are to be suitably supported.

c) For other configurations, loads according to 2.11.5(d)(ii) of this Chapter are to be applied, and means of support determined in order to comply with the requirements above. Brackets, where fitted, are to be of suitable thickness and length according to their height.

d) Final (gross) pipe thickness for air pipes is not to be taken less than as indicated below. The wall thicknesses of vent pipes where exposed to the weather are to be not less than that specified below. For vent pipes located on the fore deck, as defined in 2.11.5(d)(i) of this Chapter, the wall thickness requirements are to also comply with 2.11.5(d)(ii) and 2.11.5(d)(iii) of this Chapter:

Nominal Size, d	Min. Wall Thickness
$d \leq 65$ mm	6.0 mm
65 mm < d < 150 mm	6+0.0029(d-65)
$d \geq 150$ mm	8.5 mm

e) The minimum internal diameter of the air pipe or overflow is not to be less than 38 mm.

(3) Ventilators

a) For standard ventilators of 900 mm height closed by heads of not more than the tabulated projected area, pipe thicknesses and bracket heights are specified in Table III 2-35 of this Chapter. Brackets, where required, are to be as specified in 2.11.5(d)(iii)(2)b) of this Chapter.

b) For ventilators of height greater than 900 mm, brackets or alternative means of support are to be provided. Coaming is not to be taken less than as indicated in 2.11.5(b) nor in Table III 2-34 of this Chapter.

(4) Components and Connections. All component parts and connections of the tank vents and overflows or ventilators are to be capable of withstanding the loads defined in 2.11.5(d)(ii) of this Chapter.

(5) Rotary Heads. Rotating type mushroom ventilator heads are not to be used for application in this location.

Table III 2-34
760 mm High Tank Vents and Overflows Thickness and Bracket Standards

Nominal Pipe Size (mm)	Minimum Fitted Gross Thickness (mm)	Maximum Projected Area of Head (cm^2)	Height [(1)] of Brackets (mm)
65	6.0	---	480
80	6.3	---	460
100	7.0	---	380
125	7.8	---	300
150	8.5	---	300
175	8.5	---	300
200	8.5[(2)]	1900	300[(2)]
250	8.5[(2)]	2500	300[(2)]
300	8.5[(2)]	3200	300[(2)]
350	8.5[(2)]	3800	300[(2)]
400	8.5[(2)]	4500	300[(2)]

Notes:

(1) Brackets [see 2.11.5(d)(iii)(2) of this Chapter] need not extend over the joint flange for the head.

(2) Brackets are required where the as fitted (gross) thickness is less than 10.5 mm, or where the tabulated projected head area is exceeded.

Note: For other air pipe heights, the relevant requirements of 2.11.5(d)(iii) of this Chapter are to be applied.

Table III 2-35
900 mm High Ventilator Thickness and Bracket Standards

Nominal Pipe Size (mm)	Minimum Fitted Gross Thickness (mm)	Maximum Projected Area of Head (cm^2)	Height [(1)] of Brackets (mm)
80	6.3	-	460
100	7.0	-	380
150	8.5	-	300
200	8.5	550	-
250	8.5	880	-
300	8.5	1200	-
350	8.5	2000	-
400	8.5	2700	-
450	8.5	3300	-
500	8.5	4000	-

Note: For other ventilator heights, the relevant requirements of 2.11.5(d)(iii) of this Chapter are to be applied.

2.12 Protective Coatings

2.12.1 General

Unless otherwise approved, all steel work is to be suitably coated with paint or equivalent. No final painting or coating is to be performed until all surveys and testing have been completed. All areas not being coated are to be protected during painting, and upon completion of the work any paint accidentally applied to the areas are to be removed.

2.12.2 Preparation

Surfaces that are to be painted are to be completely free of rust, loose paint, dirt, scale, oil, grease, salt deposits, and moisture. Protective coatings are to be applied as soon as practical after cleaning before corrosion or soil forms on the cleaned surface.

If more than seven days elapse between epoxy coats, the surface should be cleaned prior to an application of a tack coat (1-2 wet mils) before the application of the next full coat.

2.12.3 Protection of Steel

(a) Preparation

All steel surfaces that will be coated are to be abrasive blast cleaned. Prior to abrasive blast cleaning, surfaces contaminated with oil or grease are to be cleaned and weld splatters, slag, and flux compounds are to be removed by grinding, sanding, or chipping. In areas where abrasive blasting is not feasible, the surfaces are to be cleaned by mechanical means to remove foreign matter.

Galvanized steels shall be roughened with a light abrasive blast or by mechanical means prior to painting.

(b) All Spaces

Unless otherwise approved, all steel work is to be suitably coated with paint or equivalent.

(c) Salt Water Ballast Space

Tanks or holds for salt water ballast are to have a corrosion-resistant hard type coating such as epoxy or zinc on all structural surfaces. Where a long retention of salt water is expected due to the type of craft or unit, special consideration for the use of inhibitors or sacrificial anodes may be given.

(d) Oil Spaces

Tanks intended for oil need not be coated.

2.12.4 Protection of Aluminum

(a) General

Aluminum alloys intended for hull construction are to be used generally only under conditions that will not induce excessive corrosion. Where exposure to environment that would induce excessive corrosion is expected, suitable coatings, tapes, sacrificial anodes, impressed-current systems or other corrosion prevention measures are to be used. When tapes are used for corrosion protection, they are to be non-wicking and non- water absorbing. Grease containing graphite is not to be used with aluminum, instead, zinc or other suitable base grease is to be used.

(b) Preparation

All aluminum surfaces that will be coated are to be thoroughly cleaned to bare metal, free of corrosion products, dirt, and other contaminants, by light abrasive blasting. Spot cleaning after blasting can be done by power brushing or orbital sanding.

(c) Coatings

Coatings are to be applied in accordance with the manufacturer’s instructions, and are to be preceded by appropriate cleaning and possibly chemical conversion of surfaces as may be required in accordance with the manufacturer’s recommendations. Coatings are to be free from voids, scratches or other imperfections that are potential sites for localized corrosion.

The composition of coatings is to be compatible with aluminum. Coatings containing copper, lead, mercury or other metals that can induce galvanic or other forms of corrosion are not to be used. Zinc chromate coatings may be used. Insulating coatings intended to prevent galvanic corrosion are not to contain graphite or other conducting materials.

(d) Faying Surfaces – Aluminum to Aluminum

Aluminum faying surfaces that will be exposed to weather, seawater, or other corrosive environment are to be suitable coated to minimize crevice corrosion in way of the faying surfaces.

(e) Faying Surface between Aluminum and Other Metals

(i) Hull

Suitable means are to be taken to avoid direct contact of faying surfaces of aluminum to other metals. When such faying surfaces occur in hull construction, suitable non-wicking and non-water absorbing insulation tapes or coatings are to be used. Faying surfaces between mechanically fastened metal components, except machinery foundations, are to be protected by the use of bedding compounds or adhesives. Other types of joints between aluminum and other metals may be approved in certain applications.

(ii) Piping

Suitable means, such as special pipe hangers, are to be used to avoid conductive connections between aluminum hulls and non-aluminum metal piping systems. Where watertightness is required, such as when piping passes through bulkheads, decks, tanktops, and shell, special fittings will be required to maintain isolation between dissimilar metals.

(iii) Bearing Areas

Bearing areas such as engine beds, pump foundations, propeller shafts, rudder and other appendages of metals other than aluminum are to be suitably isolated by such means as non-metallic bearing casing, non-conductive packing (not containing graphite or other conductors) or suitable tapes and coatings. Alternative methods for minimizing corrosion at these locations will be specially considered. Wicking-type tapes or water-absorbing packing materials such as canvas should not be used. The metals used for such applications are to be selected to minimize galvanic effects; stainless steels are to be considered.

The use of copper-base alloys such as brass or bronze is generally not recommended where galvanic corrosion is of concern, and these materials may only be used when specially approved. In those cases where the use of dissimilar metals cannot be avoided, or where galvanic corrosion is of concern, such as in wet tanks, a suitable sacrificial anode or impressed current system should be installed.

(f) Faying Surface between Aluminum and Non-metals

Aluminum in contact with wood or insulating-type material is to be protected from the corrosive effects of the impurities in these materials by a suitable coating or covering. Concrete used with aluminum is to be free of additives for cold weather pouring. Preformed glass insulation is recommended for piping insulation. Any adhesives which may be used to connect insulation to aluminum are to be free of agents that would be corrosive to aluminum. Foaming agents harmful to aluminum, such as Freon, are not to be used for insulating foams. Areas where dirt or soot is likely to collect and remain for prolonged periods are to be protected from pitting corrosion by the use of coatings or other suitable means.

(g) Corrosion of Wet Spaces

Suitable means are to be used to avoid arrangements that could induce crevice corrosion in wet spaces. In bilge spaces, chain lockers, and similar locations where exfoliation corrosion may be of concern, appropriate materials suitably heat treated for resistance to this form of corrosion are to be employed.

(h) Service at Elevated Temperatures

For service temperatures of 66°C or above, only aluminum alloys and filler metals specially designated for service at these temperatures are to be used.

(i) Cathodic Protection for Corrosion Prevention

For application where corrosion is of concern, consideration is to be given to the use of sacrificial anode or impressed current systems of corrosion control. Details of sacrificial anodes and arrangements are to be submitted for review. Anodes are to be in accordance with national or other recognized standard. When

impressed current systems are used, adequate precautions are to be taken that the negative voltage is not excessive.

(j) Stray Current Protection

Precautions are to be taken when in dock to prevent stray currents from welding power or other sources from adversely affecting the aluminum. Whenever possible, the cathodic protection system of the craft should be in place and operating when the craft is in the water. AC power sources are to be insulated from the hull. For battery and other DC power sources, grounding is to be avoided if possible. Where safety considerations require grounding to the hull, the negative pole is to be connected to the hull.

(k) Bi-material Joints

Such joints, when used, may be required to be appropriately painted, coated, wrapped or protected by other methods to prevent galvanic corrosion. Where aluminum is to be joined to other materials, each faying surface is to be suitably coated to minimize corrosion. In addition, when one or both sides of an aluminum or steel connection to dissimilar metal joints are exposed to weather, sea water, or wet spaces, a minimum of 0.5 mm of suitable insulation is to be installed between faying surfaces and extended beyond the edge of the joint. Non-welded oil or water stops are to be of plastic insulation tape or equivalent which would provide a suitably corrosion resistant system. Insulating materials are to be non-porous and have mechanical properties suitable for the application.

2.12.5 Protection of Fiber Reinforced Plastic

(a) General

Cured gel-coat resins and lay-up resin are to be highly resistant to water and other liquid absorption; appropriate materials, lay-up, and lay-up procedures are to be used and manufacturer's recommendations followed to attain this. Care is to be taken in the use of laminates containing carbon fibers so that they are not close to or do not induce galvanic corrosion with metal fittings.

(b) Preparation

Composite surfaces that are not coated in the mold are to be sanded lightly to remove any foreign matter. Care is to be taken not to expose any of the structural glass. Surfaces are to be cleaned with water and solvent to ensure the removal of residual mold release compound, oil, or grease.

(c) Tanks

In water, fuel oil, or other approved tanks, the resins used are to be compatible with the contents of the tanks; the contents of the tanks are not to affect the cured properties of the tank laminate. The cured laminate is to be highly resistant to absorption of the liquid, and is not to have harmful, deleterious, or undesirable effects on the contents of the tank. The tank is generally to be gel-coated on the inside. See also 2.5.3(a) of this Chapter.

(d) Cathodic Protection

Cathodic protection is to be provided where shaft struts, propeller shafts, propellers, rudders, fittings, etc. are constructed of manganese bronze, brass, stainless steel or mild steel. Details of the sacrificial anodes and arrangements are to be submitted for review. Anodes are to be in accordance with ASTM or other recognized standard.

Chapter 3
Subdivision and Stability

3.1 General Requirements

3.1.1 General

Craft of the following categories are to have subdivision and stability in accordance with the criteria as shown.

3.1.2 Criteria

(a) Intact Stability

All craft which have a length of 24 m or over as defined in the International Convention on Load Lines are to have intact stability guidance as required by Regulation 10 of the International Convention on Load Lines. Following criteria may be used for classification purposes:

(i) For all cargo craft ≥ 500 GT making voyages that are no more than 8 hours at operational speed from a place of refuge and having design speeds greater than $3.7\nabla^{1/6}$ m/sec – IMO International Code of Safety for High-Speed Craft – Chapter 2.

(ii) For all passenger craft making voyages that are no more than 4 hours at operational speed from a place of refuge and having design speeds greater than $3.7\nabla^{1/6}$ m/sec – IMO International Code of Safety for High-Speed Craft – Chapter 2.

(iii) Other craft of all sizes – International Code on Intact Stability (2008 IS Code)

where

∇ = volumetric displacement of the vessel in the design condition m^3

GT = the gross tonnage as defined in 1.1.15 of this Part

In case the above criteria are not applicable to a particular craft, the intact stability will be reviewed by CR in accordance with other recognized criteria appropriate to the craft's type, size, and intended service.

(b) Subdivision and Damage Stability

Craft of applicable size, type, and service are to have subdivision and damage stability as required by the International Code of Safety for High-Speed Craft, or the International Convention for the Safety of Life at Sea, 1974, as amended as follows:

(i) Passenger craft making voyages that are no more than 4 hours at operational speed and having design speeds greater than $3.7\nabla^{1/6}$ m/sec – IMO International Code of Safety for High-Speed Craft – Chapter 2.

(ii) Other passenger craft – SOLAS Regulation II-1/4 through 8.

(iii) Cargo craft ≥ 500 GT making voyages that are no more than 8 hours at operation speed and having design speeds greater than $3.7\nabla^{1/6}$ m/sec – IMO International Code of Safety for High-Speed Craft – Chapter 2.

(iv) Other cargo craft ≥ 500 GT – SOLAS Regulation II-1/4 through 7-3.

3.1.3 Onboard Computers for Stability Calculations

The use of onboard computers for stability calculations is not a requirement of class. However, if stability software is installed onboard craft contracted on or after 1 July 2005, it should cover all stability requirements applicable to the craft and is to be approved by CR for compliance with the requirements of Appendix 4 of this Part, "Onboard Computers for Stability Calculations".

Chapter 4

Fire Safety Measures

4.1 Structural Fire Protection

4.1.1 General

(a) SOLAS Application

For classification purposes, the fire and safety measures contained in the International Convention for the Safety of Life at Sea, 1974 (1974 SOLAS), as amended, are applicable to vessels of type, size and service coming under that Convention. This includes the IMO International Code of Safety for High-Speed Craft (HSC Code), incorporated as Chapter X of 1974 SOLAS, as applicable.

This section does not relax the requirements in other sections of the Rules. Gross tonnage is to be taken as defined in 1.1.15 of this Part.

(b) Regulation

Regulation means the regulation contained in 1974 SOLAS, as amended. An abbreviated notation is used, e.g., Regulation II-2/5.2 means Regulation 5.2 of Chapter II-2.

(c) Definitions

See Regulation II-2/3.

(d) Materials Containing Asbestos

Installation of materials which contain asbestos is prohibited.

(e) For a craft not engaged in international voyage, if the requirements of the Rules are not fully applicable, the relevant drawings and documents are to be submitted to the Society for evaluation of approved alternative requirements, equipment or methods. The alternatives may be accepted by the Society for special consideration.

4.1.2 Passenger Craft

For passenger craft engaged in international voyage as defined in 1.1 through 1.4 of the HSC Code, the relevant requirements in Chapter 7, Part A and Part B of the HSC Code are applicable. See also Part V Chapter 1.

For all passenger craft subject to 1974 SOLAS as amended, see Part IX of the Rules for Steel Ships.

4.1.3 Cargo Craft

For cargo craft as defined engaged in international voyage in 1.1 through 1.4 of the HSC Code, the relevant requirements in Chapter 7, Part A, Part C and Part D of the HSC Code are applicable.

For all cargo craft subject to 1974 SOLAS as amended, see Part IX of the Rules for Steel Ships.

4.1.4 Light Structure Craft (LSC)

Structural fire safety measures for crafts not engaged in international voyage with LSC notation are to be in accordance with Table I 1-5 in Part I of the Rules.

Chapter 5

Equipment

5.1 Equipment

5.1.1 Documents to be submitted

A detailed drawing, showing all the elements necessary for the evaluation of the equipment number of the craft, is to be submitted together with the calculations of the EN number. The anchoring equipment to be fitted on the concerned craft is to be specified.

Windlass, brake and chain stopper are subject to approval by the Society, the relevant documentation is to be submitted.

5.1.2 General

(a) The anchoring equipment required in 5.1.3 is intended for temporary, occasional mooring of a craft within a harbour or sheltered area when the craft is awaiting berth, tide, etc.

(b) The equipment is therefore not designed to hold a craft off fully exposed coasts in rough weather or to stop a craft which is moving or drifting. In this condition the loads on the anchoring equipment increase to such a degree that its components may be damaged or lost owing to the high energy forces generated, particularly in large craft.

(c) For craft where frequent anchoring in open sea is expected, the owner's and shipyard's attention is drawn to the fact that anchoring equipment should be provided in excess of the requirements of these Rules.

(d) The anchoring equipment required in 5.1.3 is designed to hold a ship in good holding ground in conditions such as to avoid dragging of the anchor. In poor holding ground the holding power of the anchors will be significantly reduced.

(e) For small craft, with a length L ≤ 25 m, some partial exemption from these Rules may be accepted especially for what concerns anchor operation; in particular, where proper and safe anchor operation is assured, hand-operated machinery and/or absence of hawse pipe may be accepted.

5.1.3 Equipment number

(a) General

(i) The equipment is in general to be in accordance with the requirements given in Table III 5-1, and may be reduced as per Table III 5-2 in accordance with the ship's Service Restriction Notation.

(ii) When two bow anchors are fitted, the mass of each anchor, the diameter and the length of each chain cable are to comply with the requirements given in Table III 5-1.

(iii) The equipment number EN is to be calculated as follows:

$$EN = \Delta^{2/3} + 2BH + 0.1A$$

where

Δ	=	the maximum displacement	t
H	=	effective height from the summer load waterline to the top of the uppermost deckhouse, to be measured as follows: $H = a + \sum h_i \sin\theta_i$	m
a	=	the distance from summer load water line amidships to the upper deck at side	m

h_i	=	the height on the centerline of each tier of deck houses having an actual breadth greater than B/4, where B is the breadth as defined in 1.1.4 of this Part	m
θ_i	=	the angle of inclination aft of each front bulkhead as shown on Fig. III 5-1	
A	=	the area in profile view of the hull superstructures and deck houses above the summer load waterline which is within the rule length of the craft defined in 1.1.2 of this Part and with a breadth greater than B/4.	m^2

In the measurement of Σh_i and A, sheer and trim are to be ignored.

If a deck house broader than B/4 is placed on top of another deck house equal to or less than B/4 in breadth, only the widest is to be considered and the narrowest may be ignored.

Windscreens or bulwarks and hatch coamings more than 1.5 m in height above the deck at side are to be regarded as parts of superstructures and houses when determining H and A.

In the calculation of A, when a bulwark is more than 1.5 m in height, the crosshatched area of Fig. III 5-1 is to be considered.

For catamarans, the cross-sectional area of the tunnel above the waterline may be deducted from BH in the formula.

5.1.4 Anchor

(a) Mass of anchors

(i) Table III 5-1 indicates the mass of a "high holding power anchor" (HHP) i.e. anchor having a holding power equal to, at least, two times greater than that of an ordinary anchor.

(ii) "Super high holding power anchors" (SHHP), i.e. anchors having a holding power equal to, at least, four times that of an ordinary anchor, may be used as indicated in Table III 5-1.

(iii) The actual mass of each anchor may vary within (+7, -7) percent of the value shown in the table, provided that the total mass of anchors is not less than would have been required for anchors of equal mass.

(iv) Normally HHP or SHHP anchors are to be used. Possible use of ordinary anchors would be specially considered by the Society.

(b) Anchor design

(i) Anchors are to have appropriate shape and scantlings in compliance with Society requirements and are to be constructed in compliance with Society requirements.

(ii) A high or super high holding power anchor is to be suitable for use on board without any prior adjustment or special placement on the ground.

(iii) For approval and/or acceptance as a high or super high holding power anchor, the anchor is to have a holding power equal, respectively, to at least twice or four times that of an ordinary stockless anchor of the same mass.

(iv) Comparative tests on ordinary stockless anchors are to be carried out at sea and must provide satisfactory results on various types of sea beds.

Alternatively sea trials by comparison with a previously approved HHP anchor may be accepted as a basis for approval.

Such tests are to be carried out on anchors whose masses are, as far as possible, representative of the full range of sizes proposed for the approval.

At least two anchors of different sizes are to be tested. The mass of the greatest anchor to be approved is not to be in excess of 10 times that of the maximum size tested and the mass of the smallest is to be not less than 0.1 times that of the minimum size tested.

Tests are normally to be carried out by means of a tug, but, alternatively, shore-based tests may be accepted.

The length of the chain cable connected to the tested anchor, having a diameter appropriate to its mass, is to be such that the pull acting on the shank remains practically horizontal. For this purpose a scope of chain cable equal to 10 is deemed normal; however lower values may be accepted.

Three tests are to be carried out for each anchor and type of ground.

The pull is to be measured by means of a dynamometer; measurements based on the bollard pull against propeller's revolutions per minute curve may be accepted instead of dynamometer readings.

Anchor stability and its ease of dragging are to be noted down, whenever possible.

(v) Upon satisfactory outcome of the above tests, the Society will issue a certificate declaring the compliance of "high or super high holding power" anchors with its relevant Rules.

5.1.5 Chain cables

(a) Bow anchors are to be used in connection with stud link chain cables whose scantlings and steel grades are to be in accordance with the requirements of the Society.

(b) Normally grade 2 or grade 3 stud link chain cables are to be used with HHP anchors. In case of SHHP anchors grade 3 chain cables are to be used.

(c) Proposal for use of grade 1 chain cables connected to ordinary anchors will be specially considered by the Society.

(d) For craft with an Equipment Number EN ≤ 205 studless short link chain cables may be used provided that:

(i) steel grade of the studless chain is to be equivalent to the steel grade of the stud chains it replaces, i.e. referring to ISO standard 1834:

- Class M(4) [grade 40] in lieu of grade 2,
- Class P (5) [grade 50] in lieu of grade 3,

(ii) equivalence in strength is to be based on breaking load.

(iii) the studless chain cable meets the requirements of the Society.

(e) The proof loads PL and breaking loads BL, in kN, required for the studless link chain cables are given by the following formulae, where d, in mm, is the required diameter of grade 2 and grade 3 stud chain cables taken from Table III 5-1:

grade 2: $PL2 = 9.807\ d^2\ (44 - 0.08\ d)\ 10^{-3}$

$BL2 = 13.73\ d^2\ (44 - 0.08\ d)\ 10^{-3}$

grade 3: $PL3 = 13.73\ d^2\ (44 - 0.08\ d)\ 10^{-3}$

$BL3 = 19.61\ d^2\ (44 - 0.08\ d)\ 10^{-3}$

(f) The method of manufacture of chain cables and the characteristics of the steel used are to be approved by the Society for each manufacturer. The material from which chain cables are manufactured and the completed chain cables themselves are to be tested in accordance with the appropriate requirements.

(g) Chain cables are to be made of unit lengths ("shots") of 27.5 m minimum joined together by Dee or lugless shackles.

5.1.6 Steel wire ropes for anchors

(a) Steel wire ropes may be used as an alternative to stud link chain cables required in Table III 5-1 when EN ≤ 500, provided that the following requirements are complied with.

(b) The length Lswr of steel wire rope is to be not less than:

$L_{swr} = L_{ch}$ when EN ≤ 130

$L_{swr} = L_{ch}(EN+850)/900$ when 130 < EN ≤ 0

(c) where L_{ch} is the length of stud link chain cable required by the Table III 5-1.

(d) The effective breaking load of the steel wire rope is to be not less than the required breaking load of the chain cable it replaces.

(e) A short length of chain cable having scantlings complying with 5.1.5 is to be fitted between the steel wire rope and the bow anchor. The length of this chain part is to be not less than 12.50 m or the distance from the anchor in its stowed position to the windlass, whichever is the lesser.

5.1.7 Synthetic fibre ropes for anchors

(a) Synthetic fibre ropes may be used as an alternative to stud link chain cables required in Table III 5-1 when $EN \leq 130$, provided that the following requirements are complied with.

(b) Fibre ropes are to be made of polyamide or other equivalent synthetic fibres, excluding polypropylene.

(c) The length Lsfr of the synthetic fibre rope is to be not less than:

$L_{sfr} = L_{ch}$ when $EN \leq 60$

$L_{sfr} = L_{ch}(EN+170)/200$ when $60 < EN \leq 130$

where L_{ch} is the length of stud link chain cable required by the Table III 5-1.

(d) The effective breaking load P_s in kN, of the synthetic fibre rope is to be not less than the following value:

$$P_s = 2.2\ BL^{8/9}$$

where BL, in kN, is the required breaking load of the chain cable replaced by the synthetic fibre rope (BL can be determined by the formulae given in 5.1.5(e)).

(e) A short length of chain cable complying with 5.1.5 is to be fitted between the synthetic fibre rope and the bow anchor.

5.1.8 Attachment pieces

Both attachment pieces and connection fittings for chain cables are to be designed and constructed in such a way as to offer the same strength as the chain cable and are to be tested in accordance with the appropriate requirements.

5.1.9 Arrangement of anchors and chain cables

(a) The bow anchors, connected to their own chain cables, are to be so stowed as to always be ready for use.

(b) Hawse pipes are to be of a suitable size and so arranged as to create, as far as possible, an easy lead for the chain cables and efficient housing for the anchors.

(c) For this purpose chafing lips of suitable form with ample lay-up and radius adequate for the size of the chain cable are to be provided at the shell and deck. The shell plating at the hawse pipes is to be reinforced as necessary.

5.1.10 Windlass

(a) The windlass is to be power driven and suitable for the size of chain cable, and is to have the characteristics stated below.

(b) The windlass is to be fitted in a suitable position in order to ensure an easy lead of the chain cable to and through the hawse pipe; the deck, at the windlass, is to be suitably reinforced.

(c) The windlass is to be able to supply, for at least 30 minutes, a continuous duty pull P_c, in N, corresponding to the grade of the chain cables, given by the following formulae:

- for grade 2 chain cables: $P_c = 42.5\ d^2$ (N)
- for grade 3 chain cables: $P_c = 47.5\ d^2$ (N)

where d is the stud link chain cable diameter of the intended steel grade, in mm.

(d) The windlass unit prime mover is to provide the necessary temporary overload capacity for breaking out the anchor.

The temporary overload capacity or "short term pull" is to be not less than 1.5 times the continuous duty pull P_c for at least 2 minutes.

The speed in this overload period may be lower than the nominal speed specified in 5.1.10(e).

(e) The nominal speed of the chain cable when hoisting the anchor and cable may be a mean speed only and is to be not less than 0.15 m/s.

The speed is to be measured over two shots of chain cable during the entire trip; the test is to commence with 3 shots (82.5 m) of chain fully submerged, or with the longest practicable submerged chain length where the chain length does not allow 3 shots to be paid out.

(f) The windlass is to be provided with a brake having sufficient capacity to stop chain cable and anchor when paying out, even in the event of failure of the power supply.

(g) Windlass and brake not combined with a chain stopper have to be designed to withstand a pull of 80% of the breaking load of the chain cable without any permanent deformation of the stressed parts and without brake slip.

Windlass and brake combined with a chain stopper have to be designed to withstand a pull of 45% of the breaking load of the chain cable.

(h) The stresses on the parts of the windlass, its frame and brake are to be below the yield point of the material used.

The windlass, its frame and the brakes are to be efficiently anchored to the deck.

(i) Performance criteria and strength of windlasses are to be verified by means of workshop testing according to Society Rules.

5.1.11 Chain stopper

(a) A chain stopper is normally to be fitted between the windlass and the hawse pipe in order to relieve the windlass of the pull of the chain cable when the ship is at anchor.

(b) A chain stopper is to be capable of withstanding a pull of 80% of the breaking load of the chain cable; the deck at the chain stopper is to be suitably reinforced.

However, fitting of a chain stopper is not compulsory.

(c) Chain tensioners or lashing devices supporting the weight of the anchor when housed in the anchor pocket are not to be considered as chain stoppers.

(d) Where the windlass is at a distance from the hawse pipe and no chain stopper is fitted, suitable arrangements are to be provided to lead the chain cable to the windlass.

5.1.12 Chain locker

(a) The chain locker is to be of a capacity adequate to stow all chain cable equipment and provide an easy direct lead to the windlass.

(b) Where two anchor lines are fitted, the port and starboard chain cables are to be separated by a steel bulkhead in the locker.

(c) The inboard ends of chain cables are to be secured to the structure by a fastening able to withstand a force not less than 15% nor more than 30% of the breaking load of the chain cable.

In an emergency, the attachments are to be easily released from outside the chain locker.

(d) Where the chain locker is arranged aft of the collision bulkhead, its boundary bulkheads are to be watertight and a drainage system provided.

5.1.13 Anchoring sea trails

(a) The anchoring sea trials are to be carried out on board in the presence of a Society surveyor.

(b) The test is to demonstrate that the windlass complies with the requirements given in 5.1.10(e).

(c) The brake is to be tested during lowering operations.

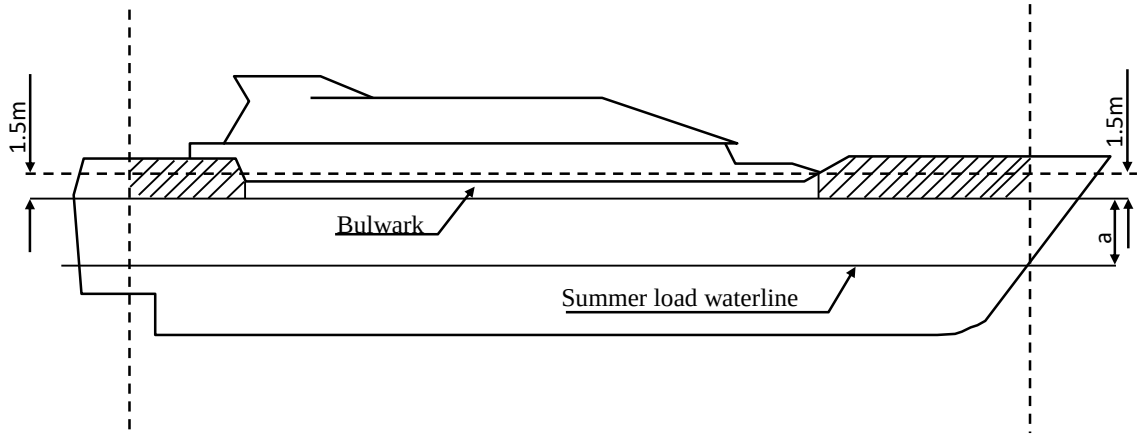


Fig. III 5-1

Table III 5-1
Equipment

Equipment No. EN		Number	Anchors		Stud-link chain cables				Mooring lines	
			Mass per anchor		Total length (m)	Diameter and steel grade			Steel or fibre ropes	
			HHP	SHHP		Grade 1	Grade 2	Grade 3	Minimum number and length	Minimum breaking strength
Over	Up to		(kg)	(kg)		(mm)	(mm)	(mm)	(m)	(kN)
30	39	1	93	62	115	12.5			2 × 40	32
40	49	1	119	79	115	12.5			2 × 40	32
50	59	1	146	97	130	14	12.5		3 × 40	34
60	69	1	171	114	130	14	12.5		3 × 40	34
70	79	1	198	138	130	16	14		3 × 50	37
80	89	1	224	149	130	16	14		3 × 50	37
90	99	1	251	167	150	17.5	16		3 × 55	39
100	109	1	276	184	150	17.5	16		3 × 55	39
110	119	1	303	202	150	19	17.5		3 × 55	44
120	129	1	329	219	150	19	17.5		3 × 55	44
130	139	1	356	237	165	20.5	17.5		3 × 60	49
140	149	1	383	255	165	20.5	17.5		3 × 60	49
150	159	1	408	272	165	22	19		3 × 60	54
160	174	1	441	294	165	22	19		3 × 60	54
175	189	1	480	320	180	24.5	20.5		3 × 60	59
190	204	1	521	347	180	24.5	20.5		3 × 60	59
205	219	1	560	373	180	26	22	20.5	4 × 60	64
220	239	1	606	404	180	26	22	20.5	4 × 60	64
240	259	1	659	439	200	28	24	22	4 × 60	69
260	279	1	711	474	200	28	24	22	4 × 60	69
288	299	1	764	509	215	30	26	24	4 × 70	74
300	319	1	816	544	215	30	26	24	4 × 70	74
320	339	1	869	579	215	32	28	24	4 × 70	78
340	359	1	926	617	215	32	28	24	4 × 70	78
360	379	1	974	649	230	34	30	26	4 × 70	88
380	399	1	1028	685	230	34	30	26	4 × 70	88
400	424	1	1086	724	230	36	32	28	4 × 70	98
425	449	1	1152	768	230	36	32	28	4 × 70	98
450	474	1	1226	817	230	36	32	28	4 × 70	108
475	499	1	1284	856	230	38	34	30	4 × 70	108
500	549	2	1403	935	248	40	34	30	4 × 80	123
550	599	2	1535	1024	264	42	36	32	4 × 80	132
600	659	2	1694	1129	264	44	38	34	4 × 80	147
660	719	2	1853	1235	264	46	40	36	4 × 80	157
720	779	2	2012	1341	281	48	42	36	4 × 85	172
780	839	2	2171	1447	281	50	44	38	4 × 85	186
840	909	2	2329	1553	281	52	46	40	4 × 85	201
910	979	2	2515	1676	297	54	48	42	4 × 85	216
980	1059	2	2700	1800	297	56	50	44	4 × 90	230
1060	1139	2	2912	1941	297	58	50	46	4 × 90	250
1140	1219	2	3124	2082	314	60	52	46	4 × 90	270
1220	1299	2	3335	2224	314	62	54	48	4 × 90	284
1300	1389	2	3574	2382	314	64	56	50	4 × 90	309
1390	1479	2	3812	2541	330	66	58	50	5 × 90	324
1480	1569	2	4050	2700	330	68	60	52	5 × 95	324
1570	1669	2	4315	2876	330	70	62	54	5 × 95	333
1670	1789	2	4632	3088	347	73	64	56	5 × 95	353
1790	1930	2	4950	3300	347	76	66	58	5 × 95	378

Table III 5-2
Equipment Reductions for Service Restriction Notations (see Table III 5-1)

Service Restriction Notation	Number of bow anchors	Mass change per anchor	Length change of stud-link chain cables
Greater Coastal Service	1	No reduction	No reduction
Coastal Service	1	-30%	No reduction
Greater Coastal Service	2	-30%	+60%
Coastal Service	2	-50%	+60%

Notes:
(1) Other specified Restricted Service Notations may be specially considered.
(2) Please refers to I/1.4.4 of the Rules for Steel Ships for the definition of Service Restriction Notation.

Chapter 6

Navigation Bridge Visibility

6.1 General

The requirements in this Chapter apply to ships of not less than 55 m in length overall (L_{OA}).

6.2 View of the Sea Surface

The view of the sea surface from the conning position is not to be obscured by more than two ship lengths overall or 500 m, whichever is less, forward of the bow to 10° on either side under all conditions of the ship's draught, trim and deck cargo. See Fig. III 6-1.

6.3 Blind Sectors

Each blind sector caused by cargo, cargo gear or other obstructions outside of the wheelhouse forward of the beam obstructing the view of the sea surface as seen from the conning position is not to exceed 10°. The total arc of blind sectors is not to exceed 20 degrees. The clear sectors between blind sectors are to be at least 5 degrees. However, in the view described in 6.2, each individual blind sector is not to exceed 5 degrees.

6.4 Horizontal Field of Vision

6.4.1 The horizontal field of vision from the conning position is to extend over an arc of not less than 225°, that is from more than 22.5° abaft the beam on one side, through forward, to more than 22.5° abaft the beam on the other side. See Fig. III 6-2.

6.4.2 From each bridge wing the horizontal field of vision is to extend over an arc from at least 45° on the opposite bow through right ahead and then aft to 180° from dead ahead. See Fig. III 6-3.

6.4.3 From main steering position the horizontal filed of vision is to extend over an arc from right ahead to at least 60°on each side. See Fig. III 6-4.

6.5 Ship's Side

The ship's side is to be visible from the navigation bridge wing. The arrangement of bridge may refer to IMO MSC.1/Circ. 1350.

6.6 Navigation Bridge Front Windows

6.6.1 The height of the lower edge of navigation bridge front windows above the deck is to kept as low as possible.

6.6.2 The upper edge of the navigation bridge front windows is to allow a forward view of the horizon when the ship is pitching in heavy seas for a person with an eye height of 1800 mm above bridge deck at the conning position. The Society, if satisfied that a 1800 mm height of eye is unreasonable and impractical, may allow reduction of the height of eye but not to less than 1600 mm.

6.6.3 To help avoid reflections, the navigation bridge front windows are to be inclined from the vertical plane top out, at an angle of not less than 10° and not more than 25°.

6.6.4 At all times, regardless of weather conditions, at least two of the navigation bridge front windows are to provide a clear view and, depending on the bridge layout, an additional number of clear view windows are to be provided.

6.6.5 Framing between navigation bridge windows is to be kept to minimum and is not to be installed immediately forward of any workstation.

6.6.6 Polarized and tinted windows are not to be fitted.

6.7 Ships of Unconventional Design

6.7.1 With ships of unconventional design which, in the opinion of the Society, the arrangements are to be provided to achieve a level of visibility that is as near as practical to those prescribed in this Chapter.

6.8 Navigation Bridge Visibility during Ballast Water Exchange

6.8.1 During the intermediate stages of ballast water exchange, navigation bridge visibility need not comply with 6.2 and 6.4 of this Chapter.

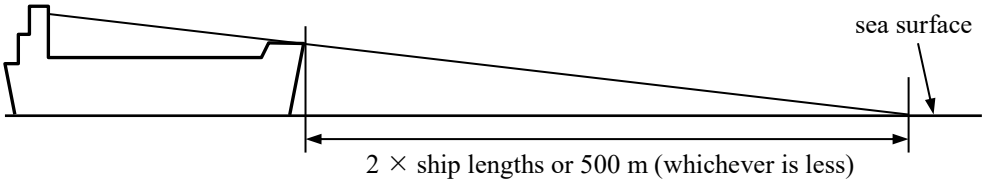


Fig. III 6-1
View of the Sea Surface from Conning Position

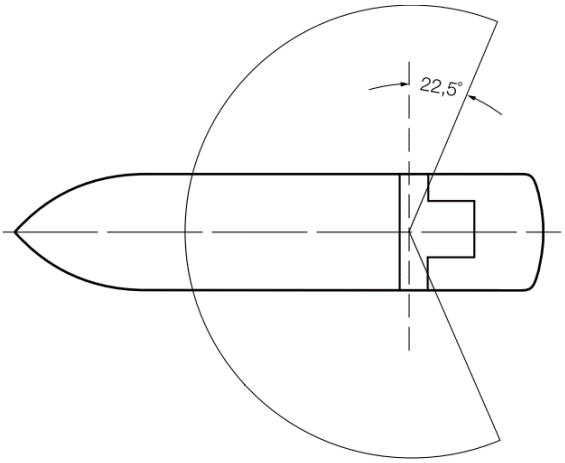


Fig. III 6-2
Field of Vision from the Workstations for Navigation/Manoeuvring

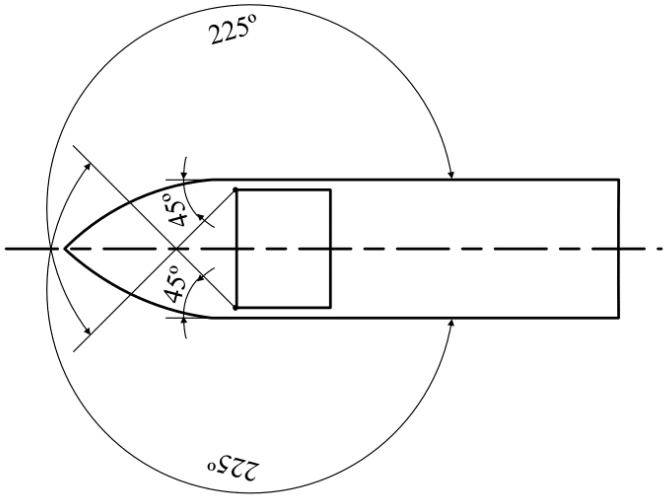


Fig. III 6-3
Horizontal Field of Vision From Each Bridge Wing

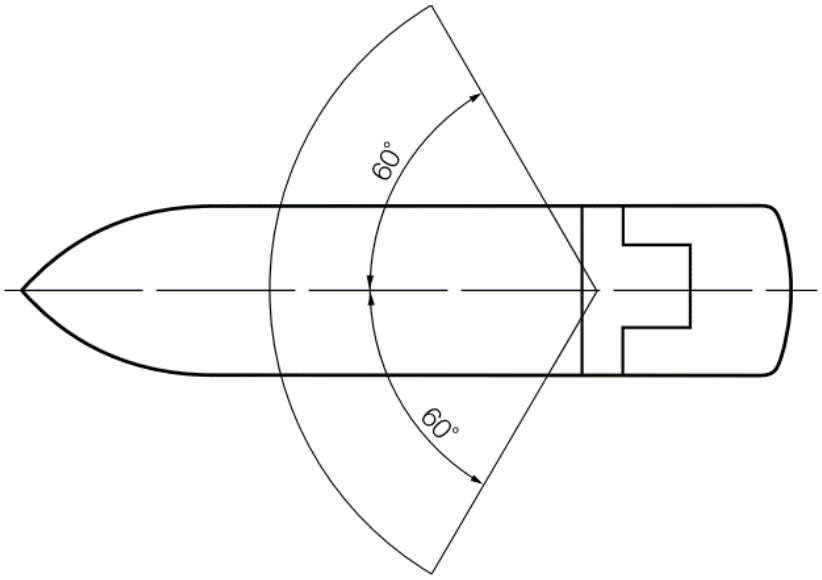


Fig. III 6-4
Horizontal Field of Vision from the Main Steering Position

Chapter 7

Testing, Trials and Surveys During Construction – Hull

7.1 Tank, Bulkhead and Rudder Tightness Testing

The testing requirements for crafts are to be in accordance with Part II, 1.4 of the Rules for Steel Ships.

7.2 Trials

7.2.1 Anchor Windlass Trials

Each windlass is to be tested under working conditions after installation onboard to demonstrate satisfactory operation. Each unit is to be independently tested for braking, clutch functioning, lowering and hoisting of chain cable and anchor, proper riding of the chain over the chain lifter, proper transit of the chain through the hawse pipe and the chain pipe, and effecting proper stowage of the chain and the anchor. It is to be confirmed that anchors properly seat in the stored position and that chain stoppers function as designed if fitted. Also, it is to be demonstrated that the windlass is capable of lifting each anchor with 82.5 meters length of chain submerged and hanging free. The braking capacity is to be tested by intermittently paying out and holding the chain cable by means of the application of the brake. Where the available water depth is insufficient, the proposed test method will be specially considered.

7.2.2 Bilge System Trials

All elements of the bilge system are to be tested to demonstrate satisfactory pumping operation, including emergency suctions and all controls. Upon completion of the trials, the bilge strainers are to be opened, cleaned and closed up in good order.

7.2.3 Steering Trials

Refer to 2.4.10 of Part IV for the technical details of the steering trials.

7.3 Surveys

7.3.1 Construction Welding and Fabrication

For surveys of hull construction welding and fabrication, refer to Part XII of the Rules for Steel Ships and Part II, Chapter 2 of the Rules.

7.3.2 Hull Castings and Forgings

For surveys in connection with the manufacture and testing of hull castings and forgings, refer to Part XI of the Rules for Steel Ships.

7.3.3 Piping

For surveys in connection with the manufacture and testing of piping, refer to Part IV, Chapter 3 of the Rules.

Appendix 1

Guidelines for Calculating Bending Moment and Shear Force in Rudders and Rudder Stocks

A1.1 Application

Bending moments, shear forces and reaction forces of rudders, stocks and bearings may be calculated according to this Appendix for the types of rudders indicated. Moments and forces on rudders of different types or shapes than those shown are to be calculated using alternative methods and will be specially considered.

A1.2 Spade Rudders

A1.2.1 Rudder Blade

(a) Shear Force

For regular spade rudders as shown in Fig. III A1-1(a) of this Appendix, the shear force, V(z), at a horizontal section of the rudder above baseline is given by the following equation:

$$V(z) = \frac{zC_R}{A}\left[c_l + \frac{z}{2l_R}(c_u - c_l)\right] \quad \text{kN}$$

where:

z	=	distance from the rudder baseline to the horizontal section under consideration	m
C_R	=	rudder force, as defined in 2.8.2 of this Part	kN
A	=	total projected area of rudder blade as defined in 2.8.2 of this Part	m^2

c_l, c_u and l_R are dimensions as indicated in Fig. III A1-1(a) of this Appendix, in m.

For spade rudders with embedded rudder trunks let deep in the rudder blade, as shown in Fig. III A1-1(b) of this Appendix, the shear forces at rudder horizontal sections above rudder baseline in areas A1, and A2, are given by the following equations:

$$V(z')_1 = \frac{z'C_{R1}}{A_1}\left[c_u + \frac{z'}{2l_l}(c_u - c_b)\right] \quad \text{kN, over } A_1$$

$$V(z)_2 = \frac{zC_{R2}}{A_2}\left[c_b + \frac{z}{2l_b}(c_b - c_l)\right] \quad \text{kN, over } A_2$$

where:

z'	=	l_R-z	
C_{R1}	=	rudder force over rudder area A_1	kN
	=	$\frac{A_1}{A} C_R$	
C_{R2}	=	rudder force over rudder area A_2	kN
	=	$\frac{A_2}{A} C_R$	
A_1	=	partial rudder blade area above neck bearing and below rudder top	mm^2
A_2	=	partial rudder blade area above rudder baseline and below neck bearing	mm^2

z, A, and C_R are as indicated in A1.2.1(a) of this Appendix.

c_l, c_b, c_u, l_u and l_b are dimensions as illustrated in Fig. III A1-1(b) of this Appendix.

(b) Bending Moment

For regular spade rudders, bending moment, *M(z)*, at a horizontal section *z* meters (feet) above the baseline of the rudder is given by the following equations:

$$M(z) = \frac{z^2 C_R}{2A}\left[c_l + \frac{z}{3l_R}(c_u - c_l)\right] \quad \text{kN-m}$$

For spade rudders with embedded rudder trunk, the bending moment at a horizontal section within area A_1 is obtained from the following:

$$M(z')_1 = \frac{(z')^2 C_{R1}}{2A_1}\left[c_u + \frac{z'}{3l_l}(c_u - c_b)\right] \quad \text{kN-m}$$

With the maximum bending moment M_1 over area A_1 equals to:

$$M_1 = C_{R1} l_l \left[1 - \frac{2c_b + c_u}{3(c_b + c_u)}\right] \quad \text{kN-m}$$

For spade rudders with embedded rudder trunk, the bending moment at a horizontal section within area A_2 is obtained from the following:

$$M(z)_2 = \frac{z^2 C_{R2}}{2A_2}\left[c_l + \frac{z}{3l_b}(c_u - c_l)\right] \quad \text{kN-m}$$

With the maximum bending moment M_2 over area A_2 equals to:

$$M_2 = C_{R2} l_b \frac{2c_l + c_b}{3(c_l + c_b)} \quad \text{kN-m}$$

where z, z', C_{R1}, C_{R2}, A_1, A_2, c_l, c_u and l_R are as defined in A1.2.1(a) of this Appendix.

A1.2.2 Lower Stock

(a) Shear Force

For regular spade rudder, the shear force, V_l, at any section of the lower stock between the top of the rudder and the neck bearing is given by the following equation:

$$V_l = C_R \quad \text{kN}$$

For spade rudder with embedded rudder trunk, the shear force at any section of the stock between the top of the rudder and the neck bearing is given by the following equation:

$$V_l = \frac{M_2 - M_1}{l_u + l_l} \quad \text{kN}$$

where C_R, l_l, and l_u are as defined in A1.2.1(a) of this Appendix.

(b) Bending Moment at Neck Bearing

For regular spade rudder, the bending moment in the rudder stock at the neck bearing, M_n, is given by the following equation:

$$M_n = C_R\left[l_l + \frac{l_R(2c_l + c_u)}{3(c_l + c_u)}\right] \quad \text{kN-m}$$

where:

C_R = rudder force, as defined in 2.8.2 of this Part

c_l, c_u, l_l and l_R are dimensions as indicated in Fig. III A1-1 of this Appendix, in m.

For spade rudder with embedded rudder trunk, the bending moment in the rudder stock at the neck bearing is given by the following equation:

$$M_n = M_2 - M_1 \quad \text{kN-m}$$

where M_1 and M_2 are as defined in A1.2.1(b) of this Appendix.

Where partial submergence of the rudder leads to a higher bending moment in the rudder stock at the neck bearing (compared with the fully submerged condition), M_n is to be calculated based on the most severe partially submerged condition.

A1.2.3 Moment at Top of Upper Stock Taper

For regular spade rudder, the bending moment in the upper rudder stock at the top of the taper, M_t, is given by the following equation:

$$M_t = C_R \left[l_l + \frac{l_R(2c_l + c_u)}{3(c_l + c_u)} \right] \times \left[\frac{(l_u + l_R + l_l - z_t)}{l_u} \right] \quad \text{kN-m}$$

For spade rudder with embedded rudder trunk, the bending moment in the upper rudder stock at the top of the taper is given by the following equation:

$$M_t = M_R \left[\frac{(l_R + l_u - z_t)}{l_u} \right] \quad \text{kN-m}$$

where:

z_t = distance from the rudder baseline to the top of the upper rudder stock taper m
C_R = rudder force, as defined in A1.2.1(a) of this Appendix
M_R is the greater of M_1 and M_2, as defined in A1.2.1(b) of this Appendix

c_l, c_u, l_l, l_u and l_R are dimensions as indicated in Fig. III A1-1 of this Appendix, in m.

A1.2.4 Bearing Reaction Forces

For regular spade rudder, the reaction forces at the bearings are given by the following equations:

P_u = reaction force at the upper bearing

$$= -\frac{M_n}{l_u} \quad \text{kN}$$

P_n = reaction force at the neck bearing

$$= C_R + \frac{M_n}{l_u} \quad \text{kN}$$

For spade rudder with embedded rudder trunk, the reaction forces at the bearings are given by the following equations:

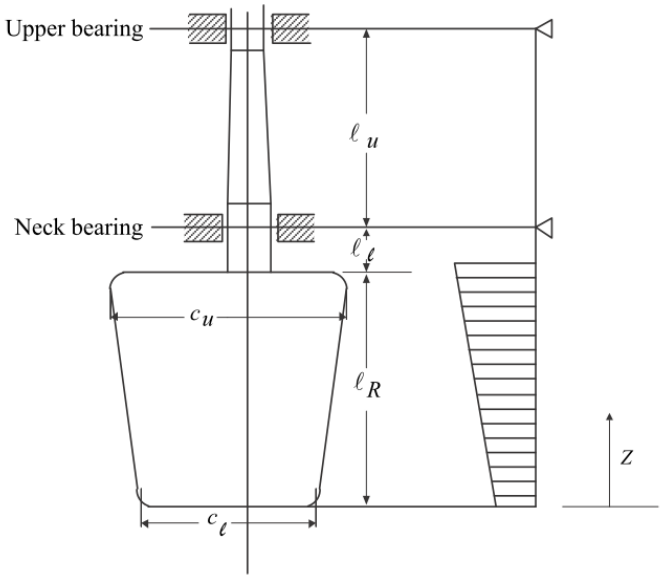
$$P_u = -\frac{M_n}{l_u + l_l} \quad \text{kN}$$

$$P_n = C_R + P_u \quad \text{kN}$$

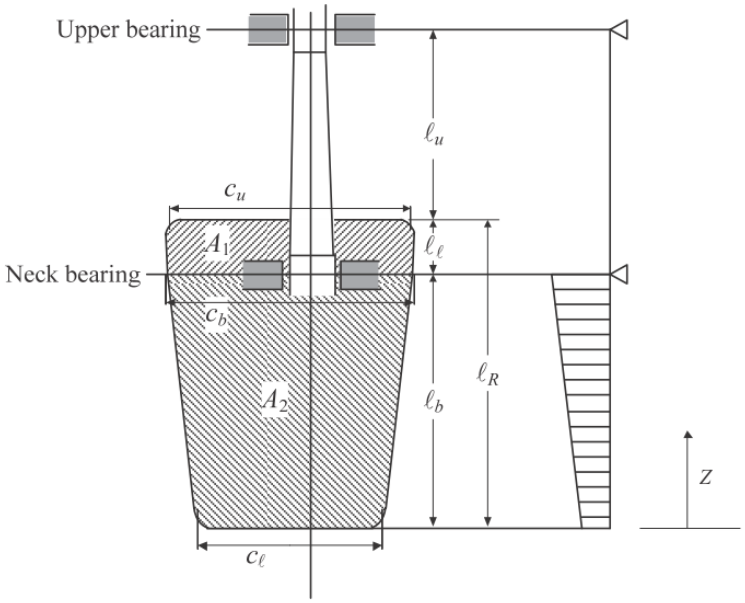
where:

M_n = bending moment at the neck bearing, as defined in A1.2.2(b) of this Appendix
C_R = rudder force, as defined in 2.8.2 of this Part

l_u is as indicated in Fig. III A1-1 of this Appendix, in m.



(a) Regular Spade Rudder



(b) Spade Rudder with Embedded Rudder Trunk

Fig. III A1-1
Spade Rudder

A1.3 Rudders Supported by Shoepiece

A1.3.1 Shear Force, Bending Moment and Reaction Forces

(a) Shear force, bending moment and reaction forces may be calculated according to the model given in Fig. III A1-2 of this Appendix.

w_R = rudder load per unit length

$= \dfrac{C_R}{l_R}$ kN/m

where:

C_R = rudder force, as defined in 2.8.2 of this Part

k_s = spring constant reflecting support of the shoe piece

$= \dfrac{6.18 I_s}{l_s^3}$ kN/m

I_s = moment of inertia of shoe piece about the vertical axis cm^4

l_l, l_s, l_R and l_u are dimensions as indicated in Fig. III A1-2 of this Appendix, in m.

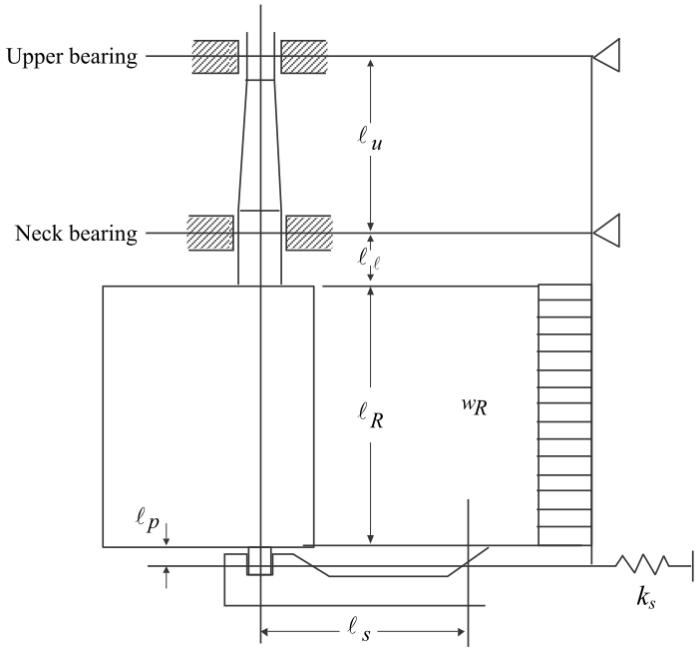


Fig. III A1-2
Rudder Supported by Shoepiece

A1.4 Rudders Supported by a Horn with One Pintle

A1.4.1 Shear Force, Bending Moment and Reaction Forces

(a) Shear force, bending moment and reaction forces are to be assessed by the simplified beam model shown in Fig. III A1-3 of this Appendix.

w_{R1} = rudder load per unit length above pintle

$= \dfrac{C_{R1}}{l_{R1}}$ kN/m

w_{R2} = rudder load per unit length below pintle

$= \dfrac{C_{R2}}{l_{R2}}$ kN/m

where:

C_{R1} = rudder force, as defined in 2.8.2(b) of this Part

C_{R2} = rudder force, as defined in 2.8.2(b) of this Part

k_h = spring constant reflecting support of the horn

$$= \frac{1}{\frac{l_h^3}{4.75 I_h} + \frac{\Sigma\left(\frac{s_i}{t_i}\right) e^2 l_h}{3.17 a^2}} \quad \text{kN/m}$$

a = mean area enclosed by the outside lines of the rudder horn — cm^2

s_i = the girth length of each segment of the horn of thickness t_i — cm

t_i = the thickness of each segment of horn outer shell of length s_i — cm

I_h = moment of inertia of horn section at I_h about the longitudinal axis — cm^4

e, l_h, l_{R1} and l_{R2} are dimensions as indicated in Fig. III A1-3 of this Appendix, in m.

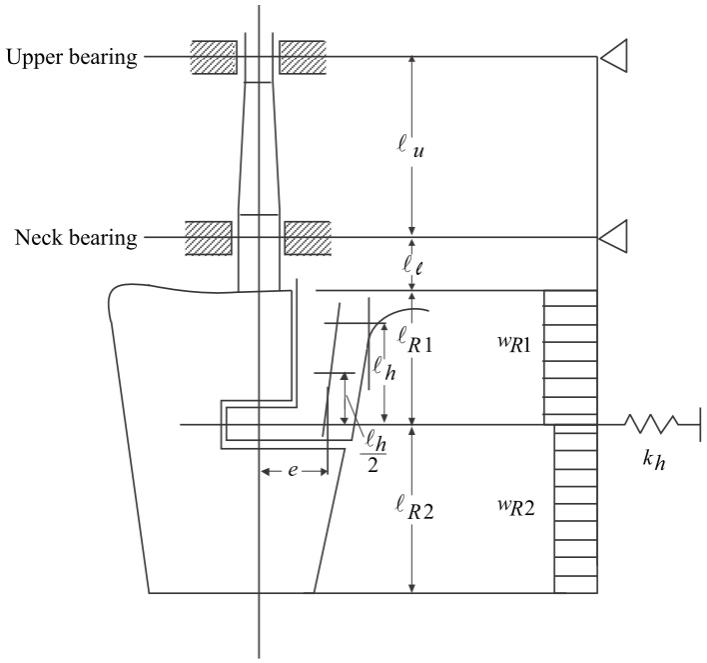


Fig. III A1-3
Rudder Supported by a Horn with One Pintle

A1.5 Rudders Supported by a Horn Arranged with Two Pintles (Supports)

A1.5.1 Shear Force, Bending Moment and Reaction Forces

(a) Shear force, bending moment and reaction forces are to be assessed by the simplified beam model shown in Fig. III A1-4 of this Appendix.

w_{R1} = rudder load per unit length above lower rudder support/pintle

$$= \frac{C_{R1}}{l_{R1}} \quad \text{kN/m}$$

w_{R2} = rudder load per unit length below lower rudder support/pintle

$$= \frac{C_{R2}}{l_{R2}} \quad \text{kN/m}$$

where:

C_{R1} = rudder force, as defined in 2.8.2(b) of this Part

C_{R2} = rudder force, as defined in 2.8.2(b) of this Part

l_{R1} and l_{R2} are dimensions as indicated in Fig. III A1-4 of this Appendix, in m.

In Fig. III A1-4 of this Appendix the variables K_{11}, K_{22}, K_{12} are rudder horn compliance constants calculated for rudder horn with 2-conjugate elastic supports. The 2-conjugate elastic supports are defined in terms of horizontal displacements, y_i, by the following equations:

- At the lower rudder horn bearing:

$$y_1 = -K_{12}B_2 - K_{22}B_1 \quad \text{m}$$

- At the upper rudder horn bearing:

$$y_2 = -K_{11}B_2 - K_{12}B_1 \quad \text{m}$$

where

y_1, y_2	=	horizontal displacement at lower and upper rudder horn bearings, respectively	
B_1, B_2	=	horizontal support force, in kN, at lower and upper rudder horn bearings, respectively	kN
K_{11}, K_{22}, K_{12}	=	spring constant of the rudder support obtained from the following:	
K_{11}	=	$1.3\frac{\lambda^3}{3EJ_{1h}} + \frac{e^2\lambda}{GJ_{th}}$	m/kN
K_{22}	=	$1.3\left[\frac{\lambda^3}{3EJ_{1h}} + \frac{\lambda^2(d-\lambda)}{2EJ_{1h}}\right] + \frac{e^2\lambda}{GJ_{th}}$	m/kN
K_{12}	=	$1.3\left[\frac{\lambda^3}{3EJ_{1h}} + \frac{\lambda^2(d-\lambda)}{EJ_{1h}} + \frac{\lambda(d-\lambda)^2}{EJ_{1h}} + \frac{(d-\lambda)^3}{3EJ_{2h}}\right] + \frac{e^2d}{GJ_{th}}$	m/kN
d	=	height of the rudder horn, defined in Fig. III A1-4 of this Appendix. This value is measured downwards from the upper rudder horn end, at the point of curvature transition, to the mid-line of the lower rudder horn pintle.	m
λ	=	length, as defined in Fig. III A1-4 of this Appendix. This length is measured downwards from the upper rudder horn end, at the point of curvature transition, to the mid-line of the upper rudder horn bearing. For λ = 0, the above formulae converge to those of spring constant kh for a rudder horn with 1-pintle (elastic support), and assuming a hollow cross section for this part.	m
e	=	rudder-horn torsion lever as defined in Fig. III A1-4 of this Appendix (value taken at vertical location $l_h/2$)	m
E	=	Young's modulus of the material of the rudder horn	kN/m^2
G	=	modulus of rigidity of the material of the rudder horn	kN/m^2
J_{1h}	=	moment of inertia of rudder horn about the x axis, for the region above the upper rudder horn bearing. Note that J1h is an average value over the length λ (see Fig. III A1-4 of this Appendix).	m^4
J_{2h}	=	moment of inertia of rudder horn about the x axis, for the region between the upper and lower rudder horn bearings. Note that J_{2h} is an average value over the length $d - \lambda$ (see Fig. III A1-4 of this Appendix).	m^4
J_{th}	=	torsional stiffness factor of the rudder horn	m^4
	=	$\frac{4F_T^2}{\sum_i \frac{u_i}{t_i}}$ for any thin wall closed section Note that the J_{th} value is taken as an average value, valid over the rudder horn height.	m^4
F_T	=	mean of areas enclosed by outer and inner boundaries of the thin walled section of rudder horn	m^2
u_i	=	length of the individual plates forming the mean horn sectional area	mm
t_i	=	thickness of the individual plates mentioned above	mm

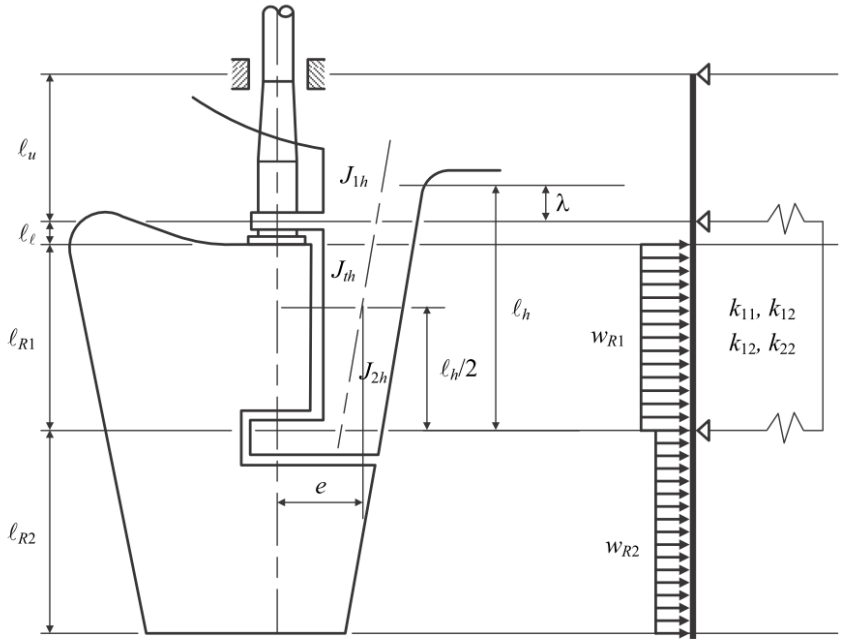


Fig. III A1-4
Rudder Supported by a Horn Arranged with Two Pintles (Supports)

Appendix 2

Guidance on Analysis of the Cross Deck Structure of a Multi-Hull Craft

Note:
This Appendix gives guidance on the analysis of a standard cross deck structure (similar to Fig. III A2-1 of this Appendix) of a multi-hulled craft. The analysis includes the determination of the craft's transverse bending stress, transverse shear stress, and the torsional stress acting on each element. The analysis of cross decks that are of advanced design or material will be specially considered.

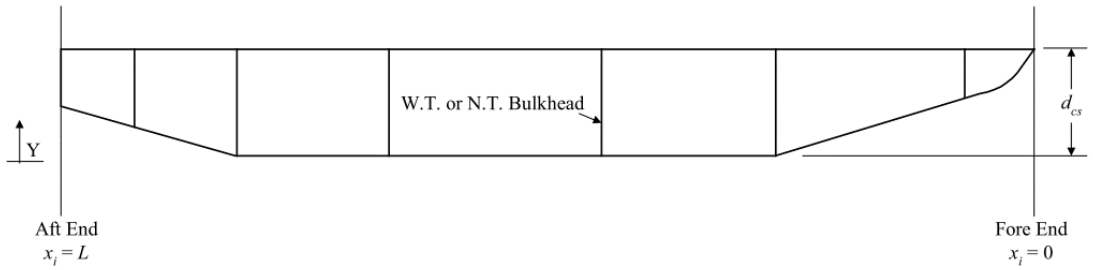


Fig. III A2-1
Typical Geometry of Centerline Section of Cross Deck

A2.1 Transverse Bending and Shear Stress

The transverse bending and shear stress of the cross structure are obtained by the following equations and are less than the allowable stresses defined in 2.1.2(c)(iii) of this Part:

$$\sigma_t = \frac{10M_{tb}}{SM_t} \qquad \text{N/mm}^2$$

$$\tau_a = \frac{10Q_t}{A_t} \qquad \text{N/mm}^2$$

where:

σ_t	=	transverse bending stress of the cross deck structure	N/mm^2
M_{tb}	=	design transverse bending moment as defined in 2.1.2(b) of this Part	kN-m
SM_t	=	offered transverse section modulus of the cross deck	cm^2-m
τ_a	=	transverse shear stress of the cross deck structure	N/mm^2
Q_t	=	design vertical shear force as defined in 2.1.2(b) of this Part	kN
A_t	=	offered shear area of the cross structure	cm^2

A2.2 Center of Torsional Rotation

$$L_c = \frac{\sum_{i=1}^{n} k_i x_i}{\sum_{i=1}^{n} k_i} \qquad \text{cm}$$

where:

k_i	=	element stiffness	
	=	$(12000E_iI_i)/L_i^3$	N/m
x_i	=	longitudinal distance from forward perpendicular	cm
n	=	total number of elements in the cross deck structure	
E	=	modulus of elasticity of the material, for each element	kN/m^2

I_i = moment of inertia of the element being considered m^4
L_i = span of cross structure, see Fig. III A2-2 of this Appendix m

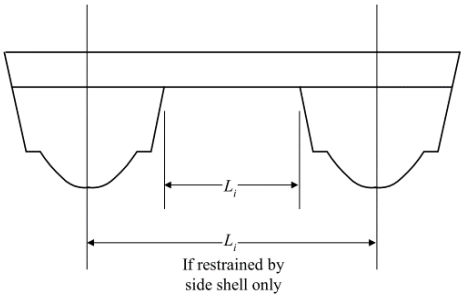


Fig. III A2-2
Typical Geometry of Centerline Section of Cross Deck

A2.3 Maximum Bending Stress on Each Element

The maximum bending stress on each element is to be less than the allowable torsional stress as defined in 2.1.2(c)(iii) of this Part.

A2.3.1 Deflection

The total amount that each element deflects can be determined by the following formula:

$$\delta_i = \frac{10^5 M_{tt} x_{ci}}{\sum_{i=1}^{n} x_{ci}^2 k_i} \quad \text{m}$$

where:

δ_i = deflection of each member m
M_{tt} = design torsional moment acting upon the transverse structure connecting the hulls, as determined 2.1.2(b) of this Part. kN-m
x_{ci} = $x_i - L_c$ cm

x_i, L_c and k_i are as defined in A2.1 of this Appendix.

A2.3.2 Bending Moment

The bending moment that is acting on each element is determined by the following formula:

$$BM_i = \frac{P_i L_i}{2} \quad \text{N-m}$$

where:

BM_i bending moment that is acting on the element under consideration N-m
P_i = $\delta_i k_i$, force that is acting on the element N
L_i = as defined in A2.1 of this Appendix
δ_i = as defined in A2.3.1 of this Appendix
k_i = as defined in A2.1 of this Appendix

A2.3.3 Maximum Stress

The maximum stress that is applied on each element can be determined by the following formula:

$$\sigma_i = \frac{1000 BM_i}{SM_i} \quad \text{kN/m}^2$$

where:

σ_i = maximum stress that is acting upon the element kN/m^2
BM_i = as defined in A2.3.2 of this Appendix
SM_i = section modulus of the element being considered cm^3

A2.3.4 Maximum Shear Stress on Each Element

The maximum shear stress on each element is to be less than the allowable transverse shear stress as defined in A2.3.2 of this Appendix.

$$\tau_i = \frac{10P_i}{A_{wi}} \qquad kN/m^2$$

where:

τ_i	=	maximum shear stress that is acting upon the element	kN/m^2
P_i	=	force acting upon the element, as defined in A2.3.2 of this Appendix	N
A_{wi}	=	area of the web of the element being considered	cm^2

Appendix 3

Alternative Method for the Determination of "V" Shaft Strut Requirements

A3.1 General

The method outlined below may be used as an alternative to the method given in 2.7.5 of this Part. Other alternatives may be considered providing they address loadings from unbalanced centrifugal forces from the propeller, hydrodynamic forces, inertial forces from ship motions, gravity forces from shaft and propeller, and vibrations resulting from all intended conditions.

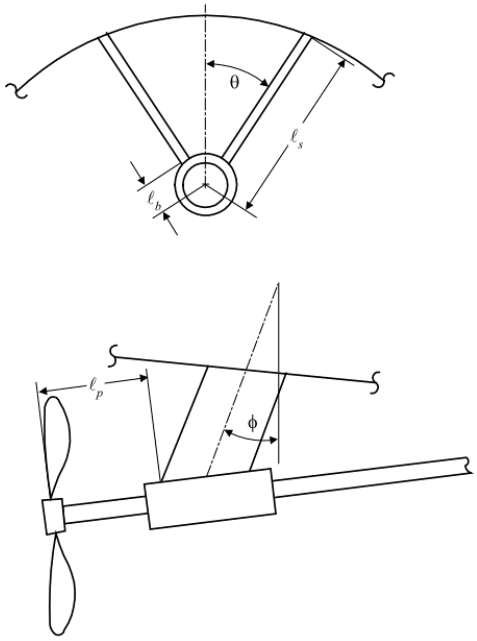


Fig. III A3-1
Strut Dimensions

A3.2 Loads and Moments Acting on Strut

The governing loads and moments acting on the shaft strut are as follows:

$$M_1 = 0.138 d_p \left[W_p l_p \left(\frac{R}{100} \right)^2 + 0.454 \frac{H_p}{V} \right] \quad \text{kN-m}$$

$$M_2 = 3.0 \times 10^{-4} S M_s \sigma_{ys} \quad \text{kN-m}$$

$$F_3 = S M_s \sigma_{ys} / d_s \quad \text{kN}$$

where

d_p	=	diameter of the propeller	m
W_p	=	weight of the propeller	kN
l_p	=	length of the overhang	m
R	=	maximum rated RPM of the shaft	

H_p	=	power at maximum rated speed	kW
V	=	maximum calm water speed of the craft	knots
SM_s	=	offered section modulus of the shaft	cm^3
d_s	=	offered diameter of the shaft	mm
σ_{ys}	=	yield strength of the shaft	N/cm^2

A3.3 Required Section Modulus of Strut at the Barrel

$$SM_{st} = 1000C_1[M + F_3(l_b sin\emptyset/1000)]/\sigma_y \qquad cm^3$$

$$C_1 = \sqrt{(C_2/sin\theta)^2 + (0.5/cos\theta)^2}$$

$$C_2 = \left[2 - \left(\frac{l_b}{l_s}\right) - \left(\frac{l_b}{l_s}\right)^2\right] \Big/ \left\{4\left[1 + \left(\frac{l_b}{l_s}\right) + \left(\frac{l_b}{l_s}\right)^2\right]\right\}$$

where

M	=	the greater of M_1 or M_2, as defined in A3.2 of this Appendix	kN-m
l_b	=	distance from center of strut barrel to the connection of the strut, see Fig. III A3-1 of this Appendix	mm
ϕ	=	cant angle of strut, see Fig. III A3-1 of this Appendix	degrees
σ_y	=	yield strength for steel struts or the welded yield strength of aluminum struts	kN/mm^2
θ	=	vee angle of strut, see Fig. III A3-1 of this Appendix	degrees
l_s	=	distance from center of strut barrel to the hull, see Fig. III A3-1 of this Appendix	mm

A3.4 Required Section Modulus of Strut at the Hull

$$SM_{st} = 1000C_1[M + F_3(l_s sin\emptyset/1000)]/\sigma_y \qquad cm^3$$

where C_1, M, F_3, l_s, ϕ and σ_y are as defined in A3.3 of this Appendix.

A3.5 Requirements for Struts Constructed of Aluminum

The required stiffness, *EI*, for aluminum strut is to be 90% of a strut constructed of CR Grade A steel that meets the requirements in A3.3 and A3.4 of this Appendix.

Appendix 4

Computer Software for Onboard Stability Calculations

A4.1 General

A4.1.1 Scope

The scope of stability calculation software is to be in accordance with the stability information as approved by the flag Administration or CR on behalf of the flag Administration. The software is at least to include all information and perform all calculations or checks as necessary to ensure compliance with the applicable stability requirements.

Approved stability software is not a substitute for the approved stability information, and is used as a supplement to the approved stability information to facilitate stability calculations.

A4.1.2 Design

The input/output information is to be easily comparable with approved stability information so as to avoid confusion and possible misinterpretation by the operator relative to the approved stability information.

An operation manual is to be provided for the onboard computer stability software.

The language in which the stability information is displayed and printed out as well as the operation manual is written is to be the same as used in the craft's approved stability information. The primary language is to be Chinese.

The onboard computer for stability calculations is to be craft specific equipment and the results of the calculations are to be only applicable to the craft for which it has been approved.

In case of modifications implying changes in the main data or internal arrangement of the craft, the specific approval of any original stability calculation software is no longer valid. The software is to be modified accordingly and reapproved.

A4.1.3 Class Notation

Ships equipped with loading computer systems designed, manufactured and tested in compliance with the requirements of this appendix, for calculation and control of stability, longitudinal and local strength, may be assigned the additional class notation **LCS**.

A4.2 Calculation Systems

This Appendix covers either system, a passive system that requires manual data entry or an active system, which replaces the manual with the automatic entry with sensors reading and entering the contents of tanks, etc., provided the active system is in the off-line operation mode. However, an integrated system, which controls or initiates actions based on the sensor-supplied inputs is not within the scope of this Appendix.

A4.3 Types of Stability Software

Four types of calculations performed by stability software are acceptable depending upon a craft's stability requirements:

A4.3.1 Type 1

Software calculating intact stability only (for craft not required to meet a damage stability criterion)

A4.3.2 Type 2

Software calculating intact stability and checking damage stability on basis of a limit curve or checking all the stability requirements (intact and damage stability) on the basis of a limit curve

A4.3.3 Type 3

Software calculating intact stability and damage stability by direct application of preprogrammed damage cases based on the relevant Conventions or Codes for each loading condition

A4.3.3 Type 4

Software calculating damage stability associated with an actual loading condition and actual flooding case, using direct application of user defined damage, for the purpose of providing operational information for safe return to port (SRtP).

Damage stability of both Type 3 and Type 4 stability software is to be based on a hull form model, that is, directly calculated from a full three-dimensional geometric model.

A4.4 Functional Requirements

A4.4.1 Calculation Program

The calculation program is to present relevant parameters of each loading condition in order to assist the Master in their judgment on whether the craft is loaded within the approval limits. The following parameters are to be presented for a given loading condition:

- Deadweight data
- Lightship data
- Trim, list
- Draft at the draft marks and perpendiculars
- Summary of loading condition displacement, VCG, LCG and, if applicable, TCG
- Downflooding angle and corresponding downflooding opening (not applicable for Type 2 software which uses limit curve for checking all the stability requirements. However, if intact stability criteria are given in addition to the limit curve, downflooding angle and the corresponding downflooding opening is to be indicated).
- Compliance with stability criteria: Listing of all calculated stability criteria, the limit values, the obtained values and the conclusions (criteria fulfilled or not fulfilled) (not applicable for Type 2 software which uses limit curve for checking all the stability requirements. However, if intact stability criteria are given in addition to the limit curve, the limit values, the obtained values and the conclusion is to be indicated).

A4.4.2 Direct Damage Stability Calculations

If direct damage stability calculations are performed, the relevant damage cases according to the applicable rules are to be pre-defined for automatic check of a given loading condition.

A4.4.3 Warning

A clear warning is to be given on screen and in hard copy printout if any of the loading limitations are not complied with.

As applicable, loading limitations are to include, but may not be limited to:

- Trim, draft, liquid densities, tank filling levels, initial heel
- Use of limit KG/GM curves in conjunction with above for Type 2

- Restrictions to the stowage height for timber where timber load lines are assigned

A4.4.4 Data Printout

The data are to be presented on screen and in hard copy printout in a clear unambiguous manner.

A4.4.5 Date and Time

The date and time of a saved calculation are to be part of the screen display and hard copy printout.

A4.4.6 Information of Program

Each hard copy printout is to include identification of the calculation program with version number.

A4.4.7 Units

Units of measurement are to be clearly identified and used consistently within a loading calculation.

A4.4.8 Computer Model

For Type 3 and Type 4 software, the system is to be pre-loaded with a detailed computer model of the complete hull, including appendages, all compartments, tanks and the relevant parts of the superstructure considered in the damage stability calculation, wind profile, down-flooding and up-flooding openings, cross-flooding arrangements, internal compartment connections and escape routes, as applicable and according to the type of stability software.

For Type 1 and Type 2 software, in case a full three dimensional model is used for stability calculations, the requirements of the computer model are to be as per the paragraph above to the extent as applicable and according to the type of stability software.

A4.4.9 Further Requirements for Type 4 Stability Software

(a) The normal (Type 1, 2 and 3) and SRtP (Type 4) software need not be “totally separated”. Where the normal and SRtP software are not totally separated:

- The function of switching between normal software and Type 4 software is to be provided.
- The actual intact loading condition is to be the same for both functions (normal operation and SRtP); and
- The SRtP module needs only to be activated in case of an incident.

Approval of Type 4 (SRtP) software is for stability only.

(b) In passenger craft which are subject to SRtP and have an onboard stability computer and shore- based support, such software need not be identical.

(c) Each internal space is to be assigned its permeability as shown below, unless a more accurate permeability has been reflected in the approved stability information.

Spaces	Permeability			
	Default	Full	Partially Filled	Empty
Container Spaces	0.95	0.70	0.80	0.95
Dry Cargo spaces	0.95	0.70	0.80	0.95
Ro-Ro spaces	0.95	0.90	0.90	0.95
Cargo liquids	0.95	0.70	0.80	0.95
Intended for consumable liquids	0.95	0.95	0.95	0.95
Stores	0.95	0.60	0.60	0.95
Occupied by machinery	0.85			
Void spaces	0.95			
Occupied by accommodation	0.95			

(d) The system is to be capable of accounting for applied moments such as wind, lifeboat launching, cargo shifts and passenger relocation.

(e) The system is to account for the effect of wind by using the method in SOLAS regulation II-1/7-2, 4.1.2 as the default, but allow for manual input of the wind speed/pressure if the on-scene pressure is significantly different ($P = 120\ N/m^2$ equates to Beaufort 6; approximately 13.8 m/s or 27 knots).

(f) The system is to be capable of assessing the impact of open main watertight doors on stability (e.g., for each damage case provided for verification, additional damage stability calculation is to be done and presented, taking into account any watertight door located within the damaged compartment(s)).

(g) The system is to utilize the latest approved lightship weight and center of gravity information.

(h) The output of the software is to be such that it provides the master with sufficient clear unambiguous information to enable quick and accurate assessment of the stability of the vessel for any actual damage, the impact of flooding on the means of escape and the controls of devices necessary for managing and/or controlling the stability of the craft.

When the actual loading condition is input in the SRtP software, the following output (intact stability) is to be available:

- Deadweight data
- Lightship data
- Trim
- Heel
- Draft at the draft marks and perpendiculars
- Summary of loading condition displacement, VCG, LCG and, if applicable, TCG
- Downflooding angle and corresponding downflooding opening
- Free surfaces
- GM value
- GZ values relevant to an adequate range of heeling (not less than 60°) available indicatively at the following intervals: 0, 5, 10, 15, 20, 25, 30, 40, 50, 60 deg
- Compliance with relevant intact stability criteria (i.e., 2008 IS Code): listing of all calculated intact stability criteria, the limiting values, the obtained values and the evaluation (criteria fulfilled or not fulfilled)
- GM/KG limiting curve according to SOLAS, Ch II-1, Regulation 5-1

When the actual loading condition is associated to the actual damage case(s) due to the casualty, the following output (damage stability) is to be available:

- Trim
- Heel
- Draft at the draft marks and perpendiculars
- Progressive flooding angle and corresponding progressive flooding openings
- GM value
- GZ values relevant to an adequate range of heeling (not less than 60°) available indicatively at the following intervals: 0, 5, 10, 15, 20, 25, 30, 40, 50, 60 deg
- Compliance with stability criteria: listing of all calculated stability criteria, the limit values, the obtained values and the conclusions (criteria fulfilled or not fulfilled)
- The survivability criteria for Type 4 software (SRtP) are left to the discretion of the Administration
- Relevant flooding points (unprotected or weathertight) with the distance from the damage waterline to each point
- List of all flooded compartments with the permeability considered
- Amount of water in each flooded compartment
- Escape route immersion angles
- A profile view, deck views and cross-sections of the craft indicating the flooded water-plane and the damaged compartments

(i) For ro-ro passenger craft, there are to be algorithms in the software for estimating the effect of water accumulation on deck (WOD) (e.g., 1. In addition to the predefined significant wave height, taken from the approved stability document, there is to be possibility for the crew to input manually the significant wave height of the craft navigation area in the system, 2. In addition to the predefined significant wave height, taken from the approved stability document, calculations with two additional significant wave heights are to be submitted for checking the correctness of the algorithms in the software for estimating the effect of WOD).*

* This paragraph applies to Ro-Ro Passenger craft subject to the Stockholm Agreement (IMO Circular Letter No. 1891)

A4.5 Acceptable Tolerances

Depending on the type and scope of programs, the acceptable tolerances are to be determined differently, according to A4.5.1 or A4.5.2 of this Appendix. In general, deviation from these tolerances is not to be accepted unless a satisfactory explanation for the difference is submitted for review and the same is satisfactorily confirmed by CR that there would be no adverse effect on the safety of the craft.

Examples of pre-programmed input data include the following:

- Hydrostatic data: Displacement, LCB, LCF, VCB, KMt and MCT vs. draft
- Stability data: KN or MS values at appropriate heel/trim angles vs. displacement, stability limits.
- Compartment data: Volume, LCG, VCG, TCG and FSM vs. level of the compartment’s contents.

Examples of output data include the following:

- Hydrostatic data: Displacement, LCB, LCF, VCB, KMt and MCT vs. draft, as well as actual drafts, trim.
- Stability data: FSC (free surface correction), GZ-values, KG, GM, KG/GM limits, derived stability criteria (e.g., areas under the GZ curve), weather criteria.

- Compartment data: Calculated Volume, LCG, VCG, TCG and FSM vs. level of the compartment's contents

The computational accuracy of the calculation program results is to be within the acceptable tolerances specified in A4.5.1 or A4.5.2 of this Appendix, of the results using an independent program or the approved stability information with identical input.

A4.5.1 Calculation Program of the Approved Stability Information

Programs which use only pre-programmed data from the approved stability information as the basis for stability calculations are to have zero tolerances for the printouts of input data.

Output data tolerances are to be close to zero. However, small differences associated with calculation rounding or abridged input data are acceptable. Additionally differences associated with the use of hydrostatic and stability data for trims that differ from those in the approved stability information are acceptable subject to review by CR.

A4.5.2 Independent Program for Assessment of Stability

Programs which use hull form models as their basis for stability calculations are to have tolerances for the printouts of basic calculated data established against either data from the approved stability information or data obtained using the approval authority's model. Acceptable tolerances shall be in accordance with Table III A4-1 below.

Table III A4-1
Acceptable Tolerances

Hull Form Dependent	Acceptable Tolerance (1)
Displacement	±2%
Longitudinal center of buoyancy, from AP	±1% or 50 cm, whichever is greater
Vertical center of buoyancy	±1% or 5 cm, whichever is greater
Transverse center of buoyancy	±0.5% of B or 5 cm, whichever is greater
Longitudinal center of flotation, from AP	±1% or 50 cm, whichever is greater
Moment to trim 1 cm	±2%
Transverse metacentric height	±1% or 5 cm, whichever is greater
Longitudinal metacentric height	±1% or 50 cm, whichever is greater
Cross curves of stability	±5 cm
Compartment Dependent	Acceptable Tolerance(1)
Volume or deadweight	±2%
Longitudinal center of gravity, from AP	±1% or 50 cm, whichever is greater
Vertical center of gravity	±1% or 5 cm, whichever is greater
Transverse center of gravity	±0.5% of B or 5 cm, whichever is greater
Free surface moment	±2%
Shifting moment	±5%
Level of contents	±2%
Trim and Stability	Acceptable Tolerance(1)
Drafts (forward, aft, mean)	±1% or 5 cm, whichever is greater
GMt (both solid and corrected for free surfaces)	±1% or 5 cm, whichever is greater
GZ values	±1% or 5 cm, whichever is greater
Downflooding angle	±2°
Equilibrium angles	±1°
Distance from WL to unprotected and weathertight openings, or other relevant point, if applicable	±5% or 5 cm, whichever is greater
Areas under righting arm curve	±5% or 0.0012 mrad

Notes:

(1) Deviation in % = [(base value – applicant's value)/base value] × 100.
Where the "base value" may be from the approved stability information or the Society's computer model.

(2) When applying a tolerance in Table III A4-1 above that contains two values, the allowable tolerance is the greater of the two values.

(3) Where differences in calculation methodology exist between the programs used in the comparison, this may be a basis for accepting deviations greater than that specified in Table III A4-1 above provided a software examination is carried out in sufficient detail to clearly document that such differences are technically justifiable.

(4) Deviation from these tolerances are not to be accepted unless CR considers that there is a satisfactory explanation for the difference and that it is clearly evident from CR's stability calculations that the deviation does not impact compliance with the required stability criteria for the craft under consideration.

A4.6 Approval Procedure

A4.6.1 Conditions of Approval of the Onboard Software for Stability Calculations

The onboard software used for stability calculations is subject to approval, which is to include:

- Verification of type approval, if any,
- Verification that the data used is consistent with the current condition of the craft (see A4.6.3 of this Appendix),
- Verification and approval of the test conditions, and
- Verification that the software is appropriate for the type of craft and stability calculations required.
- Verification that the software is installed so that failure of the primary computer or server does not prevent the stability calculation from being carried out (this is to be demonstrated onboard as noted below)
- Verification of functional requirements under A4.4 of this Appendix.

The satisfactory operation of the software for stability calculations is to be verified by testing upon installation on the primary computer or server and at least one back-up computer or redundant server onboard (see A4.6.3 of this Appendix). A copy of the approved test conditions and the operation manual for the computer/software are to be available onboard.

A4.6.2 General Approval (optional)

Upon receipt of application for general approval of the calculation program, CR may provide the applicant with test data consisting of two or more design data sets, each of which is to include a craft's hull form data, compartmentation data, lightship characteristics and deadweight data, in sufficient detail to accurately define the craft and its loading condition.

Acceptable hull form and compartmentation data may be in the form of surface coordinates for modeling the hull form and compartment boundaries (e.g., a table of offsets) or in the form of pre-calculated tabular data (e.g., hydrostatic tables, capacity tables) depending upon the form of data used by the software being submitted for approval. Alternatively, the general approval may be given based on at least two test craft agreed upon between the applicant and CR.

In general, the software is to be tested for two types of craft for which approval is requested, with at least one design data set for each of the two types. Where approval is requested for only one type of craft, a minimum of two data sets for different hull forms of that type of craft are required to be tested.

For calculation software which is based on the input of hull form data, design data sets are to be provided for three types of craft for which the software is to be approved, or a minimum of three data sets for different hull forms if approval is requested for only one type of craft. Representative craft are those types which, due to their different hull forms, typical arrangements and nature of cargo, require different design data sets.

The test data sets are to be used by the applicant to run the calculation program for the test craft. The results obtained, together with the hydrostatic data and cross-curve data developed by the program, if appropriate are to be submitted to CR for the assessment of the program's computational accuracy. CR is to perform parallel calculations using the same data sets and a comparison of these results will be made against the applicant's submitted program's results.

A4.6.3 Specific Approval

CR is to verify the accuracy of the computational results and actual craft data used by the calculation program for the particular craft on which the program will be installed.

Upon receipt of application for data verification, CR and the applicant are to agree on a minimum of 4 loading conditions, taken from the craft's approved stability information, which are to be used as the test conditions.

For craft carrying liquids in bulk, at least one of the conditions is to include partially filled tanks. Within the test conditions each compartment is to be loaded at least once. The test conditions normally are to cover the range of load drafts from the deepest envisaged loaded condition to the light ballast condition and are to include at least 1 departure and 1 arrival condition.

For Type 4 stability software for SRtP, CR is to examine at least 3 damage cases, each of them associated with at least 3 loading conditions taken from the craft's approved stability information. Output of the software is to be compared with results of corresponding load/damage case in the approved damage stability booklet or an alternative independent software source.

CR is to verify that the following data, submitted by the applicant, is consistent with arrangements and most recently approved lightship characteristics of the craft according to current plans and documentation on file with CR, subject to possible further verification onboard:

- Identification of the calculation program including version number.
- Main dimensions, hydrostatic particulars and, if applicable, the craft profile.
- The position of the forward and after perpendiculars, and if appropriate, the calculation method to derive the forward and after drafts at the actual position of the craft's draft marks.
- Craft lightweight and center of gravity derived from the most recently approved inclining experiment or light weight check.
- Lines plan, offset tables or other suitable presentation of hull form data if necessary for CR to model the craft.
- Compartment definitions, including frame spacing, and centers of volume, together with capacity tables (sounding/ullage tables), free surface corrections, if appropriate
- Cargo and Consumables distribution for each loading condition.

Verification by CR does not absolve the applicant and craft owner of responsibility for ensuring that the information programmed into the onboard computer software is consistent with the current condition of the craft and the approved stability booklet.

A4.7 Operation Manual

A simple and straightforward operation manual is to be provided, containing descriptions and instructions, as appropriate, for at least the following:

- Installation
- Function keys
- Menu displays
- Input and output data
- Required minimum hardware to operate the software
- Use of the test loading conditions
- Computer-guided dialogue steps
- List of warnings

A4.8 Installation Testing

To ensure correct working of the computer after the final or updated software has been installed, it is the responsibility of the craft's master to have test calculations carried out according to the following pattern in the presence of the Surveyor:

- From the approved test conditions at least one load case (other than lightship) is to be calculated.

  Note: Actual loading condition results are not suitable for checking the correct working of the computer.

- Normally, the test conditions are permanently stored in the computer.

Steps to be performed:

- Retrieve the test load case and start a calculation run; compare the stability results with those in the documentation.

- Change several items of deadweight (tank weights and the cargo weight) sufficiently to change the draft or displacement by at least 10%. The results are to be reviewed to ensure that they differ in a logical way from those of the approved test condition.

- Revise the above modified load condition to restore the initial test condition and compare the results. Confirm that the relevant input and output data of the approved test condition have been replicated.

- Alternatively, one or more test conditions shall be selected and the test calculation performed by entering all deadweight data for each selected test condition into the program as if it were a proposed loading. The results shall be verified as identical to the results in the approved copy of the test conditions.

A4.9 Periodical Testing

It is the responsibility of the craft's master to check the accuracy of the onboard computer for stability calculations at each Annual Survey by applying at least one approved test condition.

If the Surveyor is not present for the computer check, a copy of the test condition results obtained by the computer check is to be retained onboard as documentation of satisfactory testing for the Surveyor's verification.

At each Special Survey, this checking for all approved test loading conditions is to be done in presence of the surveyor.

The testing procedure is to be carried out in accordance with A4.8 of this Appendix.

A4.10 Other Requirements

The following features are to be provided to the software:

- Protection against unintentional or unauthorized modification of programs and data is to be provided.

- The program is to monitor operations and activate an alarm when the program is incorrectly or abnormally used.

- The program and any data stored in the system are to be protected from corruption by loss of power.

- Error messages with regard to limitations such as filling a compartment beyond capacity, or exceeding the assigned load line, etc. are to be included.

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CR Classification Society

FOUNDED 1951

RULES FOR THE CONSTRUCTION AND CLASSIFICATION OF HIGH-SPEED CRAFT 2021

PART IV — MACHINERY AND SYSTEMS

August 2020

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PART IV MACHINERY AND SYSTEMS

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Chapter 1
General

1.1 General

1.1.1 Application

The requirements of this Part are applicable to the machinery intended for crafts without special service limitations or restrictions.

(a) The Society may, however, modify the requirements in certain particular cases for their application to crafts with service limitations or restrictions.

(b) The Society may give special consideration to the novel features of design in respect of the machinery based on the available information at the time.

(c) In addition to the Rules, the Society reserves the right to impose further requirements in respect of all types of machinery, where this is unavoidable due to new findings or operational experience.

1.1.2 Plans and data

The plans and data specified as below and in each chapter, as applicable for each craft to be built under survey, are to be submitted and approved before construction is commenced, in accordance with Part I of the Rules. The sizes, dimensions, welding and other details, make and size of standard approved appliances are to be shown on the plans as clearly and fully as possible.

(a) Details of dead craft start arrangements (see 1.3.4 of this Chapter)

(b) Description of all automatic trips that may affect the craft's propulsion system

(c) Windlass or winch

In addition to the plans and data as below, the applicable requirements for windlass or winch in Chapter 4 of Part IV of the Rules for Steel Crafts are also to be complied with.

(i) Arrangements, details and stress calculations for the windlass or winch, drums, brakes, shaft, gears, coupling bolts, wildcat, sheaves, pulleys and foundation.

(ii) Control arrangements

(iii) Electric one-line diagram, including power ratings and cable specifications

(iv) Piping system diagram, including working pressures, welding details, material specifications and pipe specifications

1.1.3 Sea trial

(a) General

A final underway trial is to be made of all machinery, including the steering gear, anchor windlass and ground tackle. The entire installation is to be operated in the presence of the Surveyor to demonstrate its reliability and capability to function satisfactorily under operating conditions and its freedom from harmful vibrations within the operating range. The ability of the machinery to reverse the direction of thrust of the propeller from maximum ahead speed and to bring the craft to rest is to be demonstrated on sea trials to the satisfaction of the Surveyor.

All automatic controls, including trips which may affect the craft's propulsion system, are to be tested underway or alongside the pier to the satisfaction of the Surveyor.

The requirements specified in 2.1.6(b), 2.4.9(b) are also to be considered.

(b) Residual fuel

The viscosity of the fuel used on the sea trial are to be included in the classification report.

1.1.4 Units

(a) Units and formulae in this Part are shown in SI units.

(b) Pressure gauges may be calibrated in bar.

where: 1 bar = 0.1 MPa

1.2 Definitions

The terms used in this Part are defined as follows:

1.2.1 Machinery spaces of category A

Machinery spaces of category A are those spaces and trunks to such spaces which contain either: internal combustion machinery used for main propulsion; internal combustion machinery used for purposes other than main propulsion where such machinery has in the aggregate a total power output of not less than 375 kW; or any oil-fired boiler or oil fuel unit, or any oil-fired equipment other than boilers, such as inert gas generators, incinerators, etc.

1.2.2 Machinery spaces

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

1.2.3 Oil fuel unit

An oil-fuel unit is any equipment, such as pumps, filters and heaters, used for the preparation and delivery of fuel oil to oil-fired boilers (including incinerators, diesel engines or gas turbines at a pressure of more than 1.8 bar.

1.2.4 Accommodation spaces

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

1.2.5 Public spaces

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

1.2.6 Service spaces

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

1.2.7 Cargo spaces

Cargo spaces are spaces used for cargo, cargo oil tanks, tanks for other liquid cargo and trunks to such spaces.

1.2.8 Special category spaces

Special category spaces are those enclosed vehicle spaces above and below the bulkhead deck, into and from which vehicles can be driven and to which passengers have access. Special category spaces may be accommodated on more than one deck provided that the total overall clear height for vehicles does not exceed 10 m.

1.2.9 Sources of ignition

Sources of ignition are considered to include a flame, arc, spark and electrical equipment, machinery and other equipment having hot surfaces with the potential of causing a non-intentional explosion or fire when exposed to an explosive or flammable atmosphere or material.

1.2.10 Essential service systems

Essential service systems are those systems necessary for the craft's survivability and safety, including:

(a) Systems for fill, transfer and service of fuel oil

(b) Fire-main systems, including emergency fire pump

(c) Other required fire-extinguishing and detection systems

(d) Bilge systems, including emergency bilge suction

(e) Ballast systems

(f) Steering systems and steering control systems

(g) Propulsion systems and their necessary auxiliaries (fuel oil, lube oil, cooling water, starting system, etc.) and control systems

(h) Systems for transfer and control of cargo

(i) Craft's service and emergency electrical generation systems and their auxiliaries (fuel oil, lube oil, cooling water, starting system, etc.) and control systems

(j) Venting and sounding systems

(k) Engine room ventilation systems

(l) Other required ventilation systems

(m) Controllable pitch propeller systems, including controls

(n) Electrical power and lighting systems

(o) Systems used for navigation

(p) Required communication and alarm systems

(q) Hydraulic systems for anchor windlass/winch

(r) Systems necessary due to special characteristics or special service of a craft

(s) Any other system deemed essential by the Society

1.2.11 Dead craft condition

Dead craft condition means a condition under which:

(a) The main propulsion plant, boilers and auxiliary machinery are not in operation due to the loss of the main source of electrical power, and

(b) In restoring propulsion, the stored energy for starting the propulsion plant, the main source of electrical power and other essential auxiliary machinery is assumed to be not available.

1.2.12 Blackout

Blackout situation means the loss of the main source of electrical power resulting in the main and auxiliary machinery to be out of operation.

1.2.13 Propeller shaft

Propeller shaft is the part of the propulsion shaft to which the propeller is fitted. It may also be called screwshaft or tailshaft.

1.2.14 Stern tube shaft

Stern Tube Shaft or Tube Shaft is the part of the propulsion shaft passing through the stern tube from the forward end of the propeller end bearing to the in-board shaft seal.

1.2.15 Intermediate shaft

Intermediate shaft is the part of the propulsion shaft in-board of the vessel.

1.2.16 Thrust shaft

Thrust Shaft is that part of the propulsion shaft which transmits thrust to the thrust bearing.

1.2.17 Oil distribution shaft

Oil distribution shaft is a hollow propulsion shaft where the bore and radial holes are used for distribution of hydraulic oil in controllable pitch propeller installations.

1.3 General Requirements of Machinery and Systems

1.3.1 Materials

(a) The requirements of 1.4 of Part IV of the Rules for Steel Ships are to be complied with, as applicable.

(b) Installation of materials which contain asbestos is prohibited.

1.3.2 Ambient reference conditions

(a) The rating for classification purposes of main and essential service auxiliary machineries intended for installation in seagoing crafts to be classed for unrestricted service is to be based on a total barometric pressure of 1,000 mbar, an engine room ambient temperature or suction air temperature of 0°C to 45°C, a relative humidity of 60% and a sea water temperature of 32°C or, where applicable, the temperature of the charge air coolant at the inlet of 32°C. In the case of open deck location, the temperature range is to be -25°C to 45°C. The engine manufacturer is not expected to provide simulated ambient reference conditions at a test bed.

(b) In the case of craft to be classed for restricted service, the rating is to be suitable for the temperature conditions associated with the geographical limits of the restricted service.

1.3.3 Inclinations

Machinery installations are to be designed to operate under the conditions as shown in Table IV 1-1 below.

Table IV 1-1
Inclination of Crafts

Type of machinery installations	Athwartships(1)		Bow-and-stern(1)	
	Static inclination (list)	Dynamic inclination (rolling)	Static inclination (trim)	Dynamic inclination (pitching)
Main propulsion machinery Main boilers and important auxiliary boilers Prime movers driving generators (excluding those for emergency) auxiliary machinery (excluding auxiliary machinery for specific use etc.) and their driving units	15°	22.5°	5°	7.5°
Emergency installations (emergency generators, emergency fire pumps and prime movers to drive them) Switch gears(2) (Circuit breakers, etc.) Equipment for automatic and remote controls	22.5°(3)	22.5°(3)	10°	10°

Notes:

(1) Athwartships and bow-and-stern inclinations may occur simultaneously.

(2) Up to an angle of inclination of 45°, undesired switching operations or operational changes are not to be caused.

(3) In crafts carrying liquefied gases in bulk and crafts carrying dangerous chemicals in bulk, the arrangement is to be such that the emergency power supply must also remain operable with the craft flooded to a final athwartships inclination up to a maximum of 30°

1.3.4 Dead craft start

Craft's machinery is to be so arranged that it can be brought into operation from the "Dead craft condition" as defined in 1.2.11 of this Chapter using only the facilities available on board. "Dead craft" condition is understood to mean that the entire machinery installation, including the power supply, is out of operation and that auxiliary services such as compressed air, starting current from batteries, etc., for bringing the main propulsion into operation and for the restoration of the main power supply are not available. In order to restore operation from the "dead craft" condition, an emergency generator may be used provided that it is ensured that the emergency power supply from it is available at all times. It is assumed that means are available to start the emergency generator at all times.

1.3.5 Machinery spaces

Machinery spaces are to be arranged so as to provide access to all machinery and controls as necessary for operation or maintenance.

1.3.6 Machinery space ventilation

Machinery spaces are to be ventilated so as to ensure that when machinery is operating at full power in all weather conditions, including heavy weather, an adequate supply of air is maintained for operation of the machinery and safety of the personnel.

1.3.7 Rotating machinery

Rotating machinery is to be in accordance with the requirements of Chapter 1 through Chapter 5 in this Part, as applicable.

1.3.8 Engineers' alarm

Engineers' alarms are required on craft of 500 gross tonnage and over, which are intended for international voyages. An engineers' alarm is to be operable from the main propulsion control station. It is to be audible in the engineers' accommodations. See 4.2.5(l) of Part IV of the Rules.

1.3.9 Astern propulsion power

(a) Sufficient power for going astern is to be provided to secure proper control of the craft in all normal circumstances. The astern power of the main propelling machinery is to be capable of maintaining in free route astern at least 70% of the ahead RPM corresponding to the maximum continuous ahead power. For main propulsion systems with reversing gears, controllable pitch propellers or electric propulsion drive, running astern is not to lead to overload of the propulsion machinery.

(b) Main propulsion systems are to undergo tests to demonstrate the astern response characteristics. The tests are to be carried out at least over the maneuvering range of the propulsion system and from all control positions. A test plan is to be provided by the yard and accepted by the surveyor. If specific operational characteristics have been defined by the manufacturer, these shall be included in the test plan. The ability of the machinery, including the blade pitch control system of controllable pitch propellers, to reverse the direction of thrust of the propeller in sufficient time, and so to bring the vessel to rest within a reasonable distance from maximum ahead service speed, is to be demonstrated and recorded during trials.

1.3.10 Shipboard automatic or remote control and monitoring systems

Automatic or remote control and monitoring systems associated with propulsion machinery and monitoring systems of propulsion-machinery space installed onboard classed craft are to comply with the requirements in Chapter 1 to Chapter 3 of Part VIII of Steel Ship Rules, as applicable. Additionally, where requested by the Owner and provided that compliance with Chapter 5 or Chapter 6 is met, the aforementioned systems will be assigned the optional symbols **CAU** or **CAB**, respectively. See Chapter 1 of Part VIII of Steel Ship Rules.

1.3.11 Automatic trips

A description of all automatic trips that may affect the craft's propulsion system is to be submitted for review.

1.3.12 Thrusters and dynamic positioning systems

Compliance with the applicable requirements in Chapter 4 of Part IV of the Rules for Steel Ships is required for main propulsion thrusters and is optional for propulsion-assist thrusters and athwartship thrusters. Dynamic positioning systems, including their thrusters, are to comply with Chapter 10 of Part IV of the Rules for Steel Ships.

1.3.13 Seating and fixing

(a) The machinery seating is to be of rigid construction and adequately attached to the hull. The effects of hull structure deformation on the machinery and excessive stressing due to shock and vibration as well as the thermal expansion of machinery are to be taken into account. Provision is to be made, as far as practicable, to ensure continuity between the longitudinal and transverse elements of the seating and the corresponding elements of the adjacent hull.

(b) The machinery is to be so securely bolted to the seating as to prevent any displacement due to the movements of the craft. The bedplate chock is to be of uniform fit before bolts are tightened.

(c) The accessories of machinery as well as spare parts of large dimensions are to be strongly secured so that they can not move or become loose under the movements of the craft.

1.3.14 Machinery equations

The equations for rotating parts of the machinery in the following sections are based upon strength considerations only. Their application does not relieve the manufacturer from responsibility for the presence of dangerous vibrations in the installation at speeds within the operating range. See also 2.6.6 of this Part.

1.3.15 Deck machinery and essential auxiliaries

The windlass, mooring winch, capstan, reciprocating compressor and essential service pumps are to comply with the requirements of Chapter 4 of Part IV of the Rules for Steel Ships.

Chapter 2

Machinery Installations, Boilers and Pressure Vessels

2.1 Diesel Engines Including Couplings and Reduction Gears

2.1.1 General

The requirements of this Section apply to diesel engines and reduction gears.

(a) Construction and installation

(i) Diesel engines and associated reduction gears are to be constructed in accordance with Chapter 3 and Chapter 5 of Part IV of the Rules for Steel Ships and installed in accordance with the following requirements to the satisfaction of the Surveyor.

(ii) For diesel engines driving generators, refer to the additional requirements of 4.3 of this Part.

(iii) Additional requirements for exhaust emission abatement equipment connected to diesel engines or boilers are provided in the Guidelines for Exhaust Gas Recirculation Systems, Guidelines for Selective Catalytic Reduction Systems or Guidelines for SO_x Scrubber Systems published by the Society, whichever is applicable.

(b) Piping systems, pressure vessels and heat exchangers

(i) Piping systems are to comply with the applicable requirements in Chapter 3 in addition to requirements in this section.

(ii) Pressure vessels and heat exchangers are to comply with the applicable requirements of 2.2 of this Chapter.

(c) Torsional vibration stresses

Refer to the requirements specified in 2.6.7 of this Chapter.

(d) Crankcase oil mist detection

For diesel engines of 2,250 kW maximum continuous power and above or having cylinders of more than 300 mm bore, crankcase oil mist detection arrangements are to be provided as specified in 3.4.5 of Part IV of the Rules for Steel Ships. However, in cases where alternative devices (e.g. engine bearing temperature monitors or equivalent devices) deemed appropriate by the Society are provided, such devices may be used instead of crankcase oil mist detection arrangements.

(e) Crankcase ventilation

(i) General

Provision is to be made for ventilation of an enclosed crankcase by means of a small breather or by means of a slight suction not exceeding 25 mm of water. Crankcases are not to be ventilated by a blast of air. Otherwise, the general arrangements and installation are to be such as to preclude the possibility of free entry of air to the crankcase.

(ii) Piping arrangement

Crankcase ventilation piping is not to be directly connected with any other piping system. Crankcase ventilation pipes from each engine are normally to be led independently to the weather and fitted with corrosion-resistant flame screens. However, crankcase ventilation pipes from two or more engines may lead to a common oil mist manifold.

Where a common oil mist manifold is employed, the vent pipes from each engine are to be led independently to the manifold and fitted with a corrosion-resistant flame screen within the manifold. The arrangement is not to violate the engine manufacturer's recommendations for crankcase ventilation. The common oil mist manifold is to be accessible at all times under normal conditions and effectively

vented to the weather. Where venting of the manifold to the weather is accomplished by means of a common vent pipe, the location of the manifold is to be as close as practicable to the weather such that the length of the common vent pipe is no greater than one deck height. The clear open area of the common vent pipe is not to be less than the aggregate cross-sectional area of the individual vent pipes entering the manifold. The manifold is also to be fitted with an appropriate draining arrangement.

(f) Warning notices

Suitable warning notices are to be attached in a conspicuous place on each engine and are to caution against the opening of a hot crankcase for a specified period of time after shutdown based upon the size of the engine, but not less than 10 minutes in any case. Such notice is also to warn against restarting an overheated engine until the cause of overheating has been remedied.

(g) Bedplate

The bedplate or crankcase is to be of rigid construction, oiltight, and provided with a sufficient number of bolts to secure the same to the craft's structure. The structural arrangements for supporting and securing the main engines are to be submitted for approval. Refer to 2.5.1(a)(iii) of Part III of the Rules for structural requirements. For welded construction, the requirements in Chapter 5 of Part XII of the Rules for Steel Ships are also to be considered.

(h) Couplings

(i) Flexible shaft couplings

Details of the various components of flexible couplings for main propulsion machinery and craft's service generator sets are to be submitted for approval.

(1) Design
Flexible couplings intended for use in propulsion shafting are to be of approved designs. Couplings are to be designed for the rated torque, fatigue and avoidance of overheating. Where elastomeric material is used as a torque-transmitting component, it is to withstand environmental and service conditions over the design life of the coupling, taking into consideration the full range of maximum to minimum vibratory torque. Flexible coupling design will be evaluated, based on submitted engineering analyses.

(2) Torsional displacement limiter
Flexible couplings with elastomer or spring type flexible members, whose failure will lead to total loss of propulsion capability of the craft, such as that used in the intermediate shaft of a single propeller craft, are to be provided with a torsional displacement limiter. The device is to lock the coupling or prevent excessive torsional displacement when a pre-determined torsional displacement limit is exceeded. Operation of the craft under such circumstances may be at reduced power. Warning notices for such reduced power are to be posted at all propulsion control stations.

(3) Barred range
Conditions where the allowable vibratory torque or the allowable dissipated power may be exceeded under the normal operating range of the engine are to be identified and are to be marked as a barred range in order to avoid continuous operation within this range.

(4) Diesel generators
Flexible couplings for diesel generator sets are to be capable of absorbing short time impact torque due to electrical short-circuit conditions up to 6 times the nominal torque.

(ii) Flanged couplings and coupling bolts

Refer to 2.6.5(c)(iii) for flanged couplings.

Elongation for auxiliary machinery coupling bolts made of steel having an ultimate tensile strength over 690 N/mm^2 will be subject to special consideration. Also refer to 2.6.5(c)(i) of this Chapter.

2.1.2 Plans and data

(a) Plans and data of diesel engine are to be submitted as specified in 3.2 of Part IV of the Rules for Steel Ships.

(b) Plans and data of reduction gears are to be required as specified in 5.1.2 of Part IV of the Rules for Steel Ships.

2.1.3 Starting arrangements

(a) Starting air systems

The design and construction of all air reservoirs are to be in accordance with the applicable requirements of 2.2 of this Chapter. The piping system is to be in accordance with the applicable requirements of Chapter 3 of this Part. The air reservoirs are to be so installed as to make the drain connections effective under extreme conditions of trim. Compressed air systems are to be fitted with relief valves and each air reservoir which can be isolated from a relief valve is to be provided with its own safety valves or equivalent.

All discharge pipes from starting air compressors are to be led directly to the starting air reservoirs, and all starting pipes from the air reservoirs to main or auxiliary engines are to be entirely separate from the compressor discharge piping system.

(b) Starting air capacity

Craft having main engines arranged for air starting are to be provided with at least two starting-air reservoirs of approximately equal size. The total capacity of the starting-air reservoirs is to be sufficient to provide, without recharging the air reservoirs, at least the number of starts stated below.

If other compressed air systems, such as control air, are supplied from starting air reservoirs, the capacity of the air reservoirs is to be sufficient for continued operation of these systems after the air necessary for the required number of consecutive starts has been used.

(i) Diesel propulsion

The minimum number of consecutive starts (total) required to be provided from the starting-air reservoirs is to be based upon the arrangement of the engines and shafting systems as indicated in the following table.

Quantity / Type	1 engine	2 engines	3 or more engines
Reversible Engines	12	12 (6 per engine)	3 per engine(1)
Non-reversible Engines	6	6 (3 per engine)	3 per engine(1)

Notes:

(1) However, the total capacity is not to be less than 12 starts and need not exceed 18 starts.

For arrangements of engine and shafting systems which differ from those indicated in the table, the capacity of the starting-air reservoirs will be specially considered based on an equivalent number of starts.

(ii) Diesel-electric propulsion

The minimum number of consecutive starts C required to be provided from the starting-air reservoirs is to be determined from the following table:

No. of Diesel driven Electric Generators	1	2	3 and over
C	6	8	12

(c) Starting air compressors

For craft having diesel engines arranged for air starting, there are to be two or more air compressors, at least one of which is to be driven independently of the main propulsion unit, and the total capacity of air compressors driven independently of the main propulsion unit is to be not less than 50% of the total required.

The total capacity of the air compressors is to be sufficient to supply within one hour the quantity of the air need to satisfy 2.1.3(b) by charging the reservoirs from atmospheric pressure. The capacity is to be approximately equally divided between the number of compressors fitted, excluding an emergency compressor, where fitted.

The arrangement for dead craft air starting is to be such that the necessary air for the first charge can be produced onboard without external aid. See 1.3.4 of this Chapter.

(d) Protective devices for starting-air mains

In order to protect starting air mains against explosions arising from improper functioning of starting valves, an isolation non-return valve or equivalent is to be installed at the starting air supply connection to each engine. Where engine bores exceed 230 mm, a bursting disc or flame arrester is to be fitted in way of the starting valve of each cylinder for direct reversing engines having a main starting manifold or at the supply inlet to the starting-air manifold for non-reversing engines. The above requirement is applicable to engines where the air is directly injected into the cylinder. It is not intended to apply to engines utilizing air start motors.

(e) Electrical starting

(i) Main engine

Where the main engine is arranged for electric starting, at least two separate batteries (or separate sets of batteries) are to be fitted. The arrangement is to be such that the batteries (or sets of batteries) cannot be connected simultaneously in parallel. Each battery (or set) is to be capable of starting the main engine when in cold and ready to start conditions. The combined capacity of the batteries is to be sufficient without recharging to provide within 30 minutes the number of starts of main engines as required for air starting in 2.1.3(b), and if arranged also to supply starting for auxiliary engines, the number of starts required in 2.1.3(e)(ii). See also 2.1.3(e)(iii).

(ii) Auxiliary engine

Electric starting arrangements for auxiliary engines are to have at least two separate batteries (or separate sets of batteries) or may be supplied by separate circuits from the main engine batteries when such are provided. Where one auxiliary engine is arranged for electric starting, one battery (or set) may be accepted in lieu of two separate batteries (or sets). The capacity of the batteries for starting the auxiliary engines is to be sufficient for at least three starts for each engine.

(iii) Other requirements

The starting batteries (or set of batteries) are to be used for starting and for engine's own control and monitoring purpose only. When the starting batteries are used for engine's own control and monitoring purpose, the aggregate capacity of the batteries is to be sufficient for continued operation of such system in addition to the required number of starting capacity. Provisions are to be made to continuously maintain the stored energy at all times. See also 4.6 and 4.11.7 of this Part.

(f) Hydraulic starting

Hydraulic oil accumulators for starting the main propulsion engines are to have sufficient capacity without recharging for starting the main engines, as required in 2.1.3(b) of this Chapter.

2.1.4 Air intake and exhaust arrangements

(a) Engine air intake system

Engine air intakes are to be provided with filters to protect against damage from foreign matter.

(b) Engine exhaust systems

(i) General

All engine exhaust systems are to be adequate to carry out the designed function of the machinery and that safe operation of the craft is not put at risk. The exhaust pipes are to be water-jacketed or effectively insulated. Exhaust systems are to be so installed that the craft's structure cannot be damaged by heat

from the systems. Exhaust pipes of several engines or gas turbines are not to be connected together but are to be run separately to the atmosphere unless arranged to prevent the return of gases to an idle engine or turbine.

Exhaust lines which are led overboard near the waterline are to be protected against the possibility of the water finding its way inboard. As a minimum, the highest point of the line (measured to the bottom of the pipe) is to be not less than 0.02L above the deepest seagoing draft, or to be above the deepest waterline accounting for trim (see 2.2.1(a) of Part III of the Rules), whichever is greater. The exhaust opening in the shell shall be above deepest seagoing draft. Exhaust systems are to be so arranged as to minimize the intake of exhaust gases into manned spaces, air-conditioning systems, and engine intakes. Exhaust systems are not to discharge into air-cushion intakes, where provided.

(ii) Exhaust system materials

Materials used in the exhaust system are to be resistant to saltwater corrosion, galvanically compatible to each other and resistant to exhaust products. Plate flanges will be considered where the specified material is suitable for exhaust piping pressures and temperatures.

(iii) Exhaust gas temperature

Propulsion engines with a power rating exceeding 500 kW/cylinder are to be fitted with means to display the exhaust as temperature gauge at each cylinder.

2.1.5 Fuel, lubricating and cooling arrangements

(a) Fuel oil arrangements

(i) Fuel oil pumps and oil heaters

(1) Transfer pumps
Refer to the requirements of 3.3.4 of this Part.

(2) Booster pumps

a) Standby pump, single engine installation.

An independently driven standby pump is to be provided for each service pump, booster pump and other pumps serving the same purpose.

The capacity of the pumps, with any one pump out of service, is to be sufficient for continuous operation at rated power.

b) Standby pump, multiple engine installation.

For craft fitted with two or more propulsion engines, the provision of a common standby pump (for each service pump, booster pump, etc.) capable of serving all engines sufficient for continuous operation at rated power will suffice rather than providing individual standby pumps for each engine.

c) Attached pumps.

For multiple engine installations, engines having service, booster or similar pumps attached to and driven by the engine may, in lieu of the standby pump, be provided with a complete pump carried on board as a spare. The spare pump, upon being installed, is to allow the operation of the engine at rated power.

The spare pump need not be carried, provided that, in the event of the loss of one engine, at least forty percent of the total rated propulsion power remains.

(3) Heaters
When fuel oil heaters are required for main engine operation, at least two heaters of approximately equal size are to be installed. The combined capacity of the heaters is to be not less than required to supply the main engine(s) at full power.

(ii) Fuel oil pressure piping

Pipes from booster pumps to injection systems are to be at least standard seamless steel. Pipes conveying heated oil are to be at least standard seamless or electric-resistance-welded steel (ERW). ERW pipe is to be straight seam and fabricated with no filler metal. Valves and fittings may be screwed in sizes up to and including 60 mm O.D., but screwed unions are not to be used on pressure lines in sizes 33 mm O.D. and over. Valves are to be so constructed as to permit packing under pressure.

(iii) Fuel oil injection system

(1) General

Strainers are to be provided in the fuel oil injection pump suction line.

For main propulsion engines, the arrangement is to be such that the strainers may be cleaned without interrupting the fuel supply to the engine. However, where multiple engines are provided, a dedicated simplex strainer may be fitted for each engine, provided the craft can maintain at least one-half of the design speed or seven knots, whichever is less, while operating with one engine temporarily out of service until its strainer can be cleaned.

For auxiliary engines, the arrangement is to be such that the strainers may be cleaned without undue interruption of power necessary for propulsion. Multiple auxiliary engines, each fitted with a separate strainer and arranged such that change-over to a standby unit can be accomplished without loss of propulsion capability, will be acceptable for this purpose.

Where strainers are fitted in parallel to enable cleaning without disrupting the oil supply, means are to be provided to minimize the possibility of a strainer being opened inadvertently. Strainers are to be provided with suitable means for venting when being put in operation and being depressurized before being opened. Strainers are to be so located that in the event of leakage, oil cannot be sprayed on to the exhaust manifold or surfaces with temperatures in excess of 220°C. The injection lines are to be of seamless drawn pipe. Fittings are to be extra heavy. The material used may be either steel or nonferrous, as approved in connection with the design. Also refer to 3.3 of this Part.

(2) Piping between injection pump and injectors

a) Injection piping

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 highpressure line failure. A jacketed pipe incorporates an outer pipe into which the high-pressure fuel pipe is placed, forming a permanent assembly. Metallic hose of an approved type may be accepted as the outer pipe, where outer piping flexibility is required for the manufacturing process of the permanent assembly. The jacketed piping system is to include means for collection of leakages and arrangements are to be provided for an alarm to be given of a fuel line failure.

b) Fuel oil return piping

When the peak to peak pressure pulsation in the fuel oil return piping from the injectors exceeds 20 bar, jacketing of the return pipes is also required.

c) High pressure common rail system

Where a high pressure common rail system is fitted to an engine, the high pressure common rail is to be in accordance with the requirements for pressure vessels as specified in 2.2 of this Chapter, or other recognized standards. Alternatively, the design may be verified by certified burst tests. Components are to be made of steel or cast steel. Components made of steel, other than cast steel, are to withstand not less than 4 times the maximum allowable working pressure. The cast steel common rails are to withstand not less than 5 times the maximum allowable working pressure. The use of non-ferrous materials, cast iron and nodular iron is prohibited.

The high pressure common rail system is required to be properly enclosed and provided with arrangement for leak collection and alarm in case of a failure of high pressure common rail system, see 2.1.5(a)(iii)(2)a).

(3) Piping between booster pump and injection pumps

Spray shields are to be fitted around flanged joints, flanged bonnets and any other flanged or threaded connections in fuel oil piping systems under pressure exceeding 1.8 bar which are located above or near units of high temperature, including boilers, steam pipes, exhaust manifolds, silencers or other equipment required to be insulated, and to avoid as far as practicable oil spray or oil leakage into machinery air intakes or other sources of ignition. The number of joints in such piping systems is to be kept to a minimum.

(b) Lubricating oil systems

(i) General

The following requirements are applicable for main and auxiliary diesel engines and for reduction gears associated with diesel propulsion. See also 1.3.3 and 3.4 of this Part.

(ii) Low oil pressure alarms, temperature and level indicators

An alarm device with audible and visual signals for failure of the lubricating oil system is to be fitted for propulsion and auxiliary engines having a rated power greater than 37 kW. Such events shall also cause automatic reduction of engine speed to a safe level, but automatic shutdown shall only be activated by conditions leading to a complete breakdown, fire or explosion.

Pressure and temperature indicators are to be installed in lubricating oil systems indicating that the proper circulation is being maintained.

(iii) Drain pipes

Lubricating oil drain pipes from the sump to the drain tank are to be submerged at their outlet ends. No interconnection is to be made between the drain pipes from the crankcases of two or more engines.

(iv) Lubricating oil pumps

In cases where forced lubrication is used for propulsion engines, one independently driven standby pump is to be provided in addition to the necessary pumps for normal operation. Where the size and design of an engine is such that lubrication before starting is not necessary and an attached lubricating pump is normally used, an independently driven standby pump is not required if a complete duplicate of the attached pump is carried as a spare.

The spare pump need not be provided for multiple-engine installations provided that, in the event of the loss of one engine, at least forty percent of the total rated propulsion power remains.

(v) Filters

Oil filters are to be provided. In the case of main propulsion engines which are equipped with full-flowtype filters, the arrangement is to be such that the strainers may be cleaned without interrupting the oil supply. However, where multiple engines are provided, a dedicated simplex strainer may be fitted for each engine provided the craft can maintain at least one-half of the design speed or 7 knots, whichever is less, while operating with one engine temporarily out of service until its filter can be cleaned.

For auxiliary engines, the arrangement is to be such that the filters may be cleaned without undue interruption of power necessary for propulsion. Multiple auxiliary engines, each fitted with a separate filter and arranged such that change-over to a standby unit can be accomplished without loss of propulsion capability, will be acceptable for this purpose.

The arrangement of the valving is to be such as to avoid release of debris into the lubricating-oil system upon activation of the relieving mechanism.

Where filters are fitted in parallel to enable cleaning without disrupting the oil supply, means are to be provided to minimize the possibility of a filter under pressure being opened inadvertently. Filters are to be provided with suitable means for venting when being put in operation and being depressurized before being opened. Valves and cocks with drain pipes led to a safe location are to be used for this purpose. Filters are to be so arranged as to prevent, in the event of leakage, spraying of oil onto the exhaust manifold and surfaces with temperatures in excess of 220°C.

(vi) Lubricating-oil systems for reduction gears

Where a reduction gear is driven by a single engine and a common lubricating-oil system is used for both the engine and gear, the requirements in 2.1.5(b)(i) through 2.1.5(b)(v) are applicable.

Where a reduction gear is driven by more than one engine or any other case where a separate lubricating oil system is provided for the reduction gear, the following requirements are applicable.

(1) Pumps
Two lubricating-oil pumps are to be provided, at least one of which is to be independently driven. The capacity of each pump is to be sufficient for continuous operation of the main propulsion plant at its maximum rated power.

(2) Coolers
One or more lubricating oil coolers with means for controlling the oil temperature is to be provided together with two separate cooling water pumps, at least one of which is to be independently driven. The coolers are to have sufficient capacity to maintain the required oil

temperature while the main propulsion plant is operating continuously at its maximum rated power.

(3) Indicators
Indicators are to be fitted by which the pressure and temperature of the water inlet and oil outlet may be determined. Gravity tanks are to be fitted with a low level alarm and a sight glass is to be fitted in the overflow line to the sump. Pressure systems are to be fitted with a low pressure alarm.
Sump and gravity tanks are to be provided with suitable gauges for determining the level of oil within the tank.

(4) Filters
A filter is to be provided in the lubricating-oil piping to each reduction gear. The requirements in 2.1.5(b)(v) are applicable.

(c) Cooling water systems

(i) General

Means are to be provided to ascertain the temperature of the circulating water at the return from each engine and to indicate that the proper circulation is being maintained. Drain cocks are to be provided at the lowest point of all jackets. For relief valves, see 4.3.4 of Part VI of the Rules for Steel Ships.

(ii) Sea suctions

At least two independent sea suctions are to be provided for supplying water to the engine jackets or to the heat exchangers, except that for multihull craft classed with restricted service (see 1.4.4 of Part I of the Rules), special consideration may be given. The sea suctions are to be located as to minimize the possibility of blanking off the cooling water. For multiple engine installations fitted with individual sea suctions for each engine, two means of supplying cooling water to each engine may be omitted where the craft are fitted with three or more propulsion units and can maintain half design speed with one propulsion shut down.

(iii) Strainers

Where seawater is used for direct cooling of the engines, unless other equivalent arrangements are specially approved, suitable strainers are to be fitted between the sea valves and the pump suctions. The strainers are to be either of the duplex type or otherwise arranged so they can be cleaned without interrupting the cooling water supply.

(iv) Circulating water pumps

There are to be at least two means for supplying cooling water to main and auxiliary engines, compressors, coolers, reduction gears, etc. One of these means is to be independently driven and may consist of a connection from a suitable pump of adequate size normally used for other purposes, such as a general service pump, or in the case of fresh-water circulation one of the craft's fresh-water pumps. Where, due to the design of the engine, the connection of an independent pump is impracticable, the independently driven stand-by pump will not be required if a complete duplicate of the attached pump is carried as a spare.

The spare pump need not be provided for multiple-engine installations provided that, in the event of the loss of one engine, at least 40% of the total rated propulsion power remains.

2.1.6 Tests and trials

(a) Works trials (Factory Acceptance Test)

The works trials (Factory Acceptance Test) are to comply with the applicable requirements in 3.11 of Part IV of the Rules for Steel Ships.

(b) Shipboard Trial

The shipboard trials are to comply with the applicable requirements in 3.11 of Part IV of the Rules for Steel Ships.

Before final acceptance, the entire installation is to be operated in the presence of the Surveyor to demonstrate its ability to function satisfactorily under operating conditions and its freedom from harmful vibration at speeds within the operating range. See also 1.1.3 of this Part.

2.2 Boilers and Pressure Vessels

2.2.1 Plans and data

Arrangements and details of boilers, pressure vessels and heat exchangers required by Part V of the Rules for Steel Ships.

Plans and data for hydraulic and pneumatic power cylinders, as required by 3.4 of this Part.

2.2.2 When fitted, boilers and pressure vessels are to be designed and constructed in accordance with Part V of the Rules for Steel Ships.

2.3 Propellers

2.3.1 General

(a) Application

This section applies to propellers intended for propulsion. It covers fixed pitch and controllable pitch propellers. Performance of propellers, in respect to developing the designed output, is to be demonstrated during sea trials.

(b) Plans and data to be submitted

(i) General

For all propellers (air or water), a propeller plan giving design data and characteristics of the material.

(ii) Fixed pitch propeller of conventional design

Material

Design characteristics of propeller

Dimensions and tolerances

Propeller plan

Blade thickness calculations

(iii) Controllable pitch propellers of conventional design

As per 2.3.1(b)(ii) above.

Hub and hub to propeller shaft flange attachment bolts

Propeller blade flange and bolts

Internal mechanism

Hydraulic piping control system

Instrumentation and alarm system

Strength calculations for internal mechanism

(iv) Highly skewed propeller and other unconventional designs

For skewed propellers or propeller blades of unusual design, a detailed stress analysis, as required by 2.3.4(c) or 2.3.4(d).

In addition to the foregoing, where propeller blade designs are of the types for which the Rules do not provide simplified blade thickness calculations, such as

- Highly skewed propellers with $\theta > 50°$;
- High skewed propellers made of other than CU3 materials with $50° \geq \theta > 25°$;
- Controllable pitch propellers with $\theta > 25°$;

propeller load and stress analyses demonstrating adequacy of blade strength are to be submitted.

(v) Keyless propeller

Where propellers are to be fitted to the shaft without keys, stress calculations for hub stresses and holding capacity, along with fitting instructions, are to be submitted.

(c) Definitions

For purpose of this section, the following definitions apply.

(i) Skew angle

Skew angle (θ) of a propeller is the angle measured from ray 'A' passing through the tip of blade at mid-chord line to ray 'B' tangent to the mid-chord line on the projected blade outline. See Fig. IV 2-1.

(ii) Highly skewed propeller

A highly skewed propeller is one whose skew angle is more than 25°.

(iii) Propeller rake

(1) Rake
Rake is the distance at the blade tip between the generating line and the line perpendicular to the propeller axis that meets the generating line at the propeller axis. See Fig. IV 2-2.

(2) Rake angle (ϕ).
Rake angle of a propeller is the angle measured from the plane perpendicular to shaft centerline to the tangent to the generating line at a specified radius (0.6 × radius for the purpose of this section). See Fig. IV 2-2.

(iv) Wide tipped blade propeller

A propeller blade is to be considered as a wide tipped blade if the maximum expanded blade chord length occurs at or above 0.8R, with R being the distance measured from the centerline of the propeller hub.

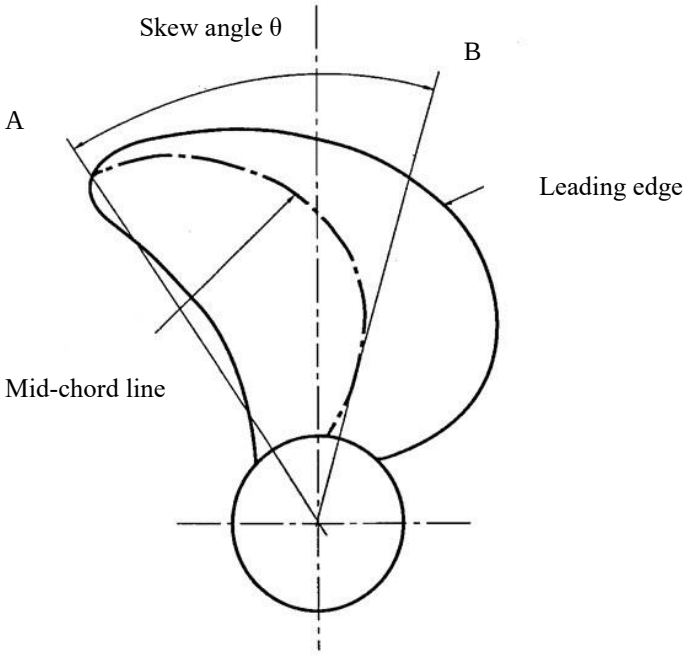


Fig. IV 2-1
Maximum Skew Angle

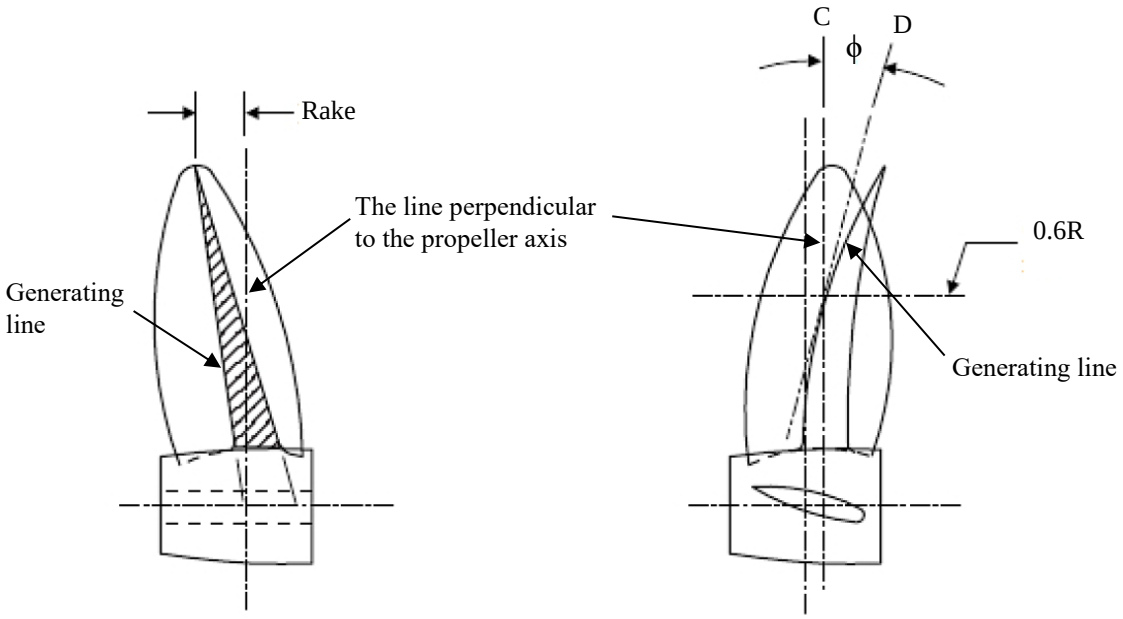


Fig. IV 2-2
Rake and Rake Angle

2.3.2 Certification

(a) Material tests

Propeller materials are to be tested in the presence of the Surveyor. See 2.3.3(c).

(b) Inspection and certification

Finished propellers are to be inspected and certified at the manufacturer's plant by the Surveyor. The blade forms, pitch, blade thickness, diameters, etc. are to be checked for conformance with approved plans. The entire surface of the finished propeller is to be examined visually and by liquid penetrant method. All finished propellers are to be statically balanced in the presence of the Surveyor. As far as practicable, reference is to be made to the provisions of ISO 484 for these purposes.

The surfaces of stainless steel propellers are to be suitably protected from the corrosive effect of the industrial environment until fitted on the craft.

2.3.3 Materials

(a) Normally used propeller materials

See 10.3 of Part XI of the Rules for Steel Ships for details of the materials. Where an alternative material specification is proposed, detailed chemical composition and mechanical properties similar to those specified in 10.3 of Part XI of the Rules for Steel Ships are to be submitted for approval.

(b) Stud materials

The material of the studs securing detachable blades to the hub is to be in accordance with Chapter 8 of Part XI of the Rules for Steel Ships.

(c) Material testing

Materials of propellers cast in one piece and materials of blades, hub, studs and other load-bearing parts of controllable pitch propellers are to be tested in the presence of the Surveyor. The requirements of material testing are specified in Part XI of the Rules for Steel Ships.

2.3.4 Design

(a) Blades of conventional design ($\theta \leq 25°$)

The required blade thickness is to be as specified in 7.2.1(a) in Part IV of the Rules for Steel Ships. For craft less than 61 m in length, however, the pitch factor k_2 used in the formula is to be 0.85 times for 0.25R section.

(b) Blades of unusual design

(i) Skewed propeller ($\theta > 25°$)

The requirements of 7.2.1(b) in Part IV of the Rules for Steel Ships are to be complied with.

However, for the following propellers, design analyses, as indicated in 2.3.4(b)(ii), are to be submitted.

(1) Propeller of materials other than CU3 in Chapter 3 of Part XI of the Rules for Steel Ships with skew angle θ; where $25° < \theta \leq 50°$

(2) Propeller blades with skew angle $\theta > 50°$

(3) Skewed propeller ($\theta > 25°$) with wide-tip blades

(ii) Cycloidal propellers, etc., are subject to special consideration based on submittal of propeller load and stress analyses. The analyses are to include, but be not limited to the following:

- Description of method to determine blade loading;
- Description of method selected for stress analysis;
- Ahead condition is to be based on propulsion machinery's maximum rating and full ahead speed;
- Astern condition is to be based on the maximum available astern power of the propulsion machinery
  (the astern power of the main propelling machinery is to be capable of 70% of the ahead RPM corresponding to the maximum continuous ahead power, as required in 1.3.9 of this Part); and is to include crash astern operation;
- Fatigue assessment; and
- Permissible stress and fatigue criteria.

(c) Blade-root fillets

Fillets at the root of the blades are not to be considered in the determination of blade thickness.

(d) Controllable pitch propellers – pitch actuation system

The required blade thickness is to be as specified in 7.2.1(d) in Part IV of the Rules for Steel Ships.

(i) Blade flange and mechanisms

The strength of the propeller blade flange and pitch changing mechanism of controllable-pitch propellers subjected to the forces from propulsion torque is to be at least 1.5 times that of the blade at design pitch conditions.

(ii) Blade pitch control

(1) Bridge control
Where the navigation bridge is provided with direct control of propulsion machinery, it is to be fitted with means to control the pitch of the propeller.

(2) Duplication of power unit
At least two hydraulic power pump units for the pitch actuating system are to be provided and arranged so that the transfer between pump units can be readily effected. For propulsion machinery spaces intended for unattended operation (**CAU**, **CAB** symbol), automatic start of the standby pump unit is to be provided.

The emergency pitch actuating system (as required by 2.3.4(d)(ii)(3)c)) may be accepted as one of the required hydraulic power pump units, provided it is no less effective.

(3) Emergency provisions
To safeguard the propulsion and maneuvering capability of the craft in the event of any single failure in either the remote pitch control system or the pitch actuating system external to the propeller shaft and oil transfer device (also known as oil distribution box), the following are to be provided:

a) Manual control of pitch at or near the pitch-actuating control valve (usually the directional valve or similar).

b) The pitch is to remain in the last ordered position until the emergency pitch actuating system is brought into operation.

c) An emergency pitch actuating system

This system is to be independent of the normal system up to the oil transfer device, provided with its own oil reservoir and able to change the pitch from full ahead to full astern.

d) Integral oil systems

Where the pitch actuating hydraulic system is integral with the reduction gear lubricating oil system and/or clutch hydraulic system, the piping is to be arranged such that any failure in the pitch actuating system will not leave the other system(s) non-operational.

e) Provisions for testing

Means are to be provided in the pitch actuating system to simulate system behavior in the event of loss of system pressure. Hydraulic pump units driven by main propulsion machinery are to be fitted with a suitable by-pass for this purpose.

f) Multiple propellers

For craft fitted with more than one controllable pitch propeller, each of which is independent of the other, only one emergency pitch actuating system (as required by 2.3.4(d)(ii)(3)c)) need be fitted, provided it is arranged such that it can be used to provide emergency pitch-changing for all propellers.

g) Hydraulic piping

Hydraulic piping is to meet the requirements of 3.4 of this Part.

(iv) Instrumentation

All controllable pitch propeller systems are to be provided with instrumentation as provided below:

(1) Pitch indicators
A pitch indicator is to be fitted on the navigation bridge. In addition, each station capable of controlling the propeller pitch is to be fitted with a pitch indicator.

(2) Monitoring
Individual visual and audible alarms are to be provided at the engine room control station to indicate hydraulic oil low pressure and high temperature and hydraulic tank low level. A high hydraulic oil pressure alarm is to be fitted if required by the proposed system design and, if fitted, is to be set below the relief valve setting.

For craft assigned with **CAU** or **CAB** symbol, see the requirements of monitoring on the navigation bridge and in the centralized control station in Part VIII of the Rules for Steel Ships.

(e) Propeller fitting

(i) Keyed fitting

For shape of the keyway in the shaft and size of the key, see 2.3.5.

(ii) Keyless fitting

The requirements of 7.3 and 7.4 of Part IV of the Rules for Steel Ships are to be complied with, as applicable.

2.3.5 Installation, tests and trial

(a) Keyed propellers

The sides of the key are to have a true fit in the keyways of the propeller hub and the shaft. See also 2.6.4(d) for propeller shaft propeller end design.

(b) Controllable pitch propellers – fit of studs and nuts

Studs, nuts and bolts are to have tight-fitting threads and are to be provided with effective means of locking. Effective sealing arrangements are to be provided in way of the bolt or stud holes against sea water ingress or oil leakage. Bolts, nuts and studs are to be of corrosion resistant materials or adequately protected from corrosion.

(c) Protection against corrosion

The exposed steel of the shaft is to be protected from the action of the water by filling all spaces between cap, hub and shaft with a suitable material. The propeller assembly is to be sealed at the forward end with a well-fitted soft-rubber packing ring. When the rubber ring is fitted in an external gland, the hub counterbore is to be filled with suitable material, and clearances between shaft liner and hub counterbore are to be kept to a minimum. When the rubber ring is fitted internally, ample clearance is to be provided between liner and hub. The rubber ring is to be sufficiently oversized to squeeze into the clearance space provided; and, where necessary, a filler piece is to be fitted in way of the propeller-hub keyway to provide a flat unbroken seating for the rubber ring.

(d) Circulating currents

Where means are provided to prevent circulating currents from passing between the propeller, shaft and the hull, a warning notice plate is to be provided in a visible place cautioning against the removal of such protection.

(e) Keyed and keyless propellers – contact area check and securing

The propeller hub to propeller shaft taper contact area is to be checked in the presence of the Surveyor. In general, the actual contact area is to be not less than 70% of the theoretical contact area. Non-contact bands extending circumferentially around the propeller hub or over the full length of the hub are not acceptable. Installation is to be in accordance with the procedure referred to in 2.3.4(e)(ii) and final pull-up travel is to be recorded. After final pull-up, propellers are to be secured by a nut on the after end of the propeller shaft.

The nut is to be secured to the propeller shaft against loosening. See also 2.6.4(d).

(f) Controllable pitch propellers – hydrostatic tests

The completed piping system of the controllable pitch propeller hydraulic system is to be hydrostatically tested at a pressure equal to 1.5 times the design pressure in the presence of the Surveyor. Relief valve operation is to be verified.

(g) Sea trial

The designed performance of the propeller at rated speed is to be demonstrated during sea trial. For controllable pitch propellers, the blade pitch control functions, from full ahead through full astern, are to be demonstrated. The emergency provisions in 2.3.4(d)(ii)(3) are also to be demonstrated.

2.4 Steering Gear

2.4.1 General

(a) Application

These requirements apply to craft which have rule-required upper rudder stock diameter less than 230 mm. Where the rule-required upper rudder stock diameter is 230 mm or above, 4.2 of Part IV of the Rules for Steel Ships are to be applied.

Where a rudder is not fitted and steering is achieved by change of setting of the propulsion units, such as the use of cycloidal, azimuthing or similar type propulsion systems, 4.6 of Part IV of the Rules for Steel Ships is to be applied.

(b) Definitions

(i) Main steering gear

Main steering gear is the machinery, rudder actuators, power units, ancillary equipment and the means of applying torque to the rudder stock (e.g., tiller or quadrant) necessary for effecting movement of the rudder for the purpose of steering the craft.

(ii) Auxiliary steering gear

Auxiliary steering gear is the equipment other than any part of the main steering gear necessary to steer the craft in the event of failure of the main steering gear, but not including the tiller, quadrant or components serving the same purpose.

(iii) Control system

Steering gear control system is the equipment by which orders are transmitted from the navigation bridge to the steering gear power actuating system. Steering gear control systems comprise transmitters, receivers, hydraulic control pumps and their associated motors, motor controllers, piping and cables required to control the steering gear power actuating system. For the purpose of the Rules, steering wheels, steering levers, and rudder angle feedback linkages are not considered to be part of the control system.

(iv) Power units

A steering gear power unit is:

(1) In the case of electric steering gears, an electric motor and its associated electrical equipment,

(2) In the case of electro-hydraulic steering gears, an electric motor and its associated electrical equipment and connected pump(s), and

(3) In the case of other hydraulic steering gears, a driving engine and connected pump(s).

(v) Power actuating system

Power actuating system is the hydraulic equipment provided for supplying power to turn the rudder stock, comprising a power unit or units together with the associated pipes and fittings and a rudder actuator. The power actuating systems may share common mechanical components (i.e., tiller, quadrant, rudder stock, or components serving the same purpose).

(vi) Rudder actuator

Rudder actuator is the component which directly converts hydraulic pressure into mechanical action to move the rudder.

(vii) Maximum working pressure

Maximum working pressure is the expected pressure in the system when the steering gear is operated to comply with 2.4.1(d).

(c) Power operation

The main steering gear is to be power-operated by one or more power units if the rule-required upper rudder stock diameter is 120 mm or greater.

Notwithstanding the above, the performance requirements stated in 2.4.1(d) and 2.4.1(e) are to be used to determine if it is necessary for the main and auxiliary steering gears to be power-operated.

(d) Main steering gear

The main steering gear is to be capable of putting the rudder from 35° on one side to 35° on the other side with the craft running ahead at maximum continuous shaft RPM and at the summer load waterline; and under the same conditions, the travel time from 35° on either side to 30° on the other side is not to be more than 28 seconds. For controllable pitch propellers, the propeller pitch is to be at the maximum design pitch approved for the above maximum continuous ahead rated RPM.

Regarding the propulsion and steering systems other than traditional arrangements for a vessel's directional control, the main steering arrangements are to be capable of changing direction of the vessel's directional control system from one side to the other at declared steering angle limits at an average rotational speed of not less than 2.3°/s with the vessel running ahead at the maximum ahead service speed.

(e) Auxiliary steering gear

The auxiliary steering gear is to be capable of putting the rudder from 15° on one side to 15° on the other side in not more than 60 seconds with the craft running ahead at half speed, or 7 knots, whichever is greater.

Regarding the propulsion and steering systems other than traditional arrangements for a vessel's directional control, the auxiliary steering arrangements are to be capable of changing direction of the vessel's directional control system from one side to the other at declared steering angle limits at an average rotational speed of not less than 0.5°/s with the vessel running ahead at one half of the maximum ahead service speed or 7 knots, whichever is the greater.

The auxiliary steering gear is to be so arranged that the failure of the main steering gear will not render it inoperative. Likewise, failure of the auxiliary steering gear is not to affect the main steering gear.

An auxiliary steering gear is not required under the following conditions.

(i) When the main steering gear comprises two or more power units, and is so arranged that after a single failure in its piping system or in one of the power units, the defect can be isolated so that the steering capability can be maintained or regained; and provided that

(1) For passenger craft, the main steering gear is capable of operating the rudder, as required in 2.4.1(d), while any one of the power units is out of operation; and

(2) For cargo craft, the main steering gear is to be capable of operating the rudder, as required by 2.4.1(d), while all the power units are in operation.

(ii) When the main steering gear is non-power-operated such as an orbitrol system, or consists solely of mechanical components such as sheaves, blocks, wires, chains, etc.

(f) Steering gear compartment unit location

The main and the auxiliary steering gears are to be protected from weather. The power units may be located either within or outside of the compartment containing the rudder actuators. In the event of loss of hydraulic fluid and of the need to restore the operation of the main or the auxiliary steering gear, the steering gear compartment is to be provided with handrails and gratings or other non-slip surfaces to promote suitable working conditions.

In the event of control system failure, or the need to operate the main or the auxiliary steering gear from within the steering compartment or from positions other than the navigation bridge, craft of 500 gross tonnage and above are to be provided with a means to indicate the position of the rudder at these positions where emergency steering is to be conducted.

2.4.2 Plans and data

Plans and data of the steering gear system to be submitted are as follows:

(a) Plans

(i) General arrangements of the main and auxiliary steering gears, and of the steering gear compartment.

(ii) Assembly of upper rudder stock, tiller, tie rod, rudder actuators, etc., as applicable.

(iii) Construction details of all torque-transmitting components of steering gear, such as tiller, tiller pin, tiller/rudder stock interference fit mechanism, tie rod, rudder actuator, etc., including bill of materials, welding procedures, nondestructive testing, as applicable.

(iv) Schematic hydraulic piping diagram, incorporating hydraulic logic diagram, and including bill of materials, typical pipe to pipe joint details, pipe to valve joint details, pipe to equipment joint details, pressure rating of valves and pipe fittings and pressure relief valve settings.

(v) Steering gear control system incorporating schematic electrical control logic diagram, instrumentation, alarm devices, etc., and including bill of materials.

(vi) Electrical power supply to power units and to steering gear control, including schematic diagram of motor controllers, feeder cables, feeder cable electrical protection.

(b) Data

(i) Rated torque of main steering gear.

(ii) Calculations of torque-transmitting components such as tiller, tie rod, rudder actuator, etc.

(c) For steering vanes

(i) Details and material specifications of torque transmitting parts

(ii) Airfoil analysis including vane freestream characteristics (lift and drag characteristics)

(iii) Control system arrangements

2.4.3 Materials

(a) General

All steering gear components transmitting a force to the rudder and pressure retaining components of the hydraulic rudder actuator are to be of steel or other approved ductile material. The use of gray cast iron or other material having an elongation less than 12% in 50 mm is not acceptable.

(b) Material testing

Except as modified below, materials for the parts and components mentioned in 2.4.3(a) are to be tested in the presence of the Surveyor in accordance with the requirements of Part XI of the Rules for Steel Ships.

(i) Material tests for steering gear coupling bolts and torque transmitting keys need not be witnessed by the Surveyor. Material tests for commercially supplied tie-rod nuts need not be witnessed by the Surveyor, provided the nuts are in compliance with the approved steering gear drawings and are appropriately marked and identified in accordance with a recognized industry standard. Mill test reports for the tie-rod nuts are to be made available to the Surveyor upon request. For all non-standard tie-rod nuts, material testing is required to be performed in the presence of the Surveyor.

(ii) Material tests for forged, welded or seamless steel parts (including the internal components) and all nonferrous parts of rudder actuators that are under 150 mm in internal diameter need not be carried out in the presence of the Surveyor. Such parts are to comply with the requirements of Part XI of the Rules for Steel Ships, or such other appropriate material specifications as may be approved in connection with a particular design, and will be accepted on the basis of presentation of mill certificates to the Surveyor for verification.

2.4.4 Design

(a) Power gear stops

Power-operated steering gears are to be provided with arrangements, such as limit switches, for stopping the steering gear before the structural rudder stops (see 2.8.1(d) of Part III of the Rules) or positive mechanical stops within the steering gear are reached. These arrangements are to be synchronized with the rudder stock or position of the steering gear itself rather than with the steering-gear control system.

(b) Mechanical components

All steering gear parts transmitting force to or from the rudder, such as tillers, quadrants, rams, pins, tie rods and keys, are to be proportioned to have strength equivalent to that of the rule-required upper rudder stock diameter.

(c) Steering gear torque

(i) Minimum required rated torque

The rated torque of the steering gear is not to be less than the expected torque, as defined in 2.8.1(c) of Part III of the Rules.

(ii) Maximum allowable torque

The transmitted torque, T_{max}, of the steering gear is not to be greater than the maximum allowable torque, T_{ar}, based on the actual rudder stock diameter.

(1) Transmitted torque

The transmitted torque, T_{max}, is to be based on the relief valve setting and to be determined in accordance with the following equations:

a) For ram type actuator:

$T_{max} = P \cdot N \cdot A \cdot L_2 / (10000 \cdot \cos^2\theta)$ kN·m

b) For rotary vane type actuator:

$T_{max} = P \cdot N \cdot A \cdot L_2 / 10000$ kN·m

c) For linked cylinder type actuator:

$T_{max} = P \cdot N \cdot A \cdot L_2 \cdot \cos\theta / 10000$ kN·m

where

P = Steering gear relief valve setting pressure, in bar

N = Number of active pistons or vanes

A = Area of piston or vane, in mm^2

L_2 = Torque arm, equal the distance from the point of application of the force on the arm to the center of the rudder stock at 0 deg of the rudder angle, in m

θ = Maximum permissible rudder angle (normally 35 degrees)

(2) Maximum allowable torque for rudder stock

The maximum allowable torque "T_{ar}" for the actual rudder stock diameter is to be determined in accordance with the following equation:

$T_{ar} = 2 (D_r / 42)^3 / K_s$ kN·m

where

K_s = Material factor for rudder stock (see 2.8.1(b) of Part III of the Rules)

D_r = Actual rudder stock diameter at minimum point below the tiller or the rotor, mm

(d) Tiller

Tillers are to comply with the following requirements. All terms in the formulae are to have consistent units.

(i) Depth of the tiller hub is not to be less than the rule-required upper rudder stock diameter.

(ii) Thickness of the tiller hub is not to be less than one third of the rule-required upper rudder stock diameter.

(iii) Notwithstanding 2.4.4(d)(ii) above, the polar section modulus of the tiller hub is not to be less than:

$$0.196S^3 \frac{K_h}{K_s}$$

where

S = Rule-required upper rudder stock diameter.

K_s = Material factor of the rudder stock (see 2.8.1(b) of Part III of the Rules)

K_h = Material factor of the hub (see 2.8.1(b) of Part III of the Rules)

(iv) The shear area of the tiller key is not to be less than:

$$\frac{0.196S^3}{r} \cdot \frac{K_k}{K_s}$$

where

r = Mean radius of the rudder stock in way of the key

K_k = Material factor of the key (see 2.8.1(b) of Part III of the Rules)

S = Rule-required upper rudder stock diameter.

K_s = Material factor of the rudder stock (see 2.8.1(b) of Part III of the Rules)

(v) Bearing stress of the tiller and rudder stock keyways are not to be more than 0.9 times the material yield stress.

(vi) If the tiller is shrink-fitted to the rudder stock, preloading and stress calculations and fitting instructions are to be submitted. The calculated torsional holding capacity is to be at least 2 times the transmitted torque based on the steering gear relief valve setting. Preload stress is not to exceed 90% of the minimum yield strength. Maximum equivalent Von-Mises Stress is not to exceed minimum yield strength considering all loads including preload stress and two times transmitted torque.

(vii) Section modulus of the tiller arm at any point within its length is not to be less than:

$$\frac{0.167S^3\ (L_2 - L_1)}{L_2} \cdot \frac{K_t}{K_s}$$

where

L_2 = Distance from the point of application of the force on the tiller to the center of rudder stock

L_1 = Distance between the section of the tiller arm under consideration and the center of the rudder stock

K_t = Material factor of the tiller or quadrant arm (see 2.8.1(b) of Part III of the Rules)

S = Rule-required upper rudder stock diameter.

K_s = Material factor of the rudder stock (see 2.8.1(b) of Part III of the Rules)

(viii) Split or semi-circular tiller or quadrant hubs assembled by bolting are to have bolts on each side having a total cross-sectional area not less than that given below (use a consistent system of units):

$$\frac{0.196S^3}{L_3} \cdot \frac{K_b}{K_s}$$

where

L_3 = Distance between the center of the bolts and the center of the rudder stock

K_b = Material factor of bolt (see 2.8.1(b) of Part III of the Rules)

S = Rule-required upper rudder stock diameter.

K_s = Material factor of the rudder stock (see 2.8.1(b) of Part III of the Rules)

The thickness of the bolting flange is not to be less than the minimum required diameter of the bolt.

(ix) Where the tiller is of welded construction, weld design and weld sizes are to be proportioned such that they are commensurate with the strength of the tiller.

(e) Pin

Shear area of the tiller pin is not to be less than:

$$\frac{0.196S^3}{L_2} \cdot \frac{K_p}{K_s}$$

where

K_p = Material factor of the pin (see 2.8.1(b) of Part III of the Rules)

S = Rule-required upper rudder stock diameter.

K_s = Material factor of the rudder stock (see 2.8.1(b) of Part III of the Rules)

L_2 = Distance from the point of application of the force on the tiller to the center of rudder stock

(f) Tie rod

The buckling strength of the tie rod is not to be less than:

$$\frac{0.113S^3U_R}{L_2}$$

where

U_R = Ultimate tensile strength of the rudder stock, in N/mm^2

L_2 = Distance from the point of application of the force on the tiller to the center of rudder stock

S = Rule-required upper rudder stock diameter.

(g) Rudder actuators

(i) General

Rudder actuators are to meet the requirements in 2.4.3 for materials and material tests. They are also to meet the requirements for pressure vessels in the Rules for Steel Ships, specifically 3.1, 3.2 and 3.4 of Part V of the Rules for Steel Ships (in association with S, as defined below) for design and 8.2 of Part V of the Rules for Steel Ships for hydrostatic tests. The maximum permissible stress, S, is not to exceed the lower of the following:

$$S = \frac{U}{A} \quad or$$

$$S = \frac{Y}{B}$$

where

U = Minimum specified tensile strength of material at room temperature, in N/mm^2

Y = Minimum specified yield point or yield strength, in N/mm^2

A, B = Factors as given in the following table.

Factor	Rolled or forged steel	Cast steel	Nodular cast iron
A	3.5	4	5
B	1.7	2	3

(ii) Oil seals

Oil seals between non-moving parts forming the external boundary are to be of the pressure seal type. Oil seals between moving parts forming the external pressure boundary are to be fitted in duplicate so

that the failure of one seal does not render the actuator inoperative. Alternative seal arrangement may be acceptable, provided equivalent protection against leakage can be ensured.

(h) Mechanical steering gear

Where mechanical steering systems are permitted, the following are applicable.

(i) Steering chains and wire ropes

Steering chains and wire rope are to be tested as required by Chapter 13 and Chapter 14 of Part XI of the Rules for Steel Ships, respectively.

(ii) Sheaves

Sheaves are to be of ample size and so placed as to provide a fair lead to the quadrant and avoid acute angles. Parts subjected to shock are not to be of cast iron. Guards are to be placed around the sheaves to protect against injury. For sheaves intended for use with ropes, the radius of the grooves is to be equal to that of the rope plus 0.8 mm, and the sheave diameter is to be determined on the basis of wire rope flexibility. For 6 × 37 wire rope, the sheave diameter is to be not less than 18 times that of the rope. For wire ropes of lesser flexibility, the sheave diameter is to be increased accordingly. Sheave diameters for chain are to be not less than 30 times the chain diameter.

(iii) Buffers

Steering gears other than the hydraulic type are to be designed with suitable buffer arrangement to relieve the gear from shocks to the rudder.

2.4.5 Hydraulic system

(a) Pipes, valves and fittings

Pipes, valves and fittings are to meet the requirements of 3.4 of this Part, as applicable. The design pressure of piping components subject to internal hydraulic pressure is to be at least 1.25 times the maximum working pressure of the system. Arrangements for bleeding air from the hydraulic system are to be provided, where necessary.

(b) Relief valves

Relief valves are to be provided for the protection of the hydraulic system at any part which can be isolated and in which pressure can be generated from the power source or from external forces. Each relief valve is to be capable of relieving not less than 110% of the full flow of the pump(s) which can discharge through it. With this flow condition, the maximum pressure rise is not to exceed 10% of the relief valve setting, taking into consideration increase in oil viscosity for extreme ambient conditions.

The relief valve setting is to be at least 1.25 times the maximum working pressure (see 2.4.1(b)(vii)), but is not to exceed the maximum design pressure (see 2.4.5(a)).

(c) Filtration

A means is to be provided to maintain cleanliness of the hydraulic fluid.

(d) Single failure

Where multiple power units are provided and an auxiliary steering gear is not fitted, the steering gear hydraulic system is to be designed so that after a single failure in its piping system, one of the power units, or mechanical connection to the power units, the defect can be isolated so that the integrity of the remaining part of the system will not be impaired and the steering capability can be maintained or regained. For this purpose, the piping system associated with each power unit is to be independent of that of the other units as far as practicable and connections are to be made only where necessary. Isolation valves are to be fitted, as necessary, to allow any single failure in the piping system to be isolated and the steering gear to be operated with the remaining intact part of the system. Isolation valves are to be fitted at the pipe connections to rudder actuators. Where a non-duplicated rudder actuator is employed, the isolation valves are to be mounted directly on the actuator. Piping systems are to be so arranged that transfer between power units can be readily affected.

(e) Reservoir and storage tank

All open-loop hydraulic systems are to be provided with an oil reservoir of suitable capacity. In addition, for craft of 500 gross tonnage and above, a fixed storage tank having sufficient capacity to recharge at least one hydraulic power system including the reservoir is to be provided. The tank is to be permanently connected by piping in such a manner that the system can be readily recharged from a position within the steering gear compartment.

2.4.6 Power units

If the rule-required upper rudder stock diameter is 120 mm or greater, power units are to be tested and certified in accordance with the following requirements. If the rule-required upper rudder stock diameter is less than 120 mm, and if the craft is 500 gross tonnage or greater, power units are to be tested and certified in accordance with 2.4.6(b) only. For craft less than 500 gross tonnage, power units may be accepted based on manufacturer's guarantee for suitability for the intended purpose and subject to satisfactory functional tests after installation.

(a) Prototype test

A prototype of each new design power unit pump is to be shop-tested for a duration of not less than 100 hours. The testing is to be carried out in accordance with an approved agenda and is to include the following as a minimum.

(i) The pump and stroke control (or directional control valve) is to be operated continuously from full flow and relief valve pressure in one direction through idle to full flow and relief valve pressure in the opposite direction.

(ii) Pump suction conditions are to simulate lowest anticipated suction head. The power unit is to be checked for abnormal heating, excessive vibration or other irregularities. Following the test, the power unit pump is to be disassembled and inspected in the presence of the Surveyor.

(b) Product test

Each power unit pump is to meet the requirements of hydraulic pressure tests and shop trials in accordance with 4.7.1 and 4.7.2 of Part IV of the Rules for Steel Ships, as applicable.

2.4.7 Steering gear control system

(a) Locations of control

(i) Main steering gear

The main steering gear is to be provided with control from the navigation bridge and local control from within the steering gear compartment. However, if the power unit is located in a space other than the steering compartment, the local control is to be provided in that space instead of the steering compartment. For the purpose of local control from the steering gear compartment (or the space containing the power unit), a means is to be provided in the steering compartment (or the space containing the power unit) to disconnect any control system from the navigation bridge. Such means for disconnecting are to be operable by a single person without the need for tools.

(ii) Auxiliary steering gear

The auxiliary steering gear is to be operable from a space in which the operation of the auxiliary steering gear can be effectively carried out, or from within the steering compartment. However, if power operated, it is to be provided with control from the navigation bridge also.

(iii) Duplicate power units

Where duplicate (or more) power units are provided and an auxiliary steering gear is not fitted, two independent systems of control are to be provided. Each of these systems is to meet the requirements of the control system of the main steering gear (See 2.4.7(a)(i)). Where the control system consists of a hydraulic telemotor, a second independent system need not be fitted.

(iv) Manual Means

If the steering gear is operated by manual means only, such as by means of a steering wheel through a mechanical or a non-power-operated hydraulic system, only the requirements of 2.4.7(d) and 2.4.7(e)(i) are applicable.

(b) General

(i) Main and auxiliary steering gears

Control systems of the main and the auxiliary steering gears are to be independent of each other in all respects. The independent control systems are to meet the following requirements.

(1) Redundancy
These control systems are to be independent in all respects and are to provide on the navigation bridge all necessary apparatus and arrangements for the starting and stopping of steering gear motors and the rapid transfer of steering power and control between units.
The control cables and piping are to be separated throughout their length as widely as is practicable.
Wires, terminals and the components for duplicated steering gear control systems installed in units, control boxes, switchboards or bridge consoles are to be separated throughout their length as widely as is practicable. Where physical separation is not practicable, separation may be achieved by means of a fire retardant plate.

(2) Duplication
All electric components of the steering gear control system are to be duplicated. This does not require duplication of a steering wheel or steering lever.

(3) Steering mode selector switch
If a joint steering mode selector switch (uniaxial switch) is employed for both steering gear control systems, the connections for the circuits of the control systems are to be divided accordingly and separated from each other by an isolating plate or by air gap.

(4) Follow-up amplifier
In the case of double follow-up control, the amplifiers are to be designed and fed so as to be electrically and mechanically separated. In the case of non-follow-up control and follow-up control, the follow-up amplifiers are to be protected selectively.

(5) Additional control systems
Control circuits for additional control systems (e.g., steering lever or autopilot) are to be designed for all-pole disconnection.

(6) Feed-back units and limit switches
The feed-back units and limit switches, if any, for the steering gear control systems are to be separated electrically and mechanically connected to the rudder stock or actuator separately.

(7) Hydraulic control components
Hydraulic system components in the power actuating or hydraulic servo systems controlling the power systems of the steering gear (e.g., solenoid valves, magnetic valves) are to be considered as part of the steering gear control system and shall be duplicated and separated.
Hydraulic system components in the steering gear control system that are part of a power unit may be regarded as being duplicated and separated when there are two or more separate power units provided and the piping to each power unit can be isolated.

(ii) Duplicate power units

If the main steering gear consists of duplicated (or more) power units and an auxiliary steering is not fitted, the two independent means of control are to comply with the requirements of 2.4.7(a)(i).

(iii) Single power units

If the main steering gear consists of a single power unit and the auxiliary steering gear is not power operated, only one control system for the main steering gear need be provided.

(iv) Computer-based systems

Steering control systems that are computer-based systems are to comply with 2.7 of Part VIII of the Rules for Steel Ships.

(v) System response under failure

The failures (as listed, but not limited to items in 2.4.7(e)) likely to cause uncontrolled movements of rudder are to be clearly identified. In the event of detection of such failure, the rudder should stop in the current position. Alternatively, the rudder may be set to return to the midship/neutral position. Failure Mode and Effect Analysis methodology may be used to identify the failures.

(c) Control system power supply

Electrical power for the steering gear control system is to be derived from the motor controller of the power unit that it is controlling, or from the main switchboard at a point adjacent to the supply to the power unit.

(d) Communication

A means of communication is to be provided between the navigation bridge and all other locations where steering can be effected, such as the steering gear compartment, the space where the power units are located and the space where auxiliary steering gear is to be operated, as applicable.

(e) Instrumentation and alarms

The following instruments and alarms are to be provided. The audible and visual alarms are to have provisions for testing.

(i) Rudder position indicator

The angular position of the rudder is to be indicated on the navigation bridge and all other locations where steering can be effected, such as the steering gear compartment, the space where the power units are located and the space where auxiliary steering gear is to be operated, as applicable. The rudder angle indication is to be independent of the steering gear control system.

(ii) Autopilot

Where autopilot is fitted, a visual and audible alarm is to be provided on the navigation bridge to indicate its failure.

Where a power unit is provided and steering is controlled from navigation bridge, the following are applicable:

(iii) Motor alarm

A visual and audible alarm is to be given on the navigation bridge and the engine room control station to indicate an overload condition of the steering gear power unit motor. Where three phase electrical power is used, a visual audible alarm is to be installed which indicates failure of any one of the supply phases. The operation of these alarms is not to interrupt the circuit.

(iv) Motor running indicators

Indicators for running indication of motors are to be installed on the navigation bridge and the engine room control station.

(v) Power failure

A visual and audible alarm is to be given on the navigation bridge and engine room control station to indicate a power failure to any one of the steering gear power units.

(vi) Control power failure

A visual and audible alarm is to be given on the navigation bridge and the engine room control station to indicate an electrical power failure in any steering gear control circuit or remote control circuit.

In addition, hydraulic power operated steering gear is to be provided with the following:

(vii) Low oil level alarm

A visual and audible alarm is to be given on the navigation bridge and engine room control station to indicate a low oil level in any power unit reservoir. The operation of this alarm is not to interrupt the power supply circuit.

(viii) Hydraulic lock

Where the arrangement is such that a single failure may cause hydraulic lock and loss of steering, an audible and visual hydraulic lock alarm which identifies the failed system or component is to be provided on the navigation bridge. The alarm is to be activated upon steering gear failure if:

- Position of the variable displacement pump control system does not correspond to the given order, or
- Incorrect position of the 3-way full flow valve or similar in the constant delivery pump system is detected.

Alternatively, an independent steering failure alarm for follow-up control systems complying with the following requirements may be provided in lieu of a hydraulic lock alarm.

Where an independent steering failure alarm is installed for follow-up control systems it is to comply with the following:

(1) The steering failure alarm system is to actuate an audible and visible alarm in the wheelhouse when the actual position of the rudder differs by more than 5 degrees from the rudder position ordered by the follow-up control systems for more than:
- 30 seconds for ordered rudder position changes of 70 degrees;
- 6.5 seconds for ordered rudder position changes of 5 degrees; and

The time period calculated by the following formula for ordered rudder positions changes between 5 degrees and 70 degrees:

$$t = (R/2.76) + 4.64$$

where:

t = Maximum time delay, in seconds.

R = Ordered rudder change, in degree.

(2) The steering failure alarm system must be separate from, and independent of, each steering gear control system, except for input received from the steering wheel shaft.

(3) Each steering failure alarm system is to be supplied by a circuit that:
a) Is independent of other steering gear system and steering alarm circuits.
b) Is fed from the emergency power source through the emergency distribution panel in the wheelhouse, if installed; and
c) Has no overcurrent protection except short circuit protection

(ix) Autopilot override

(1) Steering gear systems provided with an autopilot system are to have a device at the primary steering station to completely disconnect the autopilot control to permit change-over to manual operation of the steering gear control system. A display is to be provided at the steering station to ensure that the helmsman can readily and clearly recognize which mode of steering control (autopilot or manual) is in operation.

(2) In addition to the change-over device as in 2.4.7(e)(ix)(1), for primary steering stations, where fitted with an automatic autopilot override to change-over from autopilot control to manual operation, the following are to be provided.
a) The automatic override of the autopilot is to occur when the manual helm order is 5 degrees of rudder angle or greater.
b) An audible and visual alarm is to be provided at the primary steering station in the event that the automatic autopilot override fails to respond when the manual helm order is 5 degrees of rudder angle or greater. The alarm is to be separate and distinct from other bridge alarms and is to continue to sound until it is acknowledged.
c) An audible and visual alarm that is immediately activated upon automatic autopilot override actuation is to be provided at the primary steering station. The alarm is to be distinct from other bridge alarms and is to continue to sound until it is acknowledged.

The following instrumentation and alarms are to be provided.

(x) Loop failures

A visual and audible alarm is to be given on the navigation bridge to indicate a loop failure.

Note: Monitoring is to be provided for short circuit, broken connections and earth faults for command and feedback loops. Monitoring for loop failures is not required, when a steering failure alarm system is provided. See 2.4.7(e)(viii)(1), (2), (3) above.

(xi) Computer-based system failures

For steering control systems that are computer-based systems, a visual and audible alarm is to be given on the navigation bridge to indicate a computer-based system failure.

Note: Monitoring is to be provided for data communication errors, computer hardware failures and software failure. See also 2.3 and 2.7 of Part VIII of the Rules for Steel Ships. Monitoring for computer-based system failures is not required, when a steering failure alarm system is provided. See 2.4.7(e)(viii)(1), (2), (3) above .

(xii) Earth fault

A visual and audible alarm is to be given on the navigation bridge to indicate an earth fault on AC and DC circuits.

(xiii) Deviation

Where arrangements discussed in 2.4.7(e)(viii) ~ 2.4.7(e)(xi) above can lead to reduced or erroneous system performance of the commanded change in rudder angle, a deviation alarm visible and audible at the navigating bridge shall be initiated if the rudder's actual position does not reach the set point within acceptable time limits for the closed loop control systems (e.g., follow-up control, computer based systems, and autopilot). Deviation alarm may be caused by mechanical, hydraulic or electrical failures. See 2.4.7(e)(viii) ~ 2.4.7(e)(xi) above for acceptable time limits or angle deviations, as applicable.

(f) Operating instructions

Appropriate operating instructions with a block diagram showing the change-over procedures for steering control systems and steering gear power units are to be permanently posted at a conspicuous location on the navigation bridge and in or near the steering gear compartment. Where system failure alarms in 2.4.7(e)(viii) are provided, appropriate instructions are to be permanently posted on the navigation bridge to shut down the failed system.

2.4.8 Electrical power supply

Electrical power circuits are to meet the requirements of 4.2.3 and 4.11.4(f)(v) of this Part.

2.4.9 Testing and trials

(a) Testing of piping system

The following tests are to be performed in the presence of the Surveyor.

(i) Shop tests

After fabrication, each component of the steering gear piping system, including the power units, hydraulic cylinders and piping, is to be hydrostatically tested at the plant of manufacture to 1.5 times the relief valve setting.

(ii) Installation tests

After installation in the craft, the complete piping system, including power units, hydraulic cylinders and piping, is to be subjected to a hydrostatic test equal to 1.1 times the relief valve setting, including a check of the relief valve operation.

(b) Trials

The steering gear is to be tried out on the trial trip in order to demonstrate to the Surveyor's satisfaction that the requirements of the Rules have been met. The trial is to include the operation of the following:

(i) The main steering gear, including demonstration of the performance requirements of 2.4.1(d) or with the rudder fully submerged. Where full rudder submergence cannot be obtained in ballast conditions,

steering gear trials are to be conducted at a displacement as close as reasonably possible to full-load displacement as required by Section 6.1.2 of ISO 19019:2005 on the conditions that either:

(1) The rudder is fully submerged (zero speed waterline) and the craft is in an acceptable trim condition.

(2) The rudder load and torque at the specified trial loading condition have been predicted (based on the system pressure measurement) and extrapolated to the full load condition using the following method to predict the equivalent torque and actuator pressure at the deepest seagoing draft:

$$Q_F = Q_T \bullet \alpha$$

$$\alpha = 1.25 \left(\frac{A_F}{A_T}\right) \left(\frac{V_F}{V_T}\right)^2$$

where

α = Extrapolation factor

Q_F = Rudder stock moment for the deepest service draft and maximum service speed condition

Q_T = Rudder stock moment for the trial condition

A_F = Total immersed projected area of the movable part of the rudder in the deepest seagoing condition

A_T = Total immersed projected area of the movable part of the rudder in the trial condition

V_F = Contractual design speed of the craft corresponding to the maximum continuous revolutions of the main engine at the deepest seagoing draft

V_T = Measured speed of the craft (considering current) in the trial condition

Where the rudder actuator system pressure is shown to have a linear relationship to the rudder stock torque, the above equation can be taken as:

$$P_F = P_T \cdot \alpha$$

where

P_F = Estimated steering actuator hydraulic pressure in the deepest seagoing draft condition

P_T = Maximum measured actuator hydraulic pressure in the trial condition

Where constant volume fixed displacement pumps are utilized, the requirements can be deemed satisfied if the estimated steering actuator hydraulic pressure at the deepest draft is less than the specified maximum working pressure of the rudder actuator. Where a variable delivery pump is utilized, pump data should be supplied and interpreted to estimate the delivered flow rate that corresponds to the deepest seagoing draft in order to calculate the steering time and allow it to be compared to the required time.
Where A_T is greater than $0.95A_F$, there is no need for extrapolation methods to be applied.

(3) Alternatively the designer or builder may use computational fluid dynamic (CFD) studies or experimental investigations to predict the rudder stock moment at the full sea going draft condition and service speed. These calculations or experimental investigations are to be to the satisfaction of the Society.

In any case for the main steering gear trial, the speed of the craft corresponding to the number of maximum continuous revolution of main engine and maximum design pitch applies.

(ii) The auxiliary steering gear, if required, including demonstration to the performance requirements of 2.4.1(e) and transfer between main and auxiliary steering gear.

(iii) The power units, including transfer between power units.

(iv) The emergency power supply required by 4.11.4(f)(v) of Part IV of the Rules.

(v) The steering gear controls, including transfer of control and local control.

(vi) The means of communications, as required by 2.4.7(d).

(vii) The alarms and indicators required by 2.4.7(e) (test may be done at dockside).

(viii) The storage and recharging system contained in 2.4.5(e) (test may be done at dockside).

(ix) The isolating of one power actuating system and checking for regaining steering capability are required by 2.4.5(d), if applicable (test may be done at dockside).

(x) Where the steering gear is designed to avoid hydraulic locking, this feature is to be demonstrated.

2.5 Waterjet

2.5.1 General

Full details are to be submitted for the force transmitting parts of waterjet units, including material specifications.

(a) The units are to be manufactured under Surveys.

(b) Mill certificates are to be provided for the components of the steering section.

(c) The material tests for the impellers, shafts and couplings are to be witnessed by the Surveyor.

(d) Hydraulic cylinders are to be manufactured and inspected in accordance with the requirements of 3.4.5 of this Part.

(e) The use of galvanically dissimilar metallic materials is to be considered in the Waterjet design.

2.5.2 Design

Design basis stress calculations for the impellers, shafting, steering mechanism and reversing mechanism are to be submitted to substantiate the suitability and strength of component parts for the intended service. For the purpose of design review, the stress calculations are to cover the worst case condition for each component. The factor of safety for the above components is not to be less than 2.0 when determined by the following equation:

$$\frac{1}{F_S} = \frac{\sigma_S}{S_T} + \frac{\sigma_a}{E}$$

nor less than 4.0 when determined by the following equation:

$$F_S = \frac{S_T}{\sigma_S}$$

where

F_S = Factor of safety

σ_S = Steady stress of low cycle alternating stress

σ_a = Alternating stress

S_T = Ultimate tensile strength of material

E = Corrected fatigue strength of material (based on 10^8 cycles)

2.5.3 Housings

Calculations or test results to substantiate the suitability and strength of the pressure and suction housing are to be submitted for review. The condition with the inlet of the suction blocked is also to be considered. A factor of safety of not less than four based on the ultimate tensile strength of the material (or two based on the yield strength) is to be maintained at each point in the housing. Housing are to be hydrostatically tested to 1.5 times the maximum working pressure or to 3.4 bar, whichever is greater.

2.5.4 Reversing mechanisms

Astern thrust is to be provided in sufficient amounts to secure proper control of the craft in all normal circumstances. The reversing mechanism is to provide for reversing at full power.

2.5.5 Impeller bearings

Antifriction bearings are to have a B10 life of at least 80,000 hours.

Note: B10 life means an expected time at which 10% of the population of a product will have failed.

2.5.6 Monitoring and alarms

In addition to the requirements of 2.4.7(e) of this Chapter, alarms and monitoring requirements are indicated as follows:

(a) An indication of the angular position of the nozzle is to be provided at each station from which it is possible to control the direction of thrust from the units.

(b) An indication of both the required and actual reversing bucket position is to be provided at each station from which it is possible to control the reversal of thrust.

(c) All alarms associated with waterjet unit faults are to be indicated individually at the control stations and in accordance with the following table and the alarm system specified in 2.4.7(e) of this Chapter.

Item	Alarm	Note
Hydraulic system pressure	Low	
Hydraulic oil supply tank level	Low	
Hydraulic oil temperature	High	Where an oil cooler is fitted
Lubricating oil temperature	High	
Lubricating oil pressure	Low	In forced lubrication systems
Lubricating oil tank level	Low	Where a tank is provided
Ratio of jet RPM/vessel speed	High	Only if installed power per jet > 4 MW
Control system failure	Fault	Includes follow-up failure of steering or reversing system
Control system power supply	Failure	

2.6 Propulsion Shafting

2.6.1 General

The construction of the propellers and propulsion shafting is to be carried out in accordance with the following requirements and to the satisfaction of the Surveyor.

2.6.2 Plans and data to be submitted

(a) Detailed plans with material specifications of the propulsion shafting, couplings, coupling bolts, propulsion shafting arrangement, propeller shaft bearings and lubrication system, if oil-lubricated

(b) Calculations for flexible couplings and demountable couplings (see 2.1.1(h) and 2.6.5(c)(v) of this Part)

(c) Shaft alignment and vibration calculations, if required by 2.6.7

(d) Detailed preloading and stress calculations and fitting instructions for non-fitted coupling bolts (see 2.6.5(c)(ii))

(e) Thrust plate calculations

2.6.3 Materials and testing

(a) Materials

Materials for propulsion shafts, couplings and coupling bolts, keys and clutches are to be of forged steel or rolled bars, as appropriate, in accordance with Chapter 8 of Part XI of the Rules for Steel Ships or other specifications as may be specially approved with a specific design. Where materials other than those specified in the Rules are proposed, full details of chemical composition, heat treatment and mechanical properties, as appropriate, are to be submitted for approval.

(i) Ultimate tensile strength

In general, the minimum specified ultimate tensile strength of steel used for propulsion shafting is to be between 400 N/mm^2 and 930 N/mm^2.

(ii) Elongation

Carbon steel with elongation ($L_0/d = 4$) of less than 16% or ($L_0/d = 5$) of less than 15% is not to be used for any shafting component, with the exception that material for non-fitted alloy steel coupling bolts manufactured to a recognized standard may have elongation ($L_0/d = 4$) of not less than 10% or ($L_0/d = 5$) of not less than 9%.

Alloy steels with elongation less than ($L_0/d = 4$) 16% or ($L_0/d = 5$) 15% may be applied subject to approval.

(b) Material tests

(i) General

Materials for all torque-transmitting parts, including shafts, clutches, couplings, coupling bolts and keys are to be tested in the presence of the Surveyor. The materials are to meet the specifications of Chapter 8 of Part XI of the Rules for Steel Ships or other specifications approved in connection with the design.

(ii) Alternative test requirements

Materials for shafting, couplings and coupling bolts transmitting 373 kW or less will be accepted based on the manufacturer's certified mill tests and hardness check witnessed by the Surveyor. Bolts manufactured to a recognized standard and used as coupling bolts will not require material testing.

(c) Inspection

Shafting and couplings are to be surface-examined at the manufacturer. Propeller shafts in the finished machine condition are to be subjected to a nondestructive examination such as magnetic particle, dye penetrant or other nondestructive methods and are to be free of linear discontinuities greater than 3.2 mm, except that in the following locations, the shafts are to be free of all linear discontinuities:

(i) Tapered propeller shafts

The forward one-third length of the taper, including the forward end of any keyway and an equal length of the parallel part of the shaft immediately forward of the taper.

(ii) Flanged propeller shafts

The flange fillet area.

(d) Weldability

The carbon content of the steel used for propeller shafts is be in accordance with Chapter 8 of Part XI of the Rules for Steel Ships.

2.6.4 Design and construction

(a) Shaft diameters

The least diameter of propulsion shafting is to be determined by the following equation:

$$D = 100K \cdot \sqrt[3]{\frac{Hc_1}{N(S + c_2)}}$$

where

c_1 = 560 for single screw craft 45.7 m in length and over and multiple screw craft 61 m in length and over.

= 416.4 for single screw craft below 45.7 m and multiple screw craft below 61 m.

c_2 = 160

D = Greater of the required solid shaft diameter as required by 2.6.4 or 2.6.7 (reflective of static and dynamic stresses), except hollow shaft, in mm.

K = Shaft design factor (see Table IV 2-1 and Table IV 2-2)

H = Power at rated speed, in kW.

N = RPM at rated speed

S = Minimum specified ultimate tensile strength of the material, in N/mm^2. For calculation purposes, S is not to be taken as more than the following:

= 415 N/mm^2 for carbon, and alloy steel propeller shafts fitted with saltwater lubricated bearings and non-continuous shaft liners.

= 600 N/mm^2 for carbon, alloy and austenitic stainless steel propeller shafts fitted with oil lubricated bearings or with continuous shaft liners or equivalent.

= 930 N/mm^2 for other shaft sections and for propeller shafts manufactured of age-hardened martensitic stainless steels, higher-strength austenitic stainless steels such as ASTM Type XM-19, XM-21, or XM-28, or other high strength alloy materials.

Notes:

In general, the minimum specified ultimate tensile strength of steel used for propulsion shafting is to be between 400 N/mm^2 and 930 N/mm^2. See also 2.6.3(a).

Table IV 2-1
Shaft Design Factor K for Intermediate Shafts, Thrust Shafts, and Oil Distribution Shafts

	Design Features[1]							
	Integral Flange	Shrink Fit Coupling	Keyways[2]	Radial Holes, Transverse Holes[3]	Longitudinal Slots[4]	On Both Sides of Thrust Collars	In way of Axial Bearings used as Thrust Bearings	Straight Sections
Turbine	0.95	0.95	1.045	1.045	1.14	1.045	1.045	0.95
Electrics Devices								
Diesel Drives through slip couplings (electric or hydraulic)								
All Other Diesel Drives	1.0	1.0	1.1	1.1	1.2	1.1	1.1	1.0

Notes:

(1) Geometric features other than those listed will be specially considered.

(2) After a length of not less than 0.2D from the end of the keyway, the shaft diameter may be reduced to the diameter calculated for straight sections. Fillet radii in the transverse section of the bottom of the keyway are to be not less than 0.0125D.

(3) Diameter of bore not more than 0.3D.

(4) Length of the slot not more than 1.4D, width of the slot not more than 0.2D, whereby D is calculated with k = 1.0.

Table IV 2-2
Shaft Design Factor K for Propeller shafts and Stern Tube Shafts[1]

Propulsion Type	Stern Tube Configuration	Propeller Attachment Method[2]			
		Keyed[3]	Keyless Attachment by Shrink Fit[4]	Flanged[5]	Stern Tube Shafts[6], [7]
All	Oil-lubricated bearings	1.26	1.22		1.15
All	Water-lubricated bearings with continuous shaft liners or equivalent				
All	Water-lubricated bearings with non-continuous shaft liners	1.29	1.25		1.18

Notes:

(1) The propeller shaft diameter may be reduced to the stern tube shaft diameter forward of the bearing supporting the propeller, and the stern tube shaft diameter reduced to the intermediate shaft diameter inboard of the forward stern tube seal.

(2) Other attachments are subject to special consideration.

(3) Fillet radii in the transverse section at the bottom of the keyway are not to be less than 0.0125D.

(4) See also 2.6.4(d).

(5) The fillet radius in the base of the flange for the propeller shaft supporting the propeller is to be at least 0.125D. Special consideration will be given to fillets of multiple radii design. The fillet radius is to be accessible for nondestructive examination during propeller shaft surveys. See 2.3.1(b) of Part I of the Rules and 2.3.7 of Part I of the Rules for Steel Ships. For other fillet radii, see 2.6.5(c)(iii).

(6) K factor applies to shafting between the forward edge of the propeller-end bearing and the inboard stern tube seal.

(7) Where keyed couplings are fitted on stern tube shaft, the shaft diameters are to be increased by 10% in way of the coupling. See Note (2) of Table IV 2-1.

(b) Hollow shafts

For hollow shafts where the bore exceeds 40% of the outside diameter, the minimum shaft diameter is not to be less than that given by the following equation:

$$D_o = \mathrm{D} \cdot \sqrt[3]{\frac{1}{1 - (D_i/D_o)^4}}$$

where

D_o = Required outside diameter, in mm.
D = Solid shaft diameter required by 2.6.4, as applicable, in mm.
D_i = Actual shaft bore, in mm.

(c) Key

In general, the key material is to be of equal or higher strength than the shaft material. The effective area of the key in shear is to be not less than A, given below. The effective area is to be the gross area subtracted by materials removed by saw cuts, set screw holes, chamfer, etc., and is to exclude the portion of the key in way of spooning of the keyway.

$$\mathrm{A} = \frac{D^3}{5.1 r_m} \cdot \frac{Y_S}{Y_K}$$

where

A = Shear area of key, in mm^2.
D = Intermediate shaft diameter, mm, as determined by 2.6.4(a).
r_m = Shaft radius at mid-length of the key, in mm.
Y_S = Specified yield strength of shaft material, in N/mm^2.
Y_K = Specified yield strength of key material, in N/mm^2.

(d) Propeller shaft end design

Propeller shafts are to be provided with an accurate taper fit in the propeller hub, particular attention being given to the fit at the large end of the taper.

(i) Keyed

The key is to fit tightly in the keyway and be of sufficient size to transmit the full torque of the shaft, but it is not to extend into the liner counterbore on the forward side of the hub. The forward end of the keyway is to be so cut in the shaft as to give a gradual rise from the bottom of the keyway to the surface of the shaft.

Ample fillets are to be provided in the corners of the keyway and, in general, stress concentrations are to be reduced as far as practicable.

(ii) Keyless

Where propellers are fitted without keys, detailed stress calculations and fitting instructions are to be submitted for review. See 2.3.4(e)(ii).

2.6.5 Shafting accessories

(a) Propeller shaft liners

(i) Thickness at bearings

(1) Bronze liner

The thickness of bronze liners to be fitted to propeller shafts or tube shafts is not to be less than that given by the following equation:

$$t = T/25 + 5.1 \quad \text{(mm)}$$

where

t = Thickness of liner mm

T = Required diameter of propeller shaft mm

(2) Stainless steel liner

The thickness of stainless steel liners to be fitted to propeller shafts or tube is not to be less than one-half that required for bronze liners or 6.5 mm, whichever is greater.

(ii) Thickness between bearings

The thickness of a continuous bronze liner between bearings is to be not less than three-fourths of the thickness, t, determined by the foregoing equation.

(iii) Continuous fitted liners

Continuous fitted liners are to be in one piece or, if made of two or more lengths, the joining of the separate pieces is to be done by an approved method of fusion through not less than two-thirds the thickness of the liner or by an approved rubber seal.

(iv) Fit between bearings

If the liner does not fit the shaft tightly between the bearing portions, the space between the shaft and liner is to be filled by pressure with an insoluble, non-corrosive compound.

(v) Material and fit

Fitted liners are to be of a high-grade composition, bronze or other approved alloy, free from porosity and other defects, and are to prove tight under hydrostatic test of 1 bar. All liners are to be carefully shrunk or forced upon the shaft by pressure and they are not to be secured by pins.

(vi) Glass reinforced plastic coating

Glass reinforced plastic coatings may be fitted on propulsion shafting when applied by a trained technician, utilizing a procedure that complies with a recognized industry standard, such as ASTM D5162, to the satisfaction of the Surveyor. Such coatings are to consist of at least four plies of cross-woven glass tape impregnated with resin, or an equivalent process. Prior to coating, the shaft is to be cleaned with a suitable solvent and grit-blasted. The shaft is to be examined prior to coating and the first layer is to be applied in the presence of the Surveyor. Subsequent to coating, the finished shaft is to be subjected to a spark test or equivalent to verify freedom from porosity to the satisfaction of the Surveyor. In all cases where reinforced plastic coatings are employed, effective means are to be provided to prevent water having access to the shaft. Provisions are to be made for overlapping and adequately bonding the coating to fitted or clad liners. The end of the liner is to be stepped and tapered as required to protect the end of the wrapping.

(vii) Stainless steel cladding

Stainless steel cladding of shafts is to be carried out in accordance with an approved procedure.

(b) Propeller shaft bearings

The length of the bearing in the sternbush next to and supporting the propeller is to be as follows:

(i) Water lubricated bearings

(1) For water lubricated bearings which are lined with rubber composition or staves of approved plastics material, the length is to be not less than four times the diameter required for the screwshaft under the liner.

(2) For water lubricated bearings lined with two or more circumferentially spaced sectors, of an approved composed material, the length of the bearing is to be such that the nominal bearing

pressure will not exceed manufacturer's recommendations. The length of the bearing is to be not less than twice its diameter. However, the Society may consider to increase the length of the bearing to craft with special service purposes or restrictions.

(ii) Oil lubricated bearings

(1) For bearings which are white-metal lined, oil lubricated and provided with an approved type of oil sealing gland, the length of the bearing is to be approximately twice the diameter required for the screwshaft and is to be such that the nominal bearing pressure will not exceed 0.8 N/mm^2. The length of the bearing is to be not less than 1.5 times its diameter.

(2) For bearings of cast iron and bronze which are oil lubricated and fitted with an approved oil sealing gland, the length of the bearing is, in general, to be not less than four times the diameter required for the screwshaft.

(3) The length of synthetic rubber, reinforced resin or plastic oil-lubricated propeller end bearings fitted with an approved oil-seal gland is to be on the order of two times the required propeller shaft diameter. The length of the bearing may be less, provided the nominal bearing pressure is not more than 0.60 N/mm^2, as determined by static bearing reaction calculation taking into account shaft and propeller weight which is deemed to be exerted solely on the aft bearing, divided by the projected area of the shaft. The minimum length, however, is not to be less than 1.5 times the actual diameter. Where the material has demonstrated satisfactory testing and operating experience, consideration may be given to increased bearing pressure.

(c) Solid couplings

(i) Fitted bolts

The minimum diameter of fitted shaft coupling bolts is to be determined by the following equation.

$$d_b = 0.64\sqrt{\frac{D^3(S+c)}{NBS_b}} \qquad (mm)$$

where

d_b = Diameter of bolts at joints, in mm.

D = Minimum required shaft diameter designed considering the largest combined torque (static and dynamic), acting at the shaft in vicinity of the respective coupling flanges; mm, see 2.6.7, but not less than the minimum required intermediate shaft diameter, as per 2.6.4(a) or 2.6.4(b), in mm.

S = Minimum specific tensile strength of shaft material, in N/mm^2.

c = 160

N = Number of bolts fitted in one coupling

B = Bolt circle diameter, in mm.

S_b = Minimum specific tensile strength of bolt material, in N/mm^2. To be not less than S. S_b, is to be taken not more than 1.7S or 1,000 n/mm^2, whichever is less, for calculation purposes.

Notes:

(1) The bolts are to be assembled with an interference fit.

(2) The use of other materials will be subject to special consideration based on submitted engineering analyses.

(ii) Non-fitted bolts

The diameter of pre-stressed, non-fitted coupling bolts will be considered upon the submittal of detailed preloading and stress calculations and fitting instructions. The tensile stress on the bolt due to pre-stressing and astern pull is not to exceed 90% of the minimum specified yield strength of the bolt material. In addition, the bearing stress on any member such as the shaft, bolt, threads or nut is not to exceed 90% of the minimum specified yield strength of the material for that member.

(1) Power transmitted by prestress only

Where bolts are under pure tension, the factor of safety against slip under the worst of the operating conditions, including mean transmitted torque plus vibratory torque due to torsional loads, is to be at least as follows:

a) Inaccessible couplings (external to the hull or not readily accessible): 2.8

b) Accessible couplings (internal to the hull): 2.0

(2) Power transmitted by combination prestress and shear
Where the power is transmitted by a combination of fitted bolts and pre-stressed, non-fitted bolts, the components are to meet the following criteria:

a) Fitted bolts

The shear stress under the maximum torque corresponding to the worst loaded condition is to be not more than 50% of the minimum specified tensile yield strength of the bolt material.

b) Non-fitted bolts

The factor of safety against slip under the maximum torque corresponding to the worst loaded condition and the specified bolt tension is to be at least 1.6 for inaccessible couplings and 1.1 for accessible couplings.

(3) Dowels used for transmitting power
Dowels connecting the propeller shaft flange to the controllable pitch propeller hub, utilized with non-fitted bolts to transmit power, are considered equivalent to fitted coupling bolts and are to comply with 2.6.5(c)(i) and, if applicable, 2.6.5(c)(ii)(2)a). The dowels are to be accurately fitted and effectively secured against axial movement. The coupling is to be satisfactory for astern condition.

(iii) Flanges

The thickness of coupling flanges is not to be less than the minimum required diameter of the coupling bolts or 0.2 times D (as defined in 2.6.4(a) or 2.6.4(b)), whichever is greater. The fillet radius at the base of an integral flange is not to be less than 0.08 times the actual shaft diameter. Consideration of a recognized shaft coupling standard will be given to fillets of multiple radii design. In general, the surface finish for fillet radii is not to be rougher than 1.6 μmeters RMS. For the fillet radius for propeller shaft to propeller coupling flange, see Note (4) of Table IV 2-2.

(iv) Locking arrangement

After assembly, all coupling bolts and associated nuts are to be fitted with locking arrangement.

(v) Demountable couplings

Couplings are to be made of steel or other approved ductile material. The strength of demountable couplings and keys is to be equivalent to that of the shaft. Couplings are to be accurately fitted to the shaft. Where necessary, provisions for resisting thrust loading are to be provided.

Hydraulic and other shrink fit couplings will be specially considered upon submittal of detailed preloading and stress calculations and fitting instructions. In general, the torsional holding capacity is to be at least 2.8 times the transmitted mean torque plus vibratory torque due to torsionals for inaccessible couplings (external to the hull or not readily accessible) and at least 2.0 times for accessible couplings (internal to the hull). The preload stress is not to exceed 70% of the minimum specified yield strength.

2.6.6 Cardan shaft

Cardan shafts are to be designed in accordance with the equation for propulsion shaft in 2.6.4(a) , and flanges and bolts are to be in accordance with 2.6.5(c)(i), 2.6.5(c)(ii) and 2.6.5(c)(iii). The design of splines, yokes and cross-members are to be evaluated based on engineering analyses which are to be submitted for review. Where applicable, the cardan shaft assembly is to contain provisions for bearing thrust or pull from the propeller.

2.6.7 Alignment and vibration

(a) General

Propulsion shafting is to be aligned with the location and spacing of the shaft bearings, being such as to give acceptable bearing reactions and shaft bending moments and also acceptable amplitudes of vibration for all conditions of craft loading and operation.

The designer or the builder is to evaluate the propulsion shafting system, taking into consideration any forces or factors which may affect the reliability of the propulsion shafting system, including weight of the propeller and shafts, hydrodynamic forces acting on the propeller, number of propeller blades in relation to diesel engine cylinders, misalignment forces, thermal expansion, flexibility of engine and thrust bearing foundations, engine induced vibrations, gear tooth loadings, flexible couplings, effect of power take-off arrangements from the propulsion shafting system driving auxiliaries, etc., as applicable, as well as any limits for vibrations and loadings specified by the equipment manufacturers.

(b) Craft of 61 m in length and over

(i) Shaft alignment calculations

The requirements in 6.11 of Part IV of the Rules for Steel Ships are to be complied with.

(ii) Torsional vibrations

The requirements in 6.8 of Part IV of the Rules for Steel Ships are to be complied with.

(iii) Axial vibrations

The requirements in 6.9 of Part IV of the Rules for Steel Ships are to be complied with.

(iv) Lateral (whirling) vibrations

The requirements in 6.10 of Part IV of the Rules for Steel Ships are to be complied with.

Where the craft are expected to service at low speed continually, lateral vibration of shafting and mechanical properties of bearings are to be taken into account to prevent overwearing of the bearing.

(v) Cast resin chocks

Resin chocks and their installation are to comply with the requirements in 19.2 of Part XI of the Rules for Steel Ships.

(c) Craft below 61 m in length

(i) Torsional vibration

For craft fitted with an unusual propulsion arrangement or without vibration dampers, a torsional vibration analysis of the propulsion system showing compliance with 6.8 of Part IV of the Rules for Steel Ships is to be submitted. This is not required for craft under 20 m length or where the installation is essentially the same as previous designs which have been proven satisfactory.

(ii) Lateral (whirling) vibrations

Where the craft are expected to service at low speed continually, lateral vibration of shafting and mechanical properties of bearings are to be taken into account to prevent overwearing of the bearing.

2.6.8 Circulating currents

Where means are provided to prevent circulating currents from passing between the propeller, shaft and the hull, a warning notice plate is to be provided in a visible place cautioning against the removal of such protection.

2.7 Steam and Gas Turbines

Steam and gas turbines are to comply with the applicable requirements of Chapter 2 of Part IV of the Rules for Steel Ships. In addition, gas turbines are to comply with the requirements of this Section.

2.7.1 General

(a) Piping systems

Piping systems for gas turbines are to comply with the applicable requirements in Chapter 3 of this Part in addition to this section.

(b) Pressure vessels and heat exchangers

Pressure vessels and heat exchangers are to be in accordance with the applicable requirements of 2.2 of this Part.

(c) Automatic safety devices

Details of the manufacturer's proposed automatic safety devices to guard against hazardous conditions arising in the event of malfunction in the turbine installation are to be provided together with the Failure Mode and Effect Analysis (FMEA).

2.7.2 Fuel oil system

(a) General

In addition to the applicable requirements of 2.1 of this Part, fuel oil systems for gas turbines are to comply with the following.

(b) Pumps, heater and strainers

There are to be at least two independent fuel oil service pumps, each of sufficient capacity to supply turbines at full power and arranged that one may be overhauled while the other is in service. Oil heaters are to be similarly installed in multiples.

Oil strainers are to be installed in the suction and discharge lines and are to be either of the duplex type or other approved filter which is capable of being cleaned without interrupting the oil supply. Where strainers are fitted in parallel to enable cleaning without disrupting the oil supply, means are to be provided to minimize the possibility of a strainer under pressure being opened inadvertently. Strainers are to be provided with suitable means for venting when being put into operation and being depressurized before being opened. Valves or cocks with drain pipes led to a safe location are to be used for this purpose.

(c) Shielding of fuel oil service piping

Piping between the service pump and the combustor is to be effectively jacked or shielded as in 2.1.5(a)(ii), 2.1.5(a)(iii)(2)a) and 2.1.5(a)(iii)(2)b) of this Chapter.

(d) Drainage of excess fuel

Provision is to be made to drain all excess fuel oil, particularly fuel which might reach the interior of the jet pipe or exhaust system after a false start or after stopping, to a safe position so as to avoid a fire hazard.

(e) Low flash point fuel

The use of fuel oil with flash point of 60˚C or below is to be specially considered by the Society.

2.7.3 Starting arrangements

Staring arrangements for gas turbines installations are to be capable of providing an equivalent number of starts as that required in 2.1.3 of this Chapter.

2.7.4 Exhaust systems

Exhaust gas systems are to be in accordance with 2.1.4(b) of this Chapter as well as in accordance with the turbine manufacturer's recommendations. Gas turbine exhausts are to be located and arranged so that hot exhaust gases are directed away from walkways and other areas to which personnel have access.

2.7.5 Turbine enclosures

Where an acoustic enclosure is fitted which completely surrounds the gas turbine and the high-pressure oil pipes, a fire detection and extinguishing system is to be provided for the acoustic enclosure.

2.8 Propulsion and Lift Devices for Air Cushion Craft

2.8.1 General

(a) Application

Provisions of this Section apply to all air cushion craft.

(b) Plans and particulars to be submitted

Full details are to be submitted for all components that directly provide thrust and lift including all machinery items and any associated air propellers, ducts, vanes, scoops and nozzles.

2.8.2 Materials

(a) General

The design of propulsion and lift devices is to pay due regard to the effects of allowable corrosion, electrolytic action between different metals, erosion or cavitation which may result from operation in environments in which they are subjected to spray, debris, salt, sand, icing, etc.

(b) Material testing

The materials of the shafts, impellers, and couplings are to be tested in the presence of the Surveyor for verification of their compliance with the applicable requirements of Part XI of the Rules for Steel Ships, or such other appropriate material specifications as may be approved in connection with a particular design.

2.8.3 Design

(a) General

(i) Arrangements

Propulsion and lift arrangements may be provided by separate devices, or be integrated into a single propulsion and lift device. Propulsion devices are those which directly provide the propulsive thrust. Appropriate arrangements are to be made to ensure that:

(1) Ingestion of debris or foreign matter is minimized;

(2) The possibility of injury to personnel from shafting or rotating parts is minimized; and

(3) Where necessary, inspection and removal of debris can be carried out safely in service.

(ii) Calculations

Design basis stress calculations for propulsion and lift devices are to be submitted to substantiate the suitability and strength of the components for the intended service and compliance with a recognized standard or code of practice.

2.9 Craft less than 24 meters in Length

The requirements of this Section are applicable to all craft less than 24 meters in length. The requirements of 2.1 through 2.8 are still applicable except as modified herein.

2.9.1 Diesel engines

Diesel engines are to meet the requirements of 2.1 of this Chapter, as applicable except the requirements for sea suction as follows:

At least two independent sea suctions are to be provided for supplying water to the engine jackets or to the heat exchangers, except that for multihull craft classed with restricted service (see 1.4.4 of Part I of the Rules), special

consideration may be given. The sea suctions are to be located as to minimize the possibility of blanking off the cooling water. For multiple engine installations fitted with individual sea suctions for each engine, two means of supplying cooling water to each engine may be omitted where the craft are fitted with two or more propulsion units and can maintain 1/2 design speed with one propulsion shut down.

2.9.2 Shafting and gears

(a) Outboard engines

Outboard gasoline engines are to be built to an international or national standard acceptable to the Society or have at least two years of service in the marine industry. The installation is to be in accordance with manufacturer's recommendations.

(b) Inboard/outboard installations

(i) Inboard/outboard propulsion systems

Inboard/outboard propulsion systems (gearing, transmission, etc.) are to be rated for the maximum rating and RPM of the associated prime mover. The installation is to be in accordance with manufacturer's recommendations.

(ii) Gears for inboard and inboard/outboard propulsion systems

Gears for inboard and inboard/outboard propulsion systems are to be designed and built for installation in a marine environment and rated to the maximum rating and RPM of the associated prime mover. The gears are to be built to a standard acceptable to the Society or have at least two years of service in the marine industry. The installation is to be in accordance with manufacturer's recommendations.

(c) Inboard installations

Propulsion shafting installations are to comply with one of the following:

- 2.6.4, or
- American Boat and Yacht Council (ABYC), Section P-6.5 using a design coefficient (C_d) of at least 15, or
- Recognized standard acceptable to the Society, or
- Submission of a fatigue analysis showing that the proposed shafting size has a safety factor of at least 2.

(d) Propulsion shaft alignment and vibrations

2.6 of this Chapter is not applicable to craft under 24 meters in length.

2.9.3 Steering gears

(a) General

Hydraulic and electrical power operated steering gears and orbitrol systems are to comply with 2.4 of this Chapter, except as modified below:

- Rudder actuators will be accepted based on Manufacturer's Certification
- Hydraulic power units will be accepted based on Manufacturer's Certification

Alternatively, the following ISO standards, as applicable, may be substituted for the requirements of this Section:

- ISO 8847 : Small Craft – Steering Gear – Wire Rope and Pulley Systems
- ISO 8848 : Small Craft – Remote Steering System

- ISO 9775 : Small Craft – Remote Steering Systems for Single Outboard Motors of 15 kW to 40 kW Power
- ISO 10592 : Small Craft – Hydraulic Steering Systems

(b) System arrangements

Steering systems are to meet the requirements of 2.4.5(d) and 2.4.9(a)(ii), except when the craft can meet one of the following requirements to the satisfaction of the Head office of the Society and the Surveyor:

- For craft fitted with multiple propulsion units and the steering system disabled and/or locked in a neutral position, steering can be effected by varying the speed and direction of the propulsion units. The propulsion units are to be spaced as widely as practical and be capable of steering the craft in the worst anticipated operational conditions.
- When using mechanical steering systems, sufficient supplies are carried so as to be capable of temporarily repairing the steering system in a timely manner until permanent repairs can be affected at the nearest port of refuge.
- The steering can be effected manually under the worst anticipated operational conditions (i.e. physically turning the rudder, outboard motor, etc.).

(c) Mechanical steering gears

Where mechanical steering systems are permitted, the following are applicable.

(i) Steering chains and wire ropes

Steering chains and wire rope are to be tested, as required by Part XI of the Rules for Steel Ships.

(ii) Sheaves

Sheaves are to be of ample size and so placed as to provide a fair lead to the quadrant and avoid acute angles. Parts subjected to shock are not to be of cast iron. Guards are to be placed around the sheaves to protect against injury. For sheaves intended for use with ropes, the radius of the grooves is to be equal to that of the rope plus 0.8 mm, and the sheave diameter is to be determined on the basis of wire rope flexibility. For 6 × 37 wire rope, the sheave diameter is to be not less than 18 times that of the rope. For wire ropes of lesser flexibility, the sheave diameter is to be increased accordingly. Sheave diameters for chain are to be not less than 30 times the chain diameter.

(iii) Buffers

Steering gears other than hydraulic type are to be designed with suitable buffer arrangement to relieve the gear from shocks to the rudder.

2.9.4 Inboard/outboard and outboard installations

(a) General

Steering installations for inboard/outboard and outboard installations are to be in accordance with manufacturer's recommendations as well as the applicable requirements of this section. Steering components which are provided as part of the inboard/outboard or outboard installation are not required to be certified under 2.4.4.

(b) Instrumentation

Instrumentation is to be in accordance with 2.4.7(e), as applicable, except that a rudder angle indicator is not required for that craft for which the rudder or outboard motor is in a direct line of sight from the navigation bridge and the steering angle can be determined visually.

(c) Communications

A means of communication is not required for craft which have a direct line of sight between the main steering control station and the location of the steering gear.

(d) Installation, tests and trials

Steering gear operation is to be demonstrated to the satisfaction of the Surveyor in accordance with 2.4.7(f), 2.4.9(a)(ii) and 2.4.9(b).

Chapter 3

Piping and Pumping Systems

3.1 General

3.1.1 Piping arrangement

Piping systems are to comply with the requirements specified in 2.13 of Part VI of the Rules for Steel Ships.

3.1.2 Design pressure and design temperature

(a) Design pressure

Design pressure is the maximum working pressure of a medium inside pipe and is not to be less than the following pressures given in (i) to (iii):

(i) For piping systems fitted with a relief valve or other overpressure protective device, the pressure based on the set pressure of the relief valve or over pressure protective device. However, for steam piping systems connected to a boiler or piping systems fitted to a pressure vessel, the design pressure of the boiler shell (nominal pressure if the boiler has a superheater) or design pressure for the shell of a pressure vessel.

(ii) For piping on the discharge side of the pumps, the pressure based on the delivery pressure of the pump with the valve on the discharge side closed running the pump at rated speed. However, for pumps having relief valve or overpressure protective device, the pressure based on its set pressure.

(iii) For blow-off pipings of boilers, the pressure is not less than 1.25 times the pressure of the boiler drum.

(b) Design temperature

Design temperature is the highest working temperature of the medium inside pipes at the designed condition.

(c) Classes of pipes

Pipes are classified to comply with the requirements specified in 1.4 of Part VI of the Rules for Steel Ships according to the type of medium, design pressure and design temperature.

3.1.3 Plans and data

Plans and data are to be submitted in accordance with 1.6 of Part VI of the Rules for Steel Ships for consideration and approval.

3.1.4 Materials

In addition to the requirements specified in 1.5 of Part VI of the Rules for Steel Ships, the following requirements are to apply:

(a) Application

(i) Materials used for auxiliary machinery are to be adequate for their service conditions. The materials used for essential parts of auxiliary machinery are to comply with the standards deemed appropriate by the Society.

(ii) Materials for pipes, valves and other fittings are to comply with the requirements specified in 2.3 of Part VI of the Rules for Steel Ships.

However materials which comply with a standard deemed appropriate by the Society may be accepted for pipes with both a design pressure less than 10 bar and a design temperature of 230℃ or less.

(iii) Materials for valves or cocks (hereinafter referred to as valves in this Chapter) and pipe fittings are to comply with the requirements specified in 2.3 of Part VI of the Rules for Steel Ships.

However materials which comply with a standard deemed appropriate by the Society may be accepted for the following (1) and (2).

(1) Valves and pipe fittings used for pipes with a nominal diameter less than 100 mm.

(2) Valves and pipe fittings with both a design pressure less than 30 bar and a design temperature of 230℃ or less.

(iv) Notwithstanding the requirements above, materials for pipes, valves and pipe fittings are to comply with the requirements of the service limitations for materials specified in Chapter 2 of Part VI of the Rules for Steel Ships.

(v) In general, the use of aluminum pipes is to be restricted to the service systems mentioned as below:

(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.

but for craft not engaged on international 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.

(b) When aluminum alloy pipes are used, the following requirements are to be complied with:

(i) Aluminum alloy pipes are, as a rule, to be in accordance with the recognized standards deemed appropriate by the Society, and are to be of seamless drawn pipes or seamless extruded pipes.

(ii) Aluminum alloy pipes are not to be used for any of the following applications, unless deemed appropriate by the Society:

(1) Pipes with a design temperature exceeding 150℃

(2) Any pipe used in areas where it penetrates either A class division or B class division.

(iii) The required thickness of aluminum alloy pipes subject to an internal pressure is to be determined using the formula in 2.2 of Part VI of the Rules for Steel Ships.

In this case, permissible stress (k) is to be of the minimum value of the following values. However, when the design temperature is not in the creep region of the material, no consideration may be required for the value of k_3.

$$k_1 = \frac{R_{20}}{4.0} \qquad k_2 = \frac{E_t}{1.5} \qquad k_3 = \frac{S_R}{1.6}$$

where:

R_{20} = Specific minimum tensile strength of the material at room temperature (less than 50℃), in N/mm^2.

E_t = 0.2% proof stress of the material at the design temperature, in N/mm^2.

S_R = Mean value of creep breaking stress of the material after 100,000 hours at the design temperature, in N/mm^2.

(c) The materials not specified above are to be subject to special approval by the Society.

3.1.5 Thickness of pipes

Thickness of pipes is to comply with the requirements specified in 2.2 of Part VI of the Rules for Steel Ships.

3.1.6 Construction

(a) Valves and pipe fittings

Construction of valves and pipe fittings is to comply with the requirements specified in Chapter 2 of Part VI of the Rules for Steel Ships

(b) Storage tanks

Construction of storage tanks is to comply with the requirements specified in 4.4.3(q) of Part VI of the Rules for Steel Ships. In case where storage tanks for fuel oil are manufactured with the material other than steel plating, however, minimum thickness of plating is to be:

(i) Stainless steel: 2.5 mm

(ii) Aluminum alloy: 4.5 mm

(iii) Other than above the value specially approved by the Society.

3.1.7 Connection and forming of piping system

Connection and forming of piping system is to comply with the requirements specified in 2.10 of Part VI of the Rules for Steel Ships.

3.1.8 Sea suction valves and overboard discharge valves

(a) Location and construction

(i) Sea inlet and overboard discharge pipes are to be connected to the valves or cocks which are fitted in accordance with the requirements in 3.1.8(a)(iii) and 3.1.8(a)(iv) below.

(ii) The locations of overboard discharges subjected to pressure by the pump are not to be such that water can be discharged into life boats and liferafts at fixed launching positions including those under launching device when they are launched, unless special provision is made for preventing any discharge of water into them.

(iii) Sea suction valves and overboard discharge valves or cocks fitted to the craft's side, sea chests forming a part of the craft's structure or distance pieces attached to the shell plating are to be located at easily accessible positions.

(iv) Valves or cocks prescribed in 3.1.8(a)(iii) above are to be fitted in accordance with the following (1) to (3):

(1) Valves or cocks are to be fitted to doublings which are welded to the shell plating or sea chest by using stud bolts not piercing the shell plating and sea chest.

(2) Valves or cocks are to be fitted by bolts to distance pieces attached to the shell plating. In this case, the distance piece is to be of rigid construction and as short as practicable.

(3) Where valves or cocks are fitted to the nonmetallic shell plating such as FRP, the fitting method is to be such that deemed appropriate by the Society.

(v) The valve spindles of sea suction valves are to be extended above the lower platform where they are easily operable. Power-operated sea suction valves are to be arranged also for manual operation. Sea suction valves are to be provided with indicators to show whether they are open or closed.

(vi) Overboard discharge valves and cocks are to be fitted with spigots passing through the shell plating and a protection rings specified in 3.1.8(a)(vii)(1), but the spigots on the valves or cocks may be omitted if these fittings are attached to pads or distance pieces which themselves form spigots in way of the shell plating and protecting rings. Overboard discharge valves and cocks are to be provided with indicators to show whether they are open or closed.

(vii) Blow-off valves or cocks of boilers and evaporators are to comply with the following requirements in (1) and (2):

(1) Blow-off valves or cocks of boilers and evaporators are to be fitted in easily operable positions and to be provided with protection rings on the outside of the shell plating to prevent corrosion.

(2) Cock handles are not to be capable of being removed unless the cocks are shut, and, if valves are fitted, the hand wheels are to be suitably retained on the spindle.

(b) Sea chests

Sea chests are to be of substantial construction not to blank off the suction due to air-locking.

(c) Gratings of sea suctions

(i) Gratings are to be fitted at the sea inlets. The net area through grating is not to be less than twice the total inlet area of sea suction valves.

(ii) Provision is to be made for cleaning the gratings specified in 3.1.8(c)(i) above by use of low pressure steam, compressed air, etc.

3.1.9 Scuppers and sanitary discharges

(a) Scuppers piping sufficient in number and size to provided effective drainage are to be provided on all decks. However the Society may permit the means of drainage to be dispensed with in any particular compartment of any craft or class of craft if it is satisfied that by reason of size or internal subdivision of those spaces the safety of the craft is not thereby impaired.

(b) Scuppers and sanitary discharges are to comply with the requirements specified in Chapter 22 of Part II of the Rules for Steel Ships.

3.1.10 Air Pipes

Air pipes are to comply with the requirements specified in 3.2 and 3.3 of Part VI of the Rules for Steel Ships.

3.1.11 Overflow pipes

(a) General

(i) Where tanks which can be pumped up come under either one of the following categories, overflow pipes are to be provided:

(1) Where total sectional area of air pipes to tanks which can be pumped up is less than 1.25 times total sectional area of filling pipes.

(2) Where there is any opening below the open ends of air pipes fitted to the tanks; and

(3) Fuel oil settling tanks and fuel oil service tanks.

(ii) Overflow pipes other than those to tanks for fuel oil, lubricating oil and other flammable oils are to be led to the open air, or alternatively, to proper positions where the overflows can be disposed of.

(iii) Overflow pipes are to be arranged to be self-draining.

(b) Sizes of overflow pipes

The aggregated sectional area of overflow pipes which come under 3.1.11(a)(i) above is to be not less than 1.25 times the aggregated sectional area of filling pipes.

(c) Overflow pipes to fuel oil, lubricating oil and other flammable oil tanks

Overflow pipes to tanks for fuel oil, lubricating oil and other flammable oil are to comply with the requirements specified in 3.2 of Part VI of the Rules for Steel Ships.

(d) Preventive means of counter-flow of overflow

(i) Adequate means are to be provided on overflow pipes so that in the event of any one of the tanks being bilged, the other tanks cannot be flooded from the sea through the overflow pipes.

(ii) Overflow pipes discharging through the craft's sides are to extend above the load line, and are to be provided with non-return valves fitted on the craft's sides. Where the overflow pipes do not extend above the freeboard deck, additional effective means are to be provided to prevent the sea water from passing inboard.

3.1.12 Sounding pipes

(a) General

(i) All the tanks, cofferdams and areas the access to which is difficult are to be provided with a sounding pipe or a liquid level indicator.

(ii) Name plates are to be affixed to the upper ends of sounding pipes.

(b) Upper ends of sounding pipes

(i) Sounding pipes are to be led to positions above the bulkhead deck which are at all times readily accessible, and are to be provided with effective closing means at their upper ends. The sounding pipes, however, may be led to readily accessible positions from the platform of the machinery space provided that the following closing means are provided according to the kinds of tanks.

(1) Sounding pipes to tanks for fuel oil

a) Self-closing blanking devices on the termination of sounding pipes

b) Small diameter control cock located below the blanking device for the purpose of ascertaining that oil fuel is not present before opening the blanking device

c) Means to ensure that any spillage of fuel oil through the control cock involves no ignition hazard

(2) Sounding pipes to tanks for lubricating oil and other flammable oils
Sluice valves or cocks with self-closing means

(3) Sounding pipes to tanks other than mentioned in (1), (2) and cofferdams
Sluice valves, cocks or screw caps attached to the pipes by chain.

(ii) The upper ends of sounding pipes to tanks for fuel oil, lubricating oil and other flammable oils are not to terminate in accommodation spaces and adjacent to the electrical equipment, boilers and other heated surfaces.

(c) Construction of sounding pipes

Construction of sounding pipes is to comply with the requirements specified in 3.4 of Part VI of the Rules for Steel Ships.

(d) Construction of liquid level indicators

(i) A liquid level indicator which is specified in 3.1.12(a)(i) above is to be of the type approved by the Society. However, when a liquid level indicator conforms to a standard deemed appropriate by the Society or when it is provided with a certificate deemed appropriate by the Society, the requirements do not apply.

(ii) Glass gauges used for tanks carrying fuel oils, lubricating oils and other flammable oils are to comply with the following requirements (1) and (2):

(1) The glasses used for oil level indicators are to be of flat shape, of heat resisting quality, and adequately protected from mechanical damage.

(2) The valves or cocks at the lower ends of glass gauges are to be provided with self-closing means.

3.2 Bilge and Ballast Systems

3.2.1 General arrangement of bilge systems

A pumping system is to be provided in all craft capable of pumping from and draining any compartment when the craft is on an even keel and either upright or listed five degrees. For this purpose, wing suctions will often be necessary, except in narrow compartments at the ends of the craft. Arrangements are to be made whereby water in the compartment will drain to the suction pipes. Efficient means are to be provided for draining water from all tank tops and other watertight flats. Peak tanks and comparatively small compartments, such as chain lockers, echo sounder spaces, and decks over peak tanks, etc., may be drained by ejectors or hand pumps. Where ejectors are used for this purpose, the overboard discharge arrangements are to comply with 3.1.9 of this Chapter.

3.2.2 Bilge pumps

(a) Number of pumps

(i) Monohull craft

(1) Craft length ≥ 24 m
Each monohull craft 24 m in length or greater is to be provided with two power-driven bilge pumps, one of which may be attached to the propulsion unit.

(2) Craft length < 24 m
Each monohull craft less than 24 m in length is to be provided with at least one fixed power-driven pump, which may be an attached unit, and one portable hand pump.

(ii) Multihull craft

(1) Craft length ≥ 24 m
On multihull craft 24 m in length or greater, each hull is to be provided with at least two power-driven bilge pumps, unless a bilge pump in one hull is capable of pumping bilge in the other hull. At least one bilge pump in each hull is to be an independently-driven pump.

(2) Craft length < 24 m
On multihull craft less than 24 m in length, each hull is to be provided with at least one fixed power-driven bilge pump, which may be an attached unit, unless the system is arranged such that a single fixed power-driven bilge pump is capable of taking suction from either hull. In this case, one portable hand pump is also to be provided.

(iii) Alternative arrangement-submersible pumps
As an alternative to 3.2.2(a)(i) and 3.2.2(a)(ii) above, an arrangement utilizing submersible pumps may be utilized. In bilge pumping arrangements where a bilge main is not provided, then, with the exception of spaces forward of public spaces and crew accommodations, at least one fixed submersible pump is to be provided for each space. In addition, at least one portable pump is to be provided and be supplied from the emergency supply, if electric, for use on individual spaces.

(b) Capacity

The capacity of each pump is to be in accordance with the following:

Craft length (L)	Minimum Capacity per Pump
L < 24 m	$Q = 5.5\ m^3/hr$
24 m ≤ L < 30.5 m	$Q = 11.36\ m^3/hr$
30.5 m ≤ L < 45.7 m	$Q = 14.33\ m^3/hr$
L ≥ 45.7 m	$Q = 0.00575d^2\ m^3/hr$

Notes:

(1) The variables above are as follows:

Q = Pump capacity

d = Required diameter of main bilge line suction, mm. See 3.2.3(e) of this Section.

(2) For the craft of less than 24 m in length, minimum capacity of hand pump as specified in 3.2.2(a) above is to be 1.13 m^3/hr.

When more than two pumps are connected to the bilge system, their arrangement and aggregate capacity are not to be less effective.

The total capacity, Q_t, of fixed submersible bilge pumps for each hull is not to be less than 2.4 times the pump capacity, Q, determined in the above. The capacity, Q_n, of each submersible pump is not to be less than:

$$Q_n = \frac{Q_t}{N-1} \text{ m}^3\text{/hr, with a minimum capacity of 8 m}^3\text{/hr}$$

(c) Centrifugal pumps

Where centrifugal pumps are installed, suitable means for priming are to be provided.

(d) Independent power bilge pumps

Sanitary, ballast and general service pumps may be accepted as independent power bilge pumps, provided they are of the required capacity and are fitted with the necessary control valves required by 3.2.3(a) as below for pumping bilges.

3.2.3 Bilge and ballast piping

(a) General

The arrangement of the bilge and ballast pumping systems is to be such as to prevent the possibility of water or oil passing into the cargo and machinery spaces, or from one compartment to another, whether from the sea, water ballast or oil tanks. The bilge and ballast mains are to have separate control valves at the pumps.

(b) Installation

(i) Bilge or ballast pipes, where permitted to pass through compartments intended for the carriage of oil, are to be of either steel or wrought iron. Where the craft's hull is constructed of Aluminum or FRP, aluminum pipe may be used provided it is extra heavy.

(ii) Where bilge pipes in way of deep tanks are not led through a watertight or oil-tight tunnel, the bilge lines are to be of steel and extra heavy. Similarly, where ballast pipes in way of deep tanks other than ballast tanks are not led through a watertight or oil-tight tunnel, the ballast lines are to be of steel and extra heavy. Where the craft's hull is constructed of Aluminum or FRP, aluminum pipe may be used provided it is extra heavy.

(iii) For both bilge and ballast piping, the number of joints is to be kept to a minimum and to be arc welded or extra heavy flanged. The piping within a deep tank is to be installed to take care of expansion. A non-return valve is to be fitted at the open end of bilge pipes.

(c) Manifolds, cocks and valves

(i) General

All manifolds, cocks and valves in connection with the bilge pumping arrangement are to be in positions which are accessible at all times under ordinary circumstances. All valves in the machinery space controlling the bilge suctions from the various compartments are to be of the stop-check type. If valves are fitted at the open ends of pipes, they are to be of the non-return type.

(ii) Common-main-type bilge systems

(1) A common-main bilge system normally consists of one or more main lines installed along the length of the craft fitted with branch bilge suction connections to various compartments. Where only one fore-and-aft bilge main is installed, the bilge main is to be located inboard of 20% of the molded beam of the craft, measured inboard from the side of the craft perpendicular to the centerline at the level of the summer load line. If there is at least one bilge main on each side of the craft, then those bilge mains may be installed within 20% of the molded beam, measured inboard from the side of the craft perpendicular to the centerline at the level of the summer load

line, provided they are fitted with branch lines and control valves arranged such that it is possible to effectively pump out each compartment using the main(s) on either side of the craft.

(2) For all common-main-type bilge systems, the control valves required in the branches from the bilge main are to be accessible at all times and are to be of the stop-check type with an approved type of remote operator. Remote operators may be located in a manned machinery space, or from an accessible position above the freeboard deck or from underdeck walkways. Remote operators may be of the hydraulic, pneumatic, electric or reach-rod type.

(iii) Controls for ballast tank valves

Ballast tank valves are to be arranged so they will remain closed at all times, except when ballasting. For this purpose, manual screw thread operated valves, positive holding arrangements for butterfly type valves or other equivalent arrangements may be used. Where installed, remote controlled valves are to be arranged so they will close and remain closed upon loss of control power, or will remain in their last position and are provided with a readily accessible manual means of operation in case of loss of power to the valve control system. Remote control of bilge and ballast valves is to be clearly marked at the control station and means are to be provided to indicate whether the valve is open or closed.

(d) Strainers

Bilge lines in machinery spaces other than emergency suctions are to be fitted with strainers easily accessible from the floor plates and are to have straight tail pipes to the bilges. The ends of bilge lines in other compartments are to be fitted with suitable strainers having an open area of not less than three times the area of the suction pipe.

(e) Size of bilge suctions

The minimum internal diameter of bilge suction pipes is to be that of the nearest commercial size within 6 mm of the diameter determined by the following equations:

(i) Main line

For the diameter of main bilge line suctions and direct bilge suctions to the pumps:

$$d = 25 + 1.68\sqrt{L_f(B + D)} \qquad mm$$

(ii) Branch lines

For the equivalent diameter of the combined branch suctions to a compartment:

$$d = 25 + 2.15\sqrt{l(B + D)} \qquad mm$$

where

d = Internal diameter of pipe, in mm

L_f = Length of craft, as defined in 1.1.3 of Part III of the Rules, in m

B = Breadth of craft, as defined in 1.1.4 of Part III of the Rules, in m

l = Length of compartment, in m

D = Molded depth to bulkhead deck or freeboard deck, in m

(iii) Main line reduction

Where engine room bilge pumps are fitted primarily for drainage within the engine room, L may be reduced by the combined length of the cargo tanks or cargo holds. In such cases, the cross sectional area of the bilge main is not to be less than twice the required cross sectional area of the engine room branch lines.

(iv) Alternate size requirements

For craft less than 30.5 m in length, the bilge pipe sizes may be in accordance with the following in lieu of 3.2.3(e)(i) above.

Craft length (L)	Minimum pipe size (I.D.)
L < 24 m	25 mm
24 m ≤ L < 30.5 m	32 mm
30.5 m ≤ L < 45.7 m	38 mm

(v) Size limits

For craft of 45.7 m in length or greater, no main suction piping is to be less than 63 mm internal diameter. No branch piping need be more than 100 mm I.D., nor is it to be less than 25 mm I.D.

(vi) Bilge common-main

The diameter of each common-main bilge line may be determined by the equation for bilge branches given in 3.2.3(e)(ii) above using the combined compartment length upstream of the point where the diameter is being determined. In case of double hull construction with full depth wing tanks served by a ballast system, where the beam of the craft is not representative of the breadth of the compartment, B may be appropriately modified to the breath of the compartment. However, no common-main bilge pipe needs to be more than the diameter for the bilge main given in 3.2.3(e)(i) above.

(f) Gravity drains

Gravity drains that penetrate the main machinery space watertight bulkheads below the freeboard deck and terminate within the main machinery space are to be fitted with a valve operable from above the freeboard deck or with quick-acting, self-closing valves. The valve should preferably be located in the main machinery space. When gravity drains from other spaces are terminated in cargo holds, the cargo hold bilge well is to be fitted with a high level alarm. Gravity drains which terminate in spaces which are protected by fixed gas extinguishing systems are to be fitted with means to prevent the escape of extinguishing medium.

3.2.4 Emergency bilge suctions for main machinery spaces

(a) An emergency bilge suction is to be fitted in each machinery space containing a propulsion prime mover. The emergency bilge suction is to be led straight to the largest independently driven pump in the main machinery space, other than the required bilge pumps. Where this pump is not suitable, the second largest suitable pump in the main machinery space may be used for this service, provided that the selected pump is not one of the required bilge pumps and its capacity is not less than that of the required bilge pump.

(b) The area of the emergency bilge suction pipe is to be equal to the full suction inlet of the pump selected. The emergency bilge line is to be provided with a suction stop-check valve, which is to be so located as to enable rapid operation, and a suitable overboard discharge line. For the emergency bilge inlet, the distance between the open end of the suction inlet and the tank top is to be adequate to allow a full flow of water.

(c) The hand wheel of emergency bilge suction valve is to be situated above the lower platform.

3.3 Fuel Oil Systems

3.3.1 General

(a) Fuel oil in the oil tanks is not to be heated to the temperature within 10℃ below the flash point of the fuel oil, unless considered appropriate by the Society.

(b) The compartments in which fuel oil burning systems, fuel oil settling and service tanks, fuel oil purifiers, etc., are located are to be readily accessible and well ventilated.

(c) The fuel oil system in the main propulsion machinery room and boiler room are to be carefully considered to make maintenance and inspection easy. Due care is to be paid against oil leakage so that it may not result in fire accidents and that it may be detected easily in case of leakage. All valves or cocks are to be capable of being operated from above the platform.

(d) Valves, cocks and other fittings fitted on fuel oil tanks are to be located in safe positions so as to be protected from external damage.

(e) Stop valves or cocks are to be fitted on both suction and delivery sides of fuel oil pumps.

(f) Where pressure relief valves are provided on the delivery side of the fuel oil pumps, arrangements are to be made so that the discharged oil may be led to the suction side of the pump.

(g) Valves and pipe fittings with a design temperature above 60℃ and a design pressure above 10 bar are to be suitable for a pressure of not less than 16 bar. Valves and pipe fittings used for fuel oil transfer piping lines, fuel oil suction piping lines and other low pressure fuel oil piping lines are to be suitable for a pressure of not less than 5 bar.

(h) Union joints used for connection of fuel oil injection pipes of diesel engines or the pipes of burning systems of boilers are to be of rigid construction and to have metal contact capable of providing sufficient oil tightness.

(i) Fuel oil pipelines including fuel oil tanks are to be segregated from ballast pipelines.

3.3.2 Fuel oil filling pipes

(a) Filling pipes for tanks containing flammable liquids are to be terminated on open deck and be arranged so that leakages are collected by suitable coamings. Fuel oil filling connections are as far as practicable to be arranged on both sides of the craft.

(b) The requirements specified in 4.4.3(h)(v) of Part VI of the Rules for Steel Ships are to be complied with.

3.3.3 Valves for tank suction pipes

Valves for tank suction pipes are to comply with the requirements specified in 2.1.2(c)(iv) of Part IX of the Rules for Steel Ships.

3.3.4 Fuel oil transfer pumps

(a) In crafts where power pumps are used for pumping up to the settling and service tanks, at least two independent power fuel oil transfer pumps are to be provided, and these pumps are to be connected ready for use. Where any suitable independent power driven fuel oil pump for other purposes is available as a fuel oil transfer pump, this pump may be used as a fuel oil transfer pump.

(b) For multihull craft, notwithstanding 3.3.4(a) above, interconnecting pipe lines for fuel oil transfer pumps may be dispensed with providing that, even in the case of one engine inoperative, the craft can maintain her navigable speed.

3.3.5 Drip trays and drainage system

Drip trays and drainage system is to comply with the requirements specified in 4.4.1(h)(vii) to 4.4.1(h)(x) of Part VI of the Rules for Steel Ships.

3.3.6 Heating arrangements and temperature indication

The requirements specified in 4.4.1(f) and 4.4.1(g) of Part VI of the Rules for Steel Ships are to be complied with.

3.3.7 Fuel oil burning arrangements

The requirements specified in 4.4.2 of Part VI of the Rules for Steel Ships are to be complied with.

3.4 Lubricating Oil and Hydraulic Systems

3.4.1 General

(a) The compartment in which lubricating oil tanks, lubricating oil purifiers and hydraulic oil tanks are located are to be readily accessible and well ventilated.

(b) Lubricating oil system and hydraulic oil system in the main propulsion machinery room and boiler room are to be carefully considered to make maintenance and inspection easy. Due care is to be paid against oil leakage so that it may not result in fire accidents and that it may be detected easily in case of leakage. All valves or cocks are to be capable of being operated from above the platform.

(c) Valves, cocks and other fittings fitted on lubricating oil tanks and hydraulic oil tanks are to be located in safe positions so as to be protected from external damage.

(d) Valves for lubricating oil tank suction pipes are to comply with the requirements specified in 2.1.2(c)(iv) of Part IX of the Rules for Steel Ships (in this case the term fuel oil is to be read as lubricating oil).

(e) Drip trays and drainage arrangement of lubricating oil systems and hydraulic oil systems are to comply with the requirements as those applied for fuel oil systems specified in 4.4.1(h)(vii) to 4.4.1(h)(x) of Part IX of the Rules for Steel Ships.

(f) Lubricating oil heating arrangements and temperaure indication are to respectively comply with the requirements specified in as those applied for fuel oil systems specified in 4.4.1(f) and 4.4.1(g) of Part VI of the Rules for Steel Ships.

3.4.2 Lubricating oil pumps

Number and capacity of lubricating oil pumps for main propulsion machinery, propulsion shaftings and power transmission systems are to comply with the following requirements (a) or (b) :

(a) Two sets of lubricating oil pumps are to be provided with sufficient total capacity enough to maintain the supply of the oil at the maximum continuous output of the main propulsion machinery, and each of which has sufficient capacity to obtain navigable speed of the craft.

(b) Where two or more main propulsion machinery, propulsion shaftings and their power transmission systems are provided, such system that each of them has an exclusive lubricating oil pump may be accepted, providing that it is possible to give a navigable speed even if one of them is out of use.

3.4.3 Stop valves between engine and sump tank

For crafts of 100 meters and above in length, where a double bottom is used as a lubricating oil sump tank, a stop valve which can be easily operated from the engine room floor or suitable counterflow prevention device is to be provided.

3.4.4 Lubricating filters

(a) Where a forced lubrication system (including gravity supply from head tank) is adopted for lubrication of machinery installations, lubricating oil filters are to be provided.

(a) The filters used for the lubricating oil systems of the main propulsion machinery, power transmission of propulsion shafting and controllable pitch propeller system are to be capable of being cleaned without stopping the supply of filtered oil.

3.4.5 Hydraulic power cylinders

The requirements of 4.5 of Part VI of the Rules for Steel Ships are to be complied with.

3.5 Pneumatic Piping Systems

3.5.1 Arrangement of air compressors and pressure relief systems

(a) Air compressors are to be so arranged that any mixing between oil and incoming air is minimized as much as possible.

(b) Each air compressor is to be provided with a relief valve to prevent the pressure from rising more than 10% above the maximum working pressure of its cylinders.

(c) In cases where water jackets of air coolers might be subject to dangerous level of excessive pressure due to any leakage of compressed air into them, suitable pressure relief arrangements are to be provided for these water jackets.

3.5.2 Relief devices and other fittings for air vessels

Relief devices and other fittings for air vessels are to comply with the requirements in 4.5 of Part V of the Rules for Steel Ships.

3.5.3 Number and total capacity of air compressors

(a) In cases where the main propulsion machinery is designed for starting by compressed air, two or more starting air compressors are to be provided and arranged so as to be able to charge each air reservoir. However, in cases where cylinders are provided with air charging valves, these charging valves will be considered to be equivalent to any air compressors driven by the main propulsion machinery.

(b) One of the air compressors prescribed in 3.5.3(a) above is to be driven by a prime mover that is not the main propulsion machinery.

(c) The total capacity of air compressors is to be sufficient to supply air into the air reservoirs from atmospheric pressure to the pressure required for the consecutive starts prescribed in 2.1.3(b) of this Part within one hour.

3.5.4 Compressed air piping

(a) Drainage systems are to be provided for compressed air piping to remove any drainage remaining inside the pipes.

(b) All discharge pipes for starting air reservoirs are to be laid directly from starting air compressor.

(c) Starting air pipes from the air reservoirs to main propulsion machinery or auxiliary engines are to be entirely separate from the compressor discharge system prescribed in 3.5.4(b) above.

3.6 Other Piping Systems

3.6.1 Thermal oil systems

Thermal oil systems are to comply with the requirements specified in 4.7 of Part VI of the Rules for Steel Ships.

3.6.2 Cooling systems

(a) Cooling pumps

Number and capacity of cooling pumps for the main propulsion machinery are to comply with the following requirements (i) or (ii):

(i) Two sets of main cooling pumps are to be provided with sufficient total capacity enough to maintain the supply of water (oil) at the maximum continuous output of the main propulsion machinery, and each of which has sufficient capacity to obtain navigable speed of the craft.

(ii) Where two or more main propulsion machinery are provided, such system that each of them has an exclusive cooling pump may be accepted providing that it is possible to give a navigable speed even if one of them is out of use.

(b) Suction of sea water

Arrangement is to be provided to introduce cooling sea water from sea suction valves fitted on two or more sea chests or sea suctions. For multihull craft, however, such a system that each hull has single sea chest respectively may be accepted providing that it is possible to give a navigable speed even if one of the engine in any hull is out of use.

3.6.3 Steam piping systems and condensate systems

Steam piping systems and condensate systems are to comply with the requirements specified in 4.2 of Part VI of the Rules for Steel Ships.

3.6.4 Feed water systems for boilers

(a) Every auxiliary boiler (including steam generating systems) which provides services essential for the safety of the craft, or which could be rendered dangerous by the failure of its feed water supply, is to be provided with two separate feed water systems, each including a stop valve, a non-return valve and a feed pump.

Total capacity of feed water pumps are to be sufficient for maximum evaporation and capacity of one feed water pump is to be sufficient to obtain navigable speed of the craft.

However, a single penetration of the steam drum is acceptable.

(b) Boiler feed water pipes are not to be led through tanks which contain oil, nor are oil pipes to be led through boiler feed water tanks.

3.6.5 Exhaust gas piping arrangement

(a) Exhaust gas piping arrangement is to comply with the requirements specified in 4.8 of Part VI of the Rules for Steel Ships.

(b) Exhaust gas piping is to be arranged with consideration of heat influence to hull plates.

(c) Open ends of exhaust gas piping are to be arranged so that exhaust gas is prevented to flow into air intakes of diesel engines, gas turbines, etc.

3.6.6 Fuel storage and refueling systems for helicopter facilities

(a) Fuels with flash point above 60°C

When fixed helicopter fuel storage and pumping systems are provided and the flash point of the fuel is above 60°C, closed cup test, the installation is to comply with 3.3 and 3.6.6(b)(v) of this Chapter.

(b) Fuels with flash point at or below 60℃ – installations on an open deck

(i) General

The designated fuel storage and refueling areas are to be suitably isolated from areas which contain a source of vapor ignition, escape routes and embarkation stations, and are not to be located on landing areas. The storage and refueling areas are to be permanently marked as an area where smoking and open flames are not permitted.

(ii) Tanks

Fixed fuel storage tanks are to be of metal construction. Mounting, securing arrangements and electrical bonding of the storage tank and refueling system are to be approved.

(iii) Vents and sounding

Fuel storage tank venting and sounding arrangements are to comply with 3.1.10 and 3.1.12 as above.

(iv) Tank valves

Fuel storage tank outlet valves are to be provided with a means of remote closure. Means are also to be provided for remote shutdown of the refueling pumps.

(v) Spill containment

To contain spillage and retain fire extinguishing agents, a coaming of at least 150 mm in height is to be provided. The coaming is to surround the fuel storage area, which consists of the fuel tank, associated piping and any pumping unit adjacent to the storage tank. Where the pumping unit or any other unit such as dispenser/coalescer unit is remote from the tank, a separate coaming is to be provided around each unit.

Drainage is to be provided for the area enclosed by the coaming, complying with the following:

(1) The area within the coaming is to be sloped toward the drain line.

(2) Drainage from the area within the coaming is to be led through a valve designed for selective output (e.g., 3-way valve) either to a holding tank complying with 3.6.6(b)(ii) and 3.6.6(b)(iii) above or directly overboard. No other valves may be fitted in the drain line.

(3) The cross sectional area of the drain line from the fuel tank coaming is to be at least twice that of the fuel storage tank outlet connection.

Fuel tank coamings not provided with drainage arrangements in accordance with the above are to be sized to contain the full volume of the fuel storage tank plus 150 mm of foam.

(vi) Electrical equipment

All electrical equipment installed within 3 meters of either the tank vent outlet or the pumping/refueling equipment is to be of a certified safe type. Electrical equipment installed may be any of the types indicated in 4.1.10(b) of this Part and is to be IEC Publication 60079-20-1 group IIA class T3.

(c) Fuels with flash points at or below 60℃ – installation within enclosed spaces

(i) Independent tanks

Fuel storage tanks and their venting and sounding arrangements are to comply with 3.6.6(b)(ii) and 3.6.6(b)(iii). The valving arrangements on the tanks are to comply with 3.3 of this Chapter.

(ii) Integral tanks

The venting and sounding arrangements for integral tanks are to comply with 3.6.6(b)(iii). Overflow and valving arrangements are to comply with 3.1.11 and 3.3 of this Chapter, respectively.

Cofferdams, thoroughly oiltight and vented, having widths as required for ready access, are to be provided for the separation of all cargo tanks from galleys and living quarters, general cargo spaces which are below the uppermost continuous deck, boiler rooms, and spaces containing propulsion machinery or other machinery where sources of ignition are normally present. Pump rooms, compartments arranged solely for ballast, and fuel-oil tanks may be considered as cofferdams in compliance with this requirement.

(iii) Access arrangements

The access to the fuel storage and refueling compartment is to be from the open deck by means of a trunk, if necessary. The compartment is to be bounded by gas tight bulkheads/decks and there is to be no direct access from any other compartment to the fuel storage and refueling compartment or access trunk.

(iv) Electrical equipment

Electrical equipment installed in the refueling pump room and the space in which an independent helicopter fuel tank storage is located is to be of a certified safe type. All electrical equipment installed within 3 meters of the tank vent outlet is to be of a certified safe type. Electrical equipment installed may be any of the types indicated in 4.1.10(b) of this Part and is to be IEC Publication 60079-20-1 group IIA class T3.

(v) Pumps

Fuel pumps for helicopter refueling are to comply with 12A.7 of Part II, 4.5 and 4.7 in Part IV of the Rules for Steel Ships and are to be provided with remote shut-down.

(vi) Piping

Helicopter refueling piping systems are to comply with 3.6.6(a).

(vii) Bilge/drainage system

Provision is to be made for drainage of the refueling pump room and cofferdams. A separate bilge pump, ejector or a bilge suction from a refueling pump may be provided for this purpose. The arrangements are to be in accordance with 3.2 of this Chapter.

(viii) Ventilation

Systems for the refueling pump room and the space in which an independent helicopter fuel tank is located are comply with the below.

(1) System and arrangement
Refueling pump rooms are to have a mechanical extraction ventilating system and ducting, in accordance with the requirements as below:

a) Lower intake

Lower (main) intakes are to be located at the lowest floor level. The number of air changes through the main intake with the damper in item b) below closed is to be at least 20 changes per hour based on the gross volume of the pump room.

b) Emergency intake

An emergency intake is to be provided at approximately 2 m above the lowest floor with damper capable of being opened or closed from the exposed main deck and lowest floor level so that it can be used when the lower intakes are not available. The air changes in that condition is to be at least 15 changes per hour.

c) Dampers

Where the ratio of areas of the upper emergency intake and lower main intakes is such that the required number of respective air changes in items a) and b) above can be obtained, the dampers may not be required.

d) Floor plate

Floors are to be open grating type to allow the free flow of air. In general, floor plating is to be of an open type not to restrict the flow of air. In addition, a ventilating system is to be provided.

(2) Fan motors and fans
Fan motors are to be located outside of the pump room and outside of the ventilation ducts. Fans are to be of non-sparking construction. Provision is to be made for immediate shutdown of the fan motors upon release of the fire extinguishing medium.

Chapter 4

Electrical Instllation

4.1 General

4.1.1 General

(a) The requirements of the present Part are applicable to the electrical installation intended for craft without special service limitations or restrictions. The Society may, however, modify the requirements in certain particular cases for their application to small craft, fishing vessels and craft with service limitations or restrictions.

(b) The Society is prepared to give special consideration to the novel features of design in respect of the electrical installation based on the best information available at the time.

(c) The electrical apparatus and the wiring system of a classed craft are to be constructed, installed and tested under the supervision and to the satisfaction of the Surveyor in accordance with the following requirements. Considerations will be given, however, to the arrangements or details of the equipment and machinery which comply with other recognized standards provided they are not less effective than the requirements of this Part.

(d) When applying the requirements of the following Chapters, the so-called essential auxiliaries are to be as specified in Chapter 1 of Part IV of CR Rules for Steel Ships.

(e) Passenger craft intended for classification are to be constructed in accordance with the requirements of the Society as well as those of Governmental and International Convention Regulations.

(f) For craft having an aggregate generator capacity less than 75 kW, the requirements contained in 4.18 are to be complied with. Where generators are not arranged for parallel operation, the capacity of the largest generator may be taken as the "aggregate generator capacity". Electrical installations in machinery spaces with gasoline engines will be specially considered.

(g) For craft less than 24 meters in length, the requirements contained in 4.20 are to be complied with.

4.1.2 Drawings and Data

(a) The builder or manufacturer is to submit the following drawings and data for approval before the work commences:

(i) For propulsion machineries, generators and essential motors of 375 kW and over: – Complete rating, seating arrangements, assembly, shaft, stator and rotor details, electric propulsion coupling details, mass, main dimensions, main materials used, and data for calculation of critical speed.

(ii) For generators below 375 kW: – Complete rating, seating arrangements, type of enclosure and dimensional outline.

(iii) For essential motors over 15 kW but below 375 kW: – Complete rating, seating arrangements, type of enclosure and dimensional outline.

(iv) For switchboards: – Arrangements and details, front view, installation arrangements and wiring diagram.

(v) For wiring: – All wiring plans and circuit diagrams including load distribution, wire size, type of cable, maximum temperature rise of conductor and voltage drop, type of insulation, rating or setting of circuit breaker, rating of fuse and switch, and interrupting capacity of circuit breaker and fuse.

(vi) For arrangement: – General arrangement of electric equipment including details of the main cable runs.

(b) The builder is to submit the following specification and data for approval before the work commences:

(i) Load analysis and protective device coordination study.

(1) A protective device coordination study is to be submitted for review. This protective device coordination study is to consist of an organized time-current study of all of the protective devices in series from the utilization equipment to the source for all circuit protection devices having different setting or time-current characteristics for long-time delay tripping, short-time delay tripping and instantaneous tripping, where applicable. Where an over-current relay is provided in series and adjacent to the circuit protection device, the operating and time-current characteristics of the relay are to be considered for coordination.

(2) The electric-plant load analysis is to cover all operating conditions of the craft, such as normal sea going, cargo handling (loading/unloading), harbor in/out, emergency,and dynamic positioning operations.

(ii) Calculations of short circuit currents at main, emergency and sub-switchboards including those fed from transformers.

(1) In order to establish that the protective devices on the main and emergency switchboards have sufficient short-circuit breaking and making capacities, data are to be submitted giving the maximum calculated short-circuit current in symmetrical rms and asymmetrical peak values available at the main bus bars together with the maximum allowable breaking and making capacities of the protective device. Similar calculations are to be made at other points in the distribution system, where necessary, to determine the adequacy of the interrupting capacities of the protective devices.

(iii) Explanation of electric propulsion system.

(iv) Maintenance schedule of battieries

4.1.3 Ambient Reference Conditions

(a) 45°C is to be considered the standard ambient temperature for the inside of the boiler or machinery space and 32°C is to be considered the standard temperature for the inlet of sea water. For other spaces, a temperature of 40°C is to be taken as the standard ambient temperature.

(b) The values as specified in the tables of limits of temperature rise in this Part are based on 45°C standard ambient temperature. For the ambient temperature of 40°C, these values may be increased by 5°C.

(c) Where the ambient temperature of a space is in excess of the values specified in 4.1.3(a) above, the permissible temperature rise of the machine or equipment installed in that space is to be reduced by an amount equivalent to the excess temperature.

4.1.4 Inclination of Craft

(a) Machines and apparatus are to operate satisfactorily under all conditions with the craft inclined up to the following angles from the normal:

athwartship,

static dynamic 15°

dynamic static 22.5°

fore-and-aft,

static dynamic 5°

dynamic static 7.5°

(b) Emergency machines and apparatus fitted in accordance with statutory requirements are to operate satisfactorily when the craft is inclined up to 22.5° and/or when the trim of the craft is 10°.

4.1.5 Quality of Electrical Power Supplies

(a) Voltage and Frequency Variations

All electrical equipment supplied from the main and emergency source of electrical power is to be so designed and manufactured that it is capable of operating satisfactorily under normally occurring variations of voltage and frequency.

Unless specified otherwise, A.C. electrical equipment, other than that supplied by battery systems, is to operate satisfactorily with the following simultaneous variations, from their nominal value, when measured at the consumer input terminals.

(i) voltage:

permanent variations +6%, –10%

transient variations ± 20%

recovery time 1.5 seconds

(ii) frequency:

permanent variations ±5%

transient variations ±10%

recovery time 5 seconds

Unless specified otherwise, D.C. electrical equipment is to operate satisfactorily with the following simultaneous variations, from their nominal value, when measured at the consumer input terminals,

(iii) When supplied by D.C. generators or rectified A.C. supply:

Voltage tolerance (continuous) ± 10%

Voltage cyclic variations deviation 5%

Voltage ripple (A.C. rms over steady state D.C. voltage) 10%

(iv) When supplied by batteries:

(1) Equipment connected to the batteries during charging:
Voltage tolerance +30%, -25%

(2) Equipment not connected to the batteries during charging:
Voltage tolerance +20%, -25%

Different voltage variations as determined by the charging/discharging characteristics, including ripple voltage from the charging device, may be considered. When battery chargers/battery combinations are used as D.C. power supply systems, adequate measures are to be taken to keep the voltage within the specified limits during charging, boost charging and discharging of the battery.

(b) Harmonics

Unless specified otherwise, the total harmonic distortion (THD) of the voltage waveform at any switchboard or section-board is not to exceed 8% for all frequencies up to 50 times the supply frequency and no voltage at a frequency above 25 times supply frequency is to exceed 1.5% of the supply voltage.

4.1.6 Location and Construction

(a) Electrical equipment is to be accessibly placed in well-ventilated and adequately lighted spaces where it is not exposed to risk of mechanical injury or damage arising from water, steam or oil. Where it is unavoidable to be exposed to such risks, the equipment is to be so constructed as to meet the conditions of the locations.

(b) Bolts, nuts, pins, screws, terminals, studs, springs and such other small parts are to be made of corrosion resistant materials or steel suitably protected against corrosion.

(c) Live parts are to be effectively shielded from any accidental contact when the voltage is above 250V D.C. or 150V, A.C.

(d) All electrical apparatus are to be so constructed and so installed that it does not cause injury when handled or touched in the normal manner.

(e) All electrical equipment is to be constructed of durable and flame-retardant materials. Materials are to be resistant to corrosion, moisture, high and low temperatures, and are to have other qualities necessary to prevent deterioration in the ambient conditions that the equipment may be expected to encounter.

(f) Insulation Material

Insulating materials are to be classified by their maximum continuous operating temperatures in accordance with the following table:

Class	Maximum Continuous Temperature (°C)
A	105
E	120
B	130
F	155
H	180

Materials or combination of materials which by experience or accepted tests can be shown to be capable of satisfactory operation at temperature over 180°C will also be considered. In this regard, supporting background information, reports, tests conducted, etc. ascertaining their suitability for the intended application and operating temperature is to be submitted for review.

(g) Equipment is not to remain alive through the control circuits and/or pilot lamps when switched off by the control switch. This does not apply to synchronizing switches and/or plugs.

(h) The operation of all electrical equipment and the lubrication arrangements are to be efficient under such conditions of vibration and shock as arise in normal practice.

(i) All nuts and screws used in connection with current-carrying parts and working parts are to be effectively locked to prevent loosening due to vibration.

(j) No electrical equipment is to be installed in any space where flammable mixtures are liable to collect including those on board oil tankers or in compartments assigned principally to accumulator batteries, in paint lockers, acetylene stores or similar spaces, unless the Society is satisfied that such equipment is:

(i) essential for operational purposes;

(ii) of a type which will not ignite the mixture concerned;

(iii) appropriate to the space concerned; and

(iv) appropriately certified for safe usage in the dusts, vapours or gases likely to be encountered.

(k) Generators and motors are preferably to be placed with their axis of rotation in the fore and aft direction of the craft. Where a machine is installed athwartships, it is to be ensured that the design of the bearings and the arrangements for lubrication are satisfactory to withstand the craft's inclination specified in 4.1.4.

(l) The electrical equipment exposed to the weather or located in spaces exposed to sea splashing or other severe moisture condition is to be of the waterproof type or protected by means of waterproof enclosure.

(m) Conductors and equipment are to be placed at such a distance from the magnetic compass or all to be so screened that the interfering external magnetic field is negligible, even when circuits are switches on and off.

4.1.7 Earthing

(a) Exposed metal parts of electrical machines or equipment which are not intended to be live but which are liable under fault conditions to become live are to be earthed unless the machines or equipment are:

(i) 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 voltage; or

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

(iii) constructed in accordance with the principle of double insulation.

(b) Metal frames of all portable electric lamps, tools and similar apparatus supplied as unit's equipment and rated in excess of 50 V are to be earthed through a suitable conductor unless equivalent safety provisions are made such as by double insulation or by an isolating transformer.

(c) Where earthing connections are necessary, they are to be of copper or other approved material and are to be protected against damage and, where necessary, against electrolytic corrosion. Connections are to be so secured that they cannot work loose under vibration.

(d) In general, the nominal cross-section area of copper earthing conductor is to be equal to the cross-section of the current-carrying conductor up to 16 mm^2. Above this figure it is to be equal to at least half the cross-section of the current-carrying conductor with a minimum of 16 mm^2.

(e) The connection of the earthing conductor to the hull of the craft is to be made in an accessible position, and is to be secured by a screw or stud of diameter not less than 6 mm which is to be used for this purpose only. Bright metallic surfaces at the contact areas are to be ensured immediately before the nut or screw is tightened and, where necessary, the joint is to be protected against electrolytic corrosion. The connection is to remain unpainted.

4.1.8 Bonding for the Control of Static Electricity

(a) Bonding straps for the control of static electricity are required for cargo tanks, process plant and piping systems, for flammable products and solids liable to release flammable gas and/or combustible dust, which are not permanently connected to the hull of the craft either directly or via their bolted or welded supports and where the resistance between them and the hull exceeds 1 MΩ.

(b) Where bonding straps are required for the control of static electricity, they are to be robust, that is, having a cross-sectional area of about 10 mm^2, and are to comply with 4.1.7(c) and 4.1.7(e).

4.1.9 Clearances and Creepage Distances

(a) Clearances and creepage distances between live parts and between live parts and earthed metal, whether across surfaces or in air, are to be adequate for the working voltage having regard to the nature of the insulating material and the transient over-voltages developed by switch and fault conditions.

(b) Bare main bus bars in main and emergency switchboards, but not including the conductors between the main bus bars and the supply side of out- going units, are to have minimum clearances (in air) and creepage distances (across surfaces) as given in Table IV 4-1.

Table IV 4-1
Minimum Clearance and Creepage Distances

Rated insulation Voltage (V)	Minimum Clearances (mm)	Minimum Creepage Distances (mm)
Up to 250	15	20
Over 250 to 660	20	30
Over 660 to 1000	25	35

Notes:
(1) The values in this table apply to clearances and creepage distances between live parts as well as between live parts and exposed conductive parts, including grounding.
(2) System with nominal voltage exceeding 1 kV (phase to phase) is to comply with the requirements of high voltage system in 4.14.

4.1.10 Electrical Equipment for Use in Explosive Gas Atmospheres

(a) Where electrical equipment is installed in areas where explosive gas atmospheres may be present, it is to be of a "safe type", certified for the gases/ varpours involved. The construction and type testing is to be in accordance with IEC Publication 60079, Electrical Apparatus for Explosive Gas Atmospheres, or an equivalent national standard.

(b) Certified safe type equipment includes the following types of protection:

(i) Intrinsically safe – Ex "i".

An intrinsically safe equipment is one which is supplied by a low energy circuit which when sparking, produced normally by breaking or making the circuit or produced accidentally (i.e., by short circuit or earth-fault), is incapable under prescribed test conditions of causing ignition of a prescribed gas or vapor.

(ii) Increased safety – Ex "e"

Increased safety equipment is designed to give increased security against the possibility of excessive temperatures and the occurrence of arcs or sparks in electrical apparatus which does not produce arcs or sparks in normal service.

(iii) Flameproof – Ex "d"

Flameproof equipment is one which possesses an enclosure capable of withstanding, without damage, an explosion of a prescribed flammable gas or vapor within the enclosure and prevent the transmission of flame or sparks which would ignite the external prescribed flammable gas or vapor for which it is designed, and which normally operates at an external temperature that will not ignite the external prescribed flammable gas or vapor. A flameproof enclosure may not necessarily or ordinarily be weatherproof or dustproof.

(iv) Pressurized enclosure – Ex "p"

Pressured equipment is designed with an enclosure in which the entry of flammable gases or vapors is prevented by maintaining the air (or other non-flammable gas) within the enclosure at a specified pressure above that of the external atmosphere. Purged equipment is designed with an enclosure in which a sufficient flow of fresh air or inert gas is maintained through the enclosure to prevent the entry of any flammable gas or vapor which may be present in the ambient atmosphere.

(c) In addition, lighting fittings of the air driven type with pressurized enclosure are considered to be a ‘safe type’ of lighting fitting.

(d) When "safe type" equipment is permitted in hazardous zones or spaces all switches and protective devices are to interrupt all lines or phases and, where practicable, are to be located in a non-hazardous zone or space unless specifically permitted otherwise. Such equipment, switches and protective devices are to be suitably labeled for identification purposes.

(e) Paint stores or enclosed spaces leading to paint stores

In principle, within the paint store; open deck area within 1 m from ventilation inlet and natural ventilation outlet; and open deck area within 3 m from power ventilation outlet are to be regarded as hazardous areas.

(i) Electrical equipment is to be installed in paint stores and in ventilation ducts serving such spaces only when it is essential for operational services. Certified safe type equipment specified in 4.1.10.(b) of this chapter is acceptable.

(ii) Electrical equipment for use in paint stores is to have minimum explosion group IIB and temperature class T3.

(iii) In the areas on open deck within 1 m of inlet and exhaust ventilation openings of paint stores or 3 m of exhaust mechanical ventilation outlets of such spaces, following electrical equipment may be installed:

(1) Electrical equipment with the type of protection as permitted in paint stores.

(2) Appliances which do not generate arcs in service and whose surface does not reach unacceptably high temperature.

(3) Appliances with simplified pressurised enclosures or vapour proof enclosures (minimum class of protection IP55) whose surface does not reach unacceptably high temperature.

(4) Cables of armoured type or installed in metallic conduit are to be used.

(iv) Enclosed spaces giving access to paint stores may be considered as non-hazardous, provided that:

(i) The door to the paint store is a gastight door with self-closing devices without holding back arrangements.

(ii) The paint store is provided with an acceptable, independent, natural ventilation system ventilated from a safe area.

(iii) Warning notices are fitted adjacent to the paint store entrance stating that the store contains flammable liquids.

(f) Battery room

In principle, within the battery room; open deck area within 1 m from natural ventilation outlet, and open area within 3 m from power ventilation outlet are to be regarded as hazardous areas.

(i) Electric ventilator motors are to be outside ventilation ducts and, if within 3 m of the exhaust end of the duct, they are to be of an explosion-proof safe type. The impeller of the fan is to be of the non-sparking type.

(ii) Overcurrent protective devices are to be installed as close as possible to, but outside of, battery rooms.

(iii) Electrical cables other than those pertaining to the equipment arranged in battery rooms are not permitted.

(iv) Electrical equipment for use in battery rooms is to have minimum explosion group IIC and temperature class T1.

(g) Welding gas (Oxygen-acetylene) storage room

In principle, within the storage room; open deck area within 1 m from natural ventilation outlet, open area within 3 m from power ventilation outlet; and the area within 3 m of the gas cylinders pressure relief device discharge outlet are to be regarded as hazardous areas.

(i) Electric ventilator motors are to be outside ventilation ducts and, if within 3 m of the exhaust end of the duct, they are to be of an explosion-proof safe type. The impeller of the fan is to be of the non-sparking type.

(ii) Electrical equipment for use in oxygen-acetylene room is to have minimum explosion group IIC and temperature class T2.

4.1.11 Protection of Electrical Enclosures

Electrical equipment is to have a degree of enclosure for protection against the intrusion of foreign objects and liquids, appropriate for the location in which it is installed. The minimum degree of protection is to be in accordance with Table IV 4-2.

Table IV 4-2
Minimum Required Degree of Protection

Example of location	Condition in location	Equipment								
		Switchboard, control gear, motor starters	Generators	Motors	Transformers	Lighting fixtures	Heating appliances	Cooking appliances	Socket outlets	Accessories (e.g., switches, detector, connection boxes)
Dry accommodation spaces, dry control rooms	Danger of touching live parts only	IP20	-	IP20	IP20	IP20	IP20	IP20	IP20	IP20
Control rooms, wheel house, radio room	Danger of dripping liquid and/or moderate mechanical damage	IP22	-	IP22	IP22	IP22	IP22	IP22	IP22	IP22
Engine and boiler rooms above floor		IP22	IP22	IP22	IP22	IP22	IP22	IP22	IP44	IP44
Steering gear rooms		IP22	IP22	IP22	IP22	IP22	IP22	-	IP44	IP44
Emergency machinery rooms		IP22	IP22	IP22	IP22	IP22	IP22	-	IP44	IP44
General storerooms		IP22	-	IP22	IP22	IP22	IP22	-	IP22	IP44
Pantries		IP22	-	IP22	IP22	IP22	IP22	IP22	IP44	IP44
Provision rooms		IP22	-	IP22	IP22	IP22	IP22	-	IP44	IP44
Ventilation ducts		-	-	IP22	-	-	-	-	-	-
Bathroom and/or showers	Increased danger of liquid and/or mechanical damage	-	-	-	-	IP34	IP44	-	IP55	IP55
Engine and boiler rooms below floor		-	-	IP44	-	IP34	IP44	-	-	IP55
Closed fuel oil separator rooms		IP44	-	IP44	IP44	IP34	IP44	-	-	IP55
Closed lubricating oil separator rooms		IP44	-	IP44	IP44	IP34	IP44	-	-	IP55
Ballast pump rooms	Increased danger of liquid and mechanical damage	IP44	-	IP44(2)	IP44(2)	IP34	IP44	-	IP55	IP55
Refrigerated rooms		-	-	IP44	-	IP34	IP44	-	IP55	IP55
Galleys and laundries		IP44	-	IP44	IP44	IP34	IP44	IP44	IP44	IP44
Public bathroom and showers		-	-	IP44	IP44	IP34	IP44	-	IP44	IP44
Shaft or pipe tunnels in double bottom	Danger of liquid spraying, presence of cargo dust, serious mechanical damage, aggressive fumes	IP55	-	IP55	IP55	IP55	IP55	-	IP56	IP56
Holds for general cargo		-	-	IP55	-	IP55	IP55	-	IP56	IP56
Ventilation trunks		-	-	IP55	-	-	-	-	-	-
Open decks	Danger of liquid in massive quantities	IP56	-	IP56	-	IP55	IP56	-	IP56	IP56
Bilge wells	In water	-	-	-	-	IPX8	-	-	-	IPX8

Notes:

(1) The symbol "-" denotes equipment which it is not advised to install.

(2) Electric motors and starting transformers for lateral thruster propellers located in spaces similar to ballast pump rooms may have degree of protection IP22.

4.1.12 Testing and Inspection

(a) All generators, including emergency generators, motors, and other rotating machines for essential auxiliary services are to be tested in the presence of the Surveyor, preferably at the plant of the manufacturer.

(b) Shop tests of generators are to be carried out in accordance with Chapter 3 of Part VII of the Rules for Steel Ships.

(c) Shop tests of motors are to be carried out in accordance with Chapter 4 of Part VII of the Rules for Steel Ships.

(d) Switchboards are to be inspected in the presence of the Surveyor at the plant of the manufacturer in accordance with Chapter 5 of Part VII of the Rules for Steel Ships.

(e) Motor controllers are to be inspected in the presence of the Surveyor at the plant of the manufacturer in accordance with Chapter 9 of Part VII of the Rules for Steel Ships.

(f) The shaft material of generators and motors of 375 kW and over is to be tested in accordance with the requirements in Part XI of the Rules for Steel Ships. For the shaft material of machines below 375 kW the manufacturer's certificate of material test is to be acceptable in each case provided the test record submitted by the manufacturer is satisfactory.

(g) Transformers are to be inspected in the presence of the Surveyor at the plant of the manufacturer in accrodance with Chapter 7 of Part VII of the Rules for Steel Ships.

(h) Cables are to be inspected in the presence of the Surveyor at the plant of the manufacturer in accordance with Chapter 8 of Part VII of the Rules for Steel Ships.

(i) Semiconductor equipments are to be inspected in the presence of the Surveyor at the plant of the manufacturer in accordance with Chapter 15 of Part VII of the Rules for Steel Ships.

(j) Uninterruptible Power System are to be inspected in the presence of the Surveyor at the plant of the manufacturer in accordance with Chapter 18 of Part VII of the Rules for Steel Ships.

(j) The electrical equipment for use in explosive gas atmospheres is to be approved and tested in the presence of the Surveyor.

4.2 System Design of Distribution and Circuit Protection

4.2.1 System Design - General

(a) Distribution systems
  (i) The following distribution systems are considered as standard:
    (1) Two-wire direct current.
    (2) Three-wire direct current (three-wire insulated system or three-wire mid-wire earthed system).
    (3) Two-wire, single-phase alternating current.
    (4) Three-wire, three-phase alternating current.
    (5) Four-wire, three-phase alternating current.

(ii) The voltage of electric supply is not to exceed:

(1) 500 V A.C. and D.C. for generators, power equipment, and heating and cooking equipment connected to fixed wiring.

(2) 250 V A.C. and D.C. for lighting, heaters in cabins and public rooms, equipment other than those specified in (i).

(3) 15,000 V A.C. and 1,500 V D.C. installations for electric propulsion.

(4) 15,000 V A.C. for A.C. generators and A.C. power equipment meeting the requirements in Chapter 14.

(iii) The hull return system of distribution is not to be used for any purpose for power, heating, or lighting in all craft, except the following:

(1) Impressed current cathodic protection systems for external hull protection.

(2) Limited and locally earthed systems, provided that any possible resulting current does not flow directly through any dangerous spaces.

(3) Insulation monitoring systems provided the circulation current does not exceed 30 mA under any circumstances.

Current-carrying parts with potential to earth are to be protected against accidental contact.

Where the hull return system is used, all final subcircuits (i.e., all circuits fitted after the last protective device) are to consist of two insulated wires, the hull return being achieved by connecting to the hull one of the bus bars of the distribution board from which they originate. The earth wires are to be in accessible locations to permit their ready examination and to enable their disconnection for testing of insulation.

(iv) Earthed distribution systems

System earthing is to be effected by means independent of any earthing arrangements of the non-current-carrying parts. Means of disconnection is to be provided in the neutral earthing connection of each generator so that the generator may be disconnected for maintenance. In distribution systems with neutral earthed or for generators intended to be run with neutrals interconnected, the machines are to be designed to avoid circulating currents exceeding the prescribed value. Transformer neutral is not to be earthed unless all corresponding generator neutrals are disconnected from the system (e.g. during shore supply).

(b) Insulation monitoring system

When a distribution system, whether primary or secondary, for power, heating or lighting, with no connection to earth is used, a device capable of continuously monitoring the insulation level to earth and of giving an audible or visual indication of abnormally low insulation values is to be provided.

(c) Unbalance of load

(i) Unbalance of loads between an outer conductor and the middle wire at the switchboards, section boards and distribution boards is not to exceed 15% of the full load current as far as possible.

(ii) Unbalance of loads on each phase at the switchboards, section boards and distribution boards is not to exceed 15% of the full load current as far as possible.

(d) Diversity factor

(i) Circuits supplying two or more final-subcircuits are to be rated in accordance with the total connected load subject, where justifiable, to the application of a diversity factor. Where spare ways are provided on a section or distribution board, an allowance for future increase of load is to be added to the total connected load before application of any diversity factor.

(ii) The diversity factor specified in (i) above may be applied to the calculation of the cross sectional area of conductors and ratings of switchgears (including circuit breakers and switches) and fuses.

(e) Feeder circuits

(i) Electric motors for essential services requiring dual arrangement are to be supplied by individual circuits without the use of common feeders, protective devices and control gears.

(ii) Auxiliaries, cargo gear motors and ventilating fans in the machinery space are to be independently supplied from switchboards or distribution boards.

(iii) Ventilating fans for the cargo hold and those for the accommodation spaces are not to be supplied from the common feeder circuits.

(iv) Lighting circuits and motor circuits are to be arranged to be supplied independently from the switchboards.

(v) A final sub-circuit of rating exceeding 15 A is not to supply more than one appliance.

(f) Motor circuits

A separate final sub-circuit is to be provided for every motor for essential service and for every motor of rating at 1 kW or more.

(g) Lighting circuits

(i) Lighting circuits are to be supplied by final sub-circuits separate from those for heating and power except cabin fans and electrical appliances for domestic use.

(ii) For a lighting circuit suppplied by a final sub-circuit of rating 15 A or less , the connected load is not to exceed the lesser of the rated current carrying capacity of the conductor or 80% of the overload protective device rating or setting.

(iii) In a final sub-circuit for panel lighting and electric signs, where lampholders are closely grouped, the maximum operating current in the sub-circuit should not exceed 10 A.

(iv) In spaces such as compartments where the main engine or boilers are provided, large machinery rooms, large galleys, corridors, stairways leading to boat-decks and public spaces, lighting is to be supplied from at least two circuits and to be so arranged that failure of any one circuit will not leave these spaces in darkness. One of the circuits may be emergency lighting circuit.

(v) Emergency lighting circuits are to be in accordance with the requirements in 4.11 of this Part.

(vi) Lighting for enclosed hazardous spaces is to be supplied from at least two final sub-circuits to permit light from one circuit to be retained while maintenance is carried out on the other.

(h) Circuits for internal communication systems and navigational aids

(i) Essential internal communication and signal systems and navigational aids are to have completely self-sustaining independent circuits for ensuring the perfect maintenance of their functions as far as possible.

(ii) Cables for communication systems are to be so arranged that no induced interference would be caused.

(iii) No switch is to be provided for feeder circuits of general alarm devices, except for operating switch. Where circuit breaker is used, suitable means are to be taken to prevent the breaker from being kept "off" position.

(i) Circuits for radio installation

Feeder circuits for radio installation are to be arranged in accordance with the requirements of relevant international and national regulations.

(j) Circuits for electric heating and cooking equipment

(i) Each item of electric heating and cooking equipment is to be connected to a separate final sub-circuit except that up to 10 small electric heaters of aggregate current rating not exceeding 15 A may be connected to single final sub-circuit.

(ii) Electric heating and cooking equipment are to be controlled by the multi-pole linked switches mounted in the vicinity of the equipment. However, small electric heaters connected to the final sub-circuit of rating not exceeding 15 A may be controlled by a single-pole switch.

(k) Circuits for shore connection

(i) Where arrangements are made for the supply of electricity from a source on shore, a connection box is to be installed in a suitable position. In case where shore connection cables can be drawn into a switchboard easily and put into service safely, the connection box may be omitted, provided that the protective devices and checking devices stipulated in (ii) are equipped on the switchboard.

(ii) The connection box is to contain terminals to facilitate a satisfactory connection and a circuit-breaker or an isolating switch with fuses. Means are to be provided for checking the phase sequence (for three-phase alternating current) or the polarity (for direct current).

(iii) In case where power is supplied from the three-wire neutral earthed system, an earth terminal is to be provided for connecting the hull to an appropriate earth in addition to those specified in (ii) above.

(iv) At the connection box a notice is to be provided giving information on the system of supply and nominal voltage (and frequency if A.C.) of system and the procedure for carrying out the connection.

(v) The cables between the connection box and the switchboard are to be permanently fixed and a pilot lamp for source and a switch or a circuit-breaker are to be provided on the switchboard.

(*l*) Disconnecting switch of circuits

(i) Power circuits and lighting circuits terminating in the cargo holds or coal bunkers are to be provided with the multipole linked switches situated outside these spaces. Provision is to be made for the complete isolation of these circuits and locking in the "off" position of the switches or switch boxes.

(ii) Feeder circuits for the electrical equipment installed in dangerous spaces are to be provided with multi-pole linked isolation switches in a safe space. In addition, the isolation switches are to be clearly labelled to identify the electrical equipment to be connected with.

(m) Remote stopping of ventilating fans and pumps

(i) Power ventilation of accommodation spaces, service spaces, cargo spaces, control stations and machinery spaces is to be capable of being stopped from an easily accessible position outside the space being served. This position is not be readily cut off in the event of a fire in the spaces served. The means provided for stopping the power ventilation of the machinery spaces is to be entirely separated from the means provided for stopping ventilation of other spaces.

(ii) The motors for the fuel oil burning pumps, fuel oil transfer pumps, fuel valve cooling oil pumps, thermal oil circulating pumps, lubricating oil service pumps, or other similar pumps, fuel oil purifiers, cargo oil pumps and forced and induced draught fans are to be capable of being stopped from an easily accessible position outside the space being served. This position is not to be readily cut off in the event of a fire in the space served.

(n) Fire detection and extinguishing systems

(i) Where an electrically driven fire pump is supplied from the emergency generator the supply to such pump is not to pass through the main machinery spaces. The cables are to be of a fire resistant type where they pass through high fire risk areas.

(ii) Electrical equipment used in operating fire detecting equipment is to be served by two exclusive circuits, reserved solely for this purpose, one fed from the main power source and one from an emergency power source. Such feeders are to be connected to an automatic change-over switch situated near to the fire detection panel.

4.2.2 System Design – Protection

(a) General

Installations are to be protected against accidental overcurrents including short-circuit. The protective devices are to provide complete and coordinated protection to ensure:

(i) Continuity of service under fault conditions through discriminative action of the protective devices to maintain supply to healthy circuits.

(ii) Elimination of the fault to reduce damage to the system and hazard of fire.

(b) Protection against overload

(i) Circuit-breakers and automatic switches provided for overload protection are to have tripping characteristics appropriate to the system. Fuses above 320 A are not to be used for overload protection, but may be used for short-circuit protection.

(ii) The rating or appropriate setting of the overload protection device for each circuit is to be permanently indicated at the location of the protection device.

(iii) The overload relays of circuit-breakers for generators and the setting of preferential trip relays are to be adjustable or, if of the non-adjustable type, are to be readily replaceable by others of different values.

(c) Protection against short-circuit

(i) Protection against short-circuit currents is to be provided by circuit-breakers or fuses.

(ii) The breaking capacity of every protective device is to be not less than the maximum value of the short-circuit current which can flow at the point of installation at the instant of contact separation.

(iii) The making capacity of every circuit-breaker or switch intended to be capable of being closed, if necessary, on short-circuit, is to be not less than the maximum value of the short-circuit current at the point of installation. On alternating current this maximum value corresponds to the peak value allowing for maximum asymmetry.

(iv) Every protective device or contactor not intended for short-circuit interruption is to be adequate for the maximum short-circuit current which can occur at the point of installation having regard to the time required for the short-circuit to be removed.

(v) The use of a circuit-breaker of breaking capacity less than the prospective short-circuit current at the point of installation is permitted, provided that it is preceded on the generator side by fuses, or by a circuit-breaker having at least the necessary breaking capacity. The generator breakers are not to be used for this purpose.

(vi) Circuit-breakers with fuses connected to the load side may be used where operation of the circuit-breaker and fuses is coordinated.

(vii) The characteristics of the arrangement is to be such that:

(1) When the short-circuit current is broken, the circuit-breaker on the load side is not be damaged and is to be capable of further service.

(2) When the circuit-breaker is closed on the short circuit current, the remainder of the installation is not to be damaged. However, it is admissible that the circuit-breaker on the load side may require servicing after the fault has been cleared.

(viii) In the absence of precise data, the following short circuit currents at the machine terminals are to be assumed:

(1) Direct current systems
Ten times full load current for generators that may be connected simultaneously.
Six times full load current for motors simultaneously in service.

(2) Alternating current systems
Ten times full load current for generators that may be connected simultaneously.
Three times full load current for motors simultaneously in service.
The value derived from the above is an approximation to the r.m.s. symmetrical fault current; the peak asymmetrical fault current may be estimated to be 2.5 times this figure (corresponding to a fault power factor of approximately 0.1).

(d) Protection of circuits

(i) Each pole and phase of all insulated circuits except neutral and equalizer circuits are to be provided with short-circuit protection.

(ii) All circuits liable to be overloaded are to be provided with overload protection as indicated below:

(1) Two-wire D.C. or single-phase A.C. system – at least one line or phase.

(2) Three-wire D.C. system – both outer lines.

(3) Three-phase, three-wire system – each phase.

(4) Three-phase, four-wire system – each phase.

(iii) Fuse, non-linked switch or non-linked circuit-breaker is not to be inserted in an earthed conductor and a neutral line.

(e) Protection of generators

(i) Generators are to be protected against short- circuit and overcurrent by a multi-pole circuit-breaker arranged to open simultaneously all insulated poles, or in the case of generators less than 25KW not arranged to run in parallel, may be protected by a multipole-linked switch with fuse or a circuit-breaker in each insulated pole. The overload protection is to be suitable to the thermal capacity of generators.The long-time over-current protection is not to exceed 15% above either the full-load rating of continuous rated machines or the overload rating of special-rated machines. Where generators are operated in parallel and essential machinery is electrically driven, arrangements are to be made to disconnect automatically the excess non-essential load when the generators are overloaded. If required, this preference tripping may be carried out in one or more stages. See 4.11.2.(b) of this Part.

(ii) Protection for Alternating Current (AC) Generators

(1) Short-time Delay Trip
Short-time delay trips are to be provided with circuit breakers for AC generators. The current setting of the short time delay trip is to be less than the steady state shortcircuit current of the generator.

(2) Parallel Operation
Where AC generators are arranged for parallel operation with other AC generators, the following protective devices are to be provided.

a) Instantaneous Trip

Instantaneous trips are to be installed and set in excess of the maximum short-circuit contribution of the individual generator where three or more generators are arranged for parallel operation. Alternative suitable protection, such as generator differential protection, which will trip the generator circuit breaker in the event of a fault in the generator or in the supply cable between the generator and its circuit breaker, would also be acceptable.

b) Reverse Power Protection .

Time-delayed reverse active power protection or other devices which provide adequate protection is to be provided. The setting of protective devices is to be in the range of 2% to 6% of the rated power for turbines and in the range of 8% to 15% of the rated power for diesel engines. A setting of less than 8% of the rated power of diesel engines may be allowed with a suitable time delay recommended by the diesel engine manufacturer. A fall of 50% in the applied voltage is not to render the reverse power protection inoperative, although it may alter the setting to open the breaker within the above range.

c) Undervoltage Protection.

Means are to be provided to prevent the generator circuit breaker from closing if the generator is not generating and to open the same when the generator voltage collapses.

In the case of an undervoltage release provided for this purpose, the operation is to be instantaneous when preventing closure of the breaker, but is to be delayed for discrimination purposes when tripping a breaker.

(iii) Protection for Direct Current (DC) Generators

(1) Instantaneous Trip
DC generator circuit breakers are to be provided with an instantaneous trip set below the generator maximum short-circuit current and are to coordinate with the trip settings of feeder circuit breakers supplied by the generator.

(2) Parallel operation

a) Reverse current protection

DC generators arranged for parallel operation with other DC generators or with an accumulator battery are to be provided with instantaneous or short-time delayed reverse current protection. The setting of the protection devices is to be within the power range specified by 4.2.2(e)(ii)(2)a). When an equalizer connection is provided, the reverse current

device is to be connected on the pole opposite to the equalizer connection where the series compound winding for the generator is connected. Reverse current protection is to be adequate to deal effectively with reverse current conditions emanating from the distribution system (e.g., electric driven cargo winches).

b) Generator Ammeter Shunts.

Generator ammeter shunts are to be so located that the ammeters indicate total generator current.

c) Undervoltage Protection.

Requirements for AC generator in 4.2.2(e)(ii)(2)c)are also applicable to DC generator.

(f) Protection of feeder circuits

(i) All feeder circuits are to be protected in accordance with the current carrying capacities. Feeder and branch circuits for lighting, heating or craft's service power are to have each ungrounded conductor protected by circuit breaker or fuses of suitable interrupting capacity.

(ii) Supply circuits to section boards, distribution boards, grouped starters and the similar are to be protected against overload and short-circuit by multi-pole circuit-breakers or fuses. In case where the fuses are used, the switches which are capable of breaking and making safely a load current equal to 150% of their rated current at the rated voltage are to be provided at the power source side of the fuses.

(iii) Each insulated pole of the final sub-circuits is to be protected against short-circuit or overload by a circuit breaker or fuse. For the protection of supply circuits of the steering gears, the requirements in 4.2.3 of this Part are to apply.

(iv) Circuits which supply motors fitted with overload protection may be provided with short-circuit protection only.

(v) Where fuses are used to protect polyphase A.C. motor circuits, consideration is to be given to protection against single phasing.

(vi) Where condensers for phase advance are used, over-voltage protective devices are to be installed as required.

(g) Protection of Electric Motors

(i) Motors of rating exceeding 0.5 kW and all motors for essential services, except the motors for steering gears, are to be protected individually against overload. The overload protection of motors for the steering gears is to comply with the requirements in 4.2.3(b) of this Part.

(ii) The protective device is to have a delay characteristics to enable the motor to start.

(iii) For motors for intermittent services, the current setting and the delay are to be chosen in relation to the load factor of the motor.

(iv) Over current trips of circuit breakers or fuses are to have a rating not greater than the allowable carrying capacity of the conductors protected except that for motor branch circuits the ratings may be increased.

(v) The maximum setting of the circuit breaker trip element for motor branch circuit is to be the standard value equal to or, if not in exact agreement, next above the value stated below in percent motor full load current.

D.C. motor	150%
A.C. motor:	
Full voltage, reactor or resister starting	250%
Autotransformer starting	200%
Wound rotor	150%

(vi) Undervoltage Protection and Undervoltage Release

Undervoltage protection is to be provided for motors having power rating exceeding 0.5 kW to prevent undesired restarting upon restoration of the normal voltage, after a stoppage due to a low voltage condition or voltage failure condition.

Undervoltage release is to be provided for the following motors unless the automatic restart upon restoration of the normal voltage will cause hazardous conditions:

(1) Primary essential services (See 1.3.2 of Part IV of the Rules for Steel Ships).

(2) Only those secondary essential services necessary for safety (See 1.3.3 of Part IV of the Rules for Steel Ships), such as:

a) Fire pumps and other fire extinguishing medium pumps.

b) Ventilating fans for engine and boiler rooms where they may prevent the normal operation of the propulsion machinery.

Undervoltage protection is to be provided for ventilation fans for engine and boiler room, which are supplied by an emergency source of power for the purpose of removing smoke from the space after a fire has been extinguished.

Special attention is to be paid to the starting currents due to a group of motors with undervoltage release controllers being restarted automatically upon restoration of the normal voltage. Means such as sequential starting is to be provided to limit excessive starting current, where necessary.

(h) Protection of power and lighting transformers

The primary circuits of power and lighting transformers are to be protected against short-circuit and overcurrent by multi-pole circuit-breakers or fuses.

When transformers are arranged to operate in parallel, a means of isolation is to be provided on the secondary circuits.

(i) Protection of lighting

Lighting circuits are to be protected against short-circuit and overload.

(j) Protections of meters, pilot lamps and control circuits

(i) Protection is to be provided for voltmeters, voltage coils of measuring instruments, earth indicating devices and pilot lamps together with their connecting leads by means of fuses fitted to each insulating pole.

(ii) A pilot lamp installed as an integral part of another item of equipment need not be individually protected, provided that any damage of pilot lamp circuit does not cause failures on the supply to essential equipment.

(iii) Insulated wires for control and instrument circuits directly led from busbars and generator mains are to be protected by fuses at the nearest location to the connecting points. Insulated wires between the fuses and the connecting points are not to be bunched together with the wires for other circuits.

(iv) Fuses in circuits such as those of automatic voltage regulators where loss of voltage might have serious consequences may be omitted. If omitted, proper means are to be provided to prevent risk of fire in the unprotected part of the installation.

(k) Protection of batteries

Accumulator batteries other than engine starting batteries are to be protected against overload and short-circuit with devices placed as near as practicable to the batteries. Emergency batteries supplying essential services may have short-circuit protection only.

4.2.3 Electric Power and Control Circuits for Steering Gear

(a) Short circuit protection, an overload alarm and, in the case of polyphase circuits, an alarm to indicate single phasing is to be provided for each main and auxiliary motor circuit.

(b) Only short circuit protection is to be provided for the steering circuit on the switchboard or emergency switchboard. The setting values are to be as follows:

(i) For D.C. circuit

(1) On the main switchboard:
300 to 375% of the motor rating .

(2) On the emergency switchboard:
Not less than 200% of the motor rating.

(ii) For A.C. circuit breaker on all switchboard

200% of the steady state locked rotor current of one steering gear motor plus all other loads that may be on this feeder.

(c) Indicators for running indication of each main and auxiliary motor are to be installed on the navigating bridge and at a suitable main machinery control position.

(d) Two exclusive circuits are to be provided for each electric or electrohydraulic steering gear arrangement consisting of one or more electric motors.

(e) Each of these circuits is to be fed from the main switchboard. One 1 of these circuits may pass through the emergency switchboard.

(f) One of these circuits may be connected to the motor of an associated auxiliary electric or electro hydraulic power unit.

(g) Each of these circuits is to have adequate capacity to supply all the motors which can be connected to it and which can operate simultaneously.

(h) These circuits are to be separated throughout their length as widely as is practicable.

(i) In craft of less than 1,600 gross tonnage, if an auxiliary steering gear is not electrically powered or is powered by an electric motor primarily intended for other services, the main steering gear may be fed by one circuit from the main switchboard. Consideration will be given to other protective arrangements than described in 4.2.3(a) above for such a motor primarily intended for other services.

(j) Power from either the emergency source of power or from a source of power located within the steering gear compartment is to be provided automatically within 45 seconds for all craft having a required rudder stock of over 230 mm diameter in way of the tiller. This source of power is to be capable of moving the rudder from 15° on one side to 15° on the other side in not more than 60 seconds with the craft at its deepest seagoing draught while running ahead at $\frac{1}{2}$ of the maximum ahead service speed or 7 knots, whichever is the greater. In every craft of 10,000 gross tonnage and upward, the capacity is to be sufficient for at least 30 minutes of continuous operation and in any other craft for at least 10 minutes of continuous operation.

(k) Electric control systems are to be independent and separated as far as is practicable throughout their length.

(l) Each main and auxiliary electric control system which is to be operated from the navigating bridge is to comply with the following:

(i) It is to be served with electric power by a separate circuit supplied from the associated steering gear power circuit, from a point within the steering gear compartment, or directly from the same section of switchboard busbars, main or emergency, to which the associated steering gear power circuit is connected.

(ii) Each separate circuit is to be provided with short circuit protection only.

(m) Monitoring and alarms

Alarms and monitoring requirements are indicated in Table IV 4-3.

Table IV 4-3
Monitoring and Alarms for Steering Gear

Item	Alarm	Note
Rudder position	–	Indication
Steering gear power units, power	Failure	–
Steering gear motors	Overload, single phase	Also running indication on bridge and machinery control station, see 2.3.3 of this Part
Control system Power	Failure	–
Steering gear hydraulic oil tank level	Low	Each tank to be monitored
Auto pilot	Failure	Running indication

4.2.4 Navigation Lights

(a) Navigation Light means the following lights:

(i) masthead light, sidelights, sternlight, towing light, all-round light, flashing light as defined in Rule 21 of Convention on the International Regulations for Preventing Collisions at Sea 1972 as amended;

(ii) all-round flashing yellow light required for air-cushion vessels by Rule 23 of Convention on the International Regulations for Preventing Collisions at Sea 1972 as amended; and

(iii) maneuvering light required by Rule 34(b) of Convention on the International Regulations for Preventing Collisions at Sea 1972 as amended.

(b) Navigation lights are to be connected separately to a special distribution board which is not to supply any other group. This distribution board is to be placed in an accessible position to the officers of the watch.

(c) The navigation distribution board is to be provided with a change over switch making it possible to obtain supply for this board from the ship's main and emergency sources of electrical power, and each navigation light is to be protected by a fuse switch on each insulated pole fitted on the distribution board.

(d) Each navigation light is to be provided with an automatic indicator giving audible and visible warning in the event of extinction of the light. This requirement may be modified for tugs, trawlers of fishing and small ships.

4.2.5 Internal Communication

(a) Internal communication circuits such as the engine room telegraph, revolution counter, rudder angle indicator, alarm system (automatic or manual), siren, bell, telephone and loud speaker installation, signal lighting system, electric log, remote temperature control, indication system, etc. are to comply with the following requirements.

(b) The supply source of the internal communication system may be derived from the general lighting and power sources or from the motor-generator, transformer, storage battery and dry cell for the low voltage system.

(c) Electric interior communication and signal systems forming part of the essential operating systems of the craft are to be as independent and self-sustaining as possible.

(d) The voltage of supply for internal communication circuits is to be between 20V and 120V of D.C. or A.C. For simple circuits, voltages of not less than 6V may be used.

(e) Communication circuits other than those supplied from the primary battery are to be protected on such insulated pole by the fuse of a current rating of the cables to be protected.

(f) Cables used for the internal communication are to be suitable for the rated voltage and the current of the connected load. The voltage drop is to be so limited that the normal operation of the connected equipment is ensured. Cables are to be kept separate from the power and lighting unless they are of similar type.

(g) A general emergency alarm system complying with the requirement of following is to be provided to summon passenger and crew to muster stations and initiate the actions included in the muster list. The system is to be supplemented by either a public address system in accordance with 4.2.5 (k) or other suitable means of communication. Any entertainment sound system is to be automatically turned off when the general emergency alarm is activated.

(i) The general emergency alarm system is to be capable of sounding the general emergency alarm signal consisting of seven or more short blasts followed by one long blast on the craft's whistle or siren and additionally on an electrically operated bell or klaxon or other equivalent warning system, which is to be powered from the craft's main supply and the emergency source of electrical power required by 4.11.3 or 4.11.4. The supply is to be provided by separate feeders reserved soley for that purpose. The system is to be capable of operation from the navigation bridge and, except for the craft's whistle, also from other strategic points. The system is to be audible throughout all the accommodation and normal crew working spaces. The alarm is to continue to function after it has been triggered until it is manually turned off or is temporarily interrupted by a message on the public address system.

(ii) The minimum sound pressure levels for the emergency alarm tone in interior spaces are to be 80 dB(A) and at least 10 dB(A) above ambient noise levels existing during normal equipment operation with the craft underway in moderate weather. In cabins without a loud speaker installation, an electronic alarm transducer is to be installed, eg. a buzzer or similar.

(iii) The sound pressure levels at the sleeping position in cabins and in cabin bathrooms are to be at least 75dB(A) and at least 10 dB(A) above ambient noise levels.

(h) An engine order telegraph system is to be provided for communicating orders from the navigating bridge to the main propulsion control station in the engine room, and for transmitting acknowledgement of orders from the main propulsion control station to the navigating bridge.

(i) A common talking means of voice communication and calling is to be provided between the navigating bridge, main propulsion control station, and the steering gear compartment so that the simultaneous talking among these spaces is possible at all times and the calling to these spaces is always possible even if the line is busy. Where an elevator is installed, a telephone is to be permanently installed in all cars and connected to a continuously manned area. These systems are to be independent of the craft's service electrical system.

(j) A common talking means of voice communication and calling or engine order telegraph repeater is to be provided between the main propulsion control station and local control positions for main propulsion engines and controllable pitch propellers. Voice communication systems are to provide the capability of carrying on a conversation while the craft is being navigated. These systems are to be independent of the craft's service electrical system and the control monitoring, and alarm circuits but may be combined with the system required in 4.2.5 (i) above.

(k) A public address system is to be provided to supplement the general emergency alarm required by 4.2.5 (g), unless other suitable means of communication is provided. The public address system is to comply with the following:

(i) The system is to be a loud speaker installation enabling the broadcast of messages to all spaces where crew members or passengers, or both, are normally present and to muster stations. The system is to provide for the broadcast of messages from the navigation bridge and other places on board as may be required by the Society, with an override function so that all emergency messages may be broadcast if any loudspeaker in the spaces concerned has been turned off, its volume has been turned down or the public address system is in used for other purpose. The system is to be installed with regard to acoustically marginal conditions and is not to require any action from the addressee. The system is to be protected against unauthorized use.

(ii) With the craft underway in normal conditions, the minimum sound pressure levels for broadcasting emergency announcements in interior spaces are to be 75 dB(A) and at least 20 dB(A) above the corresponding speech interference level; and in exterior spaces are to be 80 dB(A) and at least 15 dB(A) above the corresponding speech interference level.

(iii) The system is to be connected to the emergency source of power.

(iv) Where a single system for both public address and general emergency alarm functions , the system is to be arranged so that single failure is not to cause the loss of both systems and is to minimize the effect of a single failure. The major system components, such as power supply unit, amplifier, alarm tone generator,etc.,are to be duplicated. Power supply is to comply with 4.2.5 (g)(i).
For cargo craft, the coverage provided by the arrangement of the system loops and speakers is to be such that after a single failure, the announcements and alarms are still audible in all spaces. Duplication of system loops and speakers in each room or space is not required provided the announcements and alarms are still audible in all spaces.
For passenger craft, a single system serving for both public address and general emergency alarm functions would still be required to have at least two loops sufficiently separated throughout their length with two separate and independent amplifiers.

(l) Enginners' alarm

On craft of 500 gross tons and over, an engineers' alarm operable from the centralized propulsion machinery control station in the engine room or at the propulsion machinery local control position, as appropriate, is to be provided.

(m) Refrigerated Space Alarm

Fan and diffuser rooms serving subfreezing compartments are to be provided with a device capable of activating an audible and visual alarm in a manned control center and operable from within the latter space for the protection of personnel.

(n) Elevator

A device which will activate an audible and visual alarm in a manned control center is to be provided in all cars. Such alarm system is to be independent of power and control systems of the elevator.

4.2.6 Speical requirement for non-metallic craft

The following is applicable to non-metallic craft:

(a) Bonding of Metal Parts

In order to minimize the risk of fire, structural damage, electrical shock and radio interference due to lightning strike or electrostatic discharge, all metal parts of the craft should be bonded together, in so far as possible in consideration of galvanic corrosion between dissimilar metals, to form a continuous electrical system, suitable for the earth return of electrical equipment and to connect the craft to the water when waterborne. The bonding of isolated components inside the structure is not generally necessary, except in fuel tanks.

(b) Pressure Refueling Points

Each pressure refueling point should be provided with a means of bonding the fueling equipment to the craft.

(c) Metallic Pipes

Metallic pipes capable of generating electrostatic discharges, due to the flow of liquids and gases should be bonded so as to be electrically continuous throughout their length and should be adequately earthed.

(d) Primary Conductors for Lightning Discharge

Primary conductors provided for lightning discharge currents should have a minimum cross-section of 50 mm^2 in copper or equivalent surge-carrying capacity in aluminum.

(e) Secondary Conductors

Secondary conductors provided for the equalization of static discharges, bonding of equipment, etc., but not for carrying lightning discharges should have a minimum cross section of 6.5 mm^2 copper or equivalent surge current carrying capacity in aluminum.

(f) Electrical Resistance and Cross Section of Bonding Path

The electrical resistance between bonded objects and the basic structure should not exceed 0.05 Ohms except where it can be demonstrated that a higher resistance will not cause a hazard. The bonding path should have sufficient cross-sectional area to carry the maximum current likely to be imposed on it without excessive voltage drop.

(g) Lightning Protection System

A lightning protection system consisting of a copper spike, a conductor of a minimum cross-section per 4.2.6(d) above and a grounding plate of not less than 450 cm^2 is to be installed. The spike is to project at least 150 mm above the uppermost part of the craft, the conductor is to run clear of metal objects and as straight as practicable, and the grounding plate is to be located so that it is immersed under all conditions of heel.

4.3 Generators

4.3.1 Generators are to be in accordnace with the requirements of Chapter 3 of Part VII of the Rules for Steel Ships.

4.4 Motors

4.4.1 Motors are to be in accordnace with the requirements of Chapter 4 of Part VII of the Rules for Steel Ships.

4.5 Switchboards and Mounted Equipment

4.5.1 Switchboards and Mounted Equipment are to be in accordnace with the requirements of Chapter 5 of Part VII of the Rules for Steel Ships.

4.6 Batteries

4.6.1 Batteries are to be in accordnace with the requirements of Chapter 6 of Part VII of the Rules for Steel Ships.

4.7 Transformers

4.7.1 Transformers are to be in accordnace with the requirements of Chapter 7 of Part VII of the Rules Steel Ships.

4.8 Cables

4.8.1 Cables are to be in accordnace with the requirements of Chapter 8 of Part VII of the Rules for Steel Ships.

4.9 Motor Controllers

4.9.1 Motor Controllers are to be in accordnace with the requirements of Chapter 9 of Part VII of the Rules for Steel Ships.

4.10 Accessories and Lighting Equipment

4.10.1 Accessories and Lighting Equipment are to be in accordnace with the requirements of Chapter 10 of Part VII of the Rules for Steel Ships.

4.11 Main Source and Emergency Source of Electrical Power

4.11.1 General

(a) This chapter specifies the requirements for the design of installations of main source of electrical power and emergency source of electrical power.

(b) Electrical installations are to comply with the following:

(i) All electrical auxiliary services necessary for maintaining the craft in normal operational and habitable conditions and other electrical services as deemed necessary by the Society will be ensured without recourse to the emergency source of electrical power;

(ii) Electrical services essential for safety will be ensured under various emergency conditions; and

(iii) The safety of passengers, crew and craft from electrical hazards will be ensured.

4.11.2 Main Source of Electrical Power and Lighting Systems

(a) Main source of electrical power

(i) A main source of electrical power of sufficient capacity to supply all those services specified in 4.11.1 (b) (i) is to be provided. This main source of electrical power is to consist of at least two generating sets.

(ii) The capacity of these generating sets is to be such that in the event of any one generating set being stopped it will still be possible to supply those services necessary to provide normal operational conditions of propulsion and safety and other electrical services as deemed necessary by the Society. Minimum comfortable conditions of habitability is also to be ensured which include at least adequate services for cooking, heating, domestic refrigeration, mechanical ventilation, sanitary and fresh water.

(iii) The arrangements of the craft's main source of electrical power are to be such that the services referred to the requirement in 4.11.1(b)(i) can be maintained regardless of the speed and direction of the propulsion machinery or shafting.

(iv) The generating sets are to be such as to ensure that with any one generator or its primary source of power out of operation, the remaining generating sets are to be capable of providing the electrical

services necessary to start the main propulsion plant from a dead 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 that of any other source of electrical power is sufficient to provide at the same time those services required to be supplied by the requirements in 4.11.3(f)(i)(1) to (3), 4.11.3(f)(ii)(1) to (4) or 4.11.4(f)(i) to (iv).

(v) Where the main source of electrical power is necessary for propulsion and steering of the craft, the system is to be so arranged that the electrical supply to equipment necessary for propulsion and steering and to ensure safety of the craft will be maintained or immediately restored in the case of loss of any one of the generators in service.

(b) Power management

(i) Arrangements are to be made to disconnect automatically, after an appropriate time delay, circuits of the categories noted in (ii), when the generator(s) is/are over loaded, are sufficient to ensure the connected generating set(s) not be overloaded;

(ii) The circuits that may be disconnected by the load shedding system are:

(1) Non-essential circuits.

(2) Circuits feeding services for habitability, such as cooking, heating, domestic refrigeration, mechanical ventilation, sanitary and fresh water.

(iii) If required this load shedding may be carried out in one or more stages in which case the non-essential circuits are to be included in the first group to be disconnected.

(iv) Consideration is to be given to provide means to inhibit automatically the starting of large motors, or the connection of other large loads, until sufficient generating capacity is available to supply them.

(c) Number and ratings of transformers

Where transformers constitute an essential part of the electrical supply system required by 4.11.2(a), the system is to be so arranged as to ensure the same continuity of the supply as is stated in 4.11.2(a).

(d) Lighting systems

(i) A main electric lighting system supplied from the main source of electrical power is to be provided in spaces or compartments where crew and personnel use and normally work on duty.

(ii) The main electric lighting system is to be so arranged as not to be impaired in the event of a fire or other casualty in spaces containing the emergency source of electrical power, associated transforming equipment, the emergency switchboard and the emergency lighting switchboard.

(iii) Emergency lighting is to provide sufficient illumination necessary for the safety as the requirements in 4.11.3(f)(i)(1), 4.11.3(f)(ii)(1), or 4.11.4(f)(i).

(iv) The emergency electric lighting system is to be so arranged as not to be impaired in the event of a fire or other casualty in spaces containing the main source of electrical power, associated transforming equipment, the main switchboard and the main lighting switchboard.

(e) Location of main switchboard.

The main switchboard and one main generating station are to be located in a same space. However, the main switchboard may be separated from the generators by an environmental enclosure, such as may be provided by a machinery control room situated within the main boundaries of the space.

4.11.3 Emergency Source of Electrical Power in Passenger Craft

(a) A self-contained emergency source of electrical power is to be provided.

(b) The emergency sources of electrical power, associated transforming equipment, if any, transitional source of emergency power, emergency switchboard and emergency lighting switchboard are to be located above the uppermost continuous deck and are to be readily accessible from the open deck. They are not to be located forward of the collision bulkhead.

(c) The location of the emergency source of electrical power and associated transforming equipment, if any, the transitional source of emergency power, the emergency switchboard and the emergency electric lighting switchboards in relation to the main source of electrical power, associated transforming equipment, if any, and the main switchboard are to be such as to ensure to the satisfaction of the Society that a fire or other casualty in spaces containing the main source of electrical power, associated transforming equipment, if any, and the main switchboard or in any machinery space of category A is not to interfere with the supply, control and distribution of emergency electrical power. As far as practicable, the spaces containing the emergency source of electrical power, associated transforming equipment, if any, the transitional source of emergency electrical power and the emergency switchboard are not to be contiguous to the boundaries of machinery spaces of category A or those spaces containing the main source of electrical power, associated transforming equipment, if any, or the main switchboard. Where this is not practicable, the contiguous boundaries are to be Class A60.

(d) 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.

(e) Alternative to Emergency Source of Power

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 systems, 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 4.11.3(f)(i) or 4.11.3(f)(ii), the requirements of 4.11.3(a), 4.11.3(b) and 4.11.3(d) may be considered satisfied without an additional emergency source of electrical power, provided that:

(i) There is at least one generating set, meeting the requirements of 4.11.3(n) and of sufficient capacity to meet the requirements of 4.11.3(f)(i) or 4.11.3(f)(ii) in each of at least two noncontiguous spaces;

(ii) The arrangements required by 4.11.3(e) in each such space are equivalent to those required by 4.11.3(g)(i), 4.11.3(i), (j), (k), (l), (m), and 4.11.5 so that a source of electrical power is available at all times to the services required by 4.11.3(f)(i) or 4.11.3(f)(ii); and

(iii) The generator sets referred to in 4.11.3(e)(i) and their self-contained systems are installed such that one of them remains operable after damage or flooding in any one compartment

(f) The electrical power available is to be sufficient to supply all those services that are essential for safety in an emergency, due regard being paid to such services as may have to be operated simultaneously. The emergency source of electrical power is to be capable, having regard to starting currents and the transitory nature of certain loads, of supplying simultaneously at least the following services for the periods specified hereinafter, if they depend upon an electrical source for their operation:

(i) Category A Craft

(1) For a period of 5 hours, emergency lighting:

a) At the stowage positions of life-saving appliances;

b) At all escape routes such as alleyways, stairways, exits from accommodation and service spaces, embarkation points, etc;

c) In the public spaces;

d) In the machinery spaces and main emergency generating spaces, including their control positions;

e) In control stations;

f) At the stowage positions for fireman's outfits; and

g) At the steering gear.

(2) For a period of 5 hours

a) Main navigation lights, except for ”not under command” lights;

b) Electrical internal communication equipment for announcements for passengers and crew required during evacuation;

c) Fire-detection and general alarm system and manual fire alarms; and

d) Remote control devices of fire-extinguishing systems, if electrical.

(3) For a period of 4 hours of intermittent operation:

a) The daylight signaling lamps, if they have no independent supply from their own accumulator battery; and

b) The craft's whistle, if electrically driven; spaces, embarkation points, etc.

(4) For a period of 5 hours:

a) Craft radio facilities and other loads as set out in 14.13.2 of the IMO's International Code of Safety for High-speed Craft; and

b) Emergency control monitoring systems

(5) For a period of 10 hours:

a) The “not under command” lights.

(6) For a period of 10 minutes continuous operations:
Steering gear to comply with 4.2.3(j) if powered from the emergency

(ii) Category B Craft

The electrical power available is to be sufficient to supply all those services that are essential for safety in an emergency, due regard being paid to such services as may have to be operated simultaneously. The emergency source of electrical power is to be capable, having regard to starting currents and the transitory nature of certain loads, of supplying simultaneously at least the following services for the periods specified hereinafter, if they depend upon an electrical source for their operation:

(1) For a period of 12 hours, emergency lighting:

a) At the stowage positions of life-saving appliances;

b) At all escape routes such as alleyways, stairways, exits from accommodation and servicespaces, embarkation points, etc;

c) In the passenger compartments;

d) In the machinery spaces and main emergency generating spaces, including their control positions;

e) In control stations;

f) At the stowage positions for fireman's outfits; and

g) At the steering gear.

(2) For a period of 12 hours

a) The navigation lights and other lights required by the International Regulations for Preventing Collisions at Sea in force;

b) Electrical internal communication equipment for announcements for passengers and crew required during evacuation;

c) Fire-detection and general alarm system and manual fire alarms; and

d) Remote control devices of fire-extinguishing systems, if electrical.

(3) For a period of 4 hours of intermittent operation:

a) The daylight signaling lamps, if they have no independent supply from their own accumulator battery; and

b) The craft's whistle, if electrically driven; spaces, embarkation points, etc.

(4) For a period of 12 hours:

a) The navigational equipment as required by Chapter 13 of the IMO's International Code of Safety for High-speed Craft. Where such provision is unreasonable or impracticable, the Administration may waive this requirement for craft of less than 5,000 GT;

b) Essential electrically powered instruments and controls for propulsion machinery, ifalternate sources of power are not available for such devices;

c) One of the fire pumps required by Governmental Regulations;

d) The sprinkler pump and drencher pump, if fitted;

e) The emergency bilge pump and all the equipment essential for the operation of electrically powered remote controlled bilge valves; and

f) Craft radio facilities and other loads as set out in 14.13.2 of the IMO's International Code of Safety for High-speed Craft.

(5) For a period of 30 minutes:

a) Any watertight doors to be power-operated, together with their indicators and warning signals.

(6) For a period of 10 min continuous operations:

a) Steering gear to comply with 4.2.3(j) if powered from the emergency.

(g) The emergency source of electrical power may be either a generator or an accumulator battery, which is to comply with the following:

(i) Where the emergency source of electrical power is a generator, it is to be:

(1) driven by a suitable prime-mover with an independent supply of fuel having a flashpoint (closed cup test) of not less than 43°C;

(2) started automatically upon failure of the electrical supply from the main source of electrical power and is to be automatically connected to the emergency switchboard; those services referred to 4.11.3(h) of this Part are then to be transferred automatically 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 seconds; and

(3) provided with transitional source of emergency electrical power according to 4.11.3(h) of this Part.

(ii) Where the emergency source of electrical power is an accumulator battery, it is to be cable 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; and

(3) immediately supplying at least those services specified in 4.11.3(h) of this Part.

(iii) Where electrical power is necessary to restore propulsion, the capacity is to be sufficient to restore propulsion to the craft in conjunction with other machinery, as appropriate, from a dead craft condition within 30 minutes after blackout.

(h) The transitional source of emergency electrical power required by 4.11.3(g)(i)(3) above is to consist of an accumulator battery suitable located for use in an emergency which is to operate without recharging while maintaining the voltage of the battery throughout the discharge period within 12% above or below its nominal voltage and be of sufficient capacity and so arranged as to supply automatically in the event of failure of either the main or emergency source of electrical power at least the following services, if they depend upon an electrical source for their operation:

(i) For a period of 30 min, the load specified in 4.11.3(f)(i)(1) through 4.11.3(f)(i)(3) or in 4.11.3(f)(ii)(1) through 4.11.3(f)(ii)(3)

(ii) 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 should have sufficient capacity to operate each door at least three times (i.e., closed – open – closed) against an adverse list of 15°; and

(2) Power to the control, indication and alarm circuits for the watertight doors for half an hour.

The above requirements may be considered satisfied without the installation of a transitional source of emergency electrical power if each of the services required by that paragraph has independent supplies, for the period specified, from accumulator batteries suitably located for use in an emergency. The supply of emergency power to the instruments and controls of the propulsion and direction systems should be uninterruptible.

(i) The emergency switchboard is to be installed as near as is practicable to the emergency source of electrical power.

(j) 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.

(k) No accumulator battery fitted in accordance with this Regulation is to be installed in the same space as the emergency switchboard. An indicator is to be mounted in a suitable place on the main switchboard or in the machinery control room to indicate when the batteries constituting either the emergency source of electrical power or the transitional source of emergency electrical power referred to in 4.11.3(g)(i)(3) or 4.11.3(h) above are being discharged.

(*l*) The emergency switchboard is to be supplied during normal operation from the main switchboard by an interconnector feeder which is to be adequately protected at the main switchboard against overload and short circuit and which is to be disconnected automatically at the emergency switchboard upon failure of the main source of electrical power. Where the system is arranged for feedback operation, the interconnector feeder is also to be protected at the emergency switchboard at least against short circuit.

(m) 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 power is to be available to the emergency circuits.

(n) The emergency generator and its prime-mover and any emergency accumulator battery are to be so designed and arranged as to ensure that they are to function at full rated power when the craft is upright and when inclined at any angle of list up to 22.5° or when inclined up to 10° either in the fore or aft direction, or is in any combination of angles within those limits.

(o) Provision is to be made for the periodic testing of the complete emergency system and is to include the testing of automatic starting arrangements.

(p) In addition to the emergency lighting required by 4.11.3(f)(i)(1) or 4.11.3(f)(ii)(1), on every passenger craft with ro-ro cargo spaces:

(i) All passenger public spaces* and alleyways are to be provided with supplementary electric lighting that can operate for at least three hours when all other sources of electric power have failed and under any condition of heel. The illumination provided is to be such that the approach to the means of escape can be ready seen. The source of power for the supplementary lighting is to be consist of accumulator batteries located within the lighting units that are continuously charged, where practicable, from the emergency switchboard. Alternatively, any other means of lighting which are at least as effective may be accepted by the Society. The supplementary lighting is to be such that any failure of the lamp will be immediately apparent. Any accumulator battery provided is to be replaced at intervals having regard to the specified service life in the ambient conditions that they are subject to in service; and

(ii) 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 4.11.3(f)(i)(1) / 4.11.3(f)(ii)(1), is provided.

* In category A craft having limited public spaces, emergency lighting fittings of the type described in 4.11.3(p)(i) as meeting the requirements of 4.11.3(f)(i)(1) and 4.11.3(h)(i) of this Chapter may be accepted, provided that an adequate standard of safety is attained.

(q) Distribution systems are to be so arranged that fire in any main vertical zone will not interfere with services essential for safety in any other such zone. This requirement will be met if main and emergency feeders passing through any such zone are separated both vertically and horizontally as widely as is practicable.

4.11.4 Emergency Source of Electrical Power in Cargo Craft

(a) For a cargo craft having a gross tonnage 500 and upward for unrestricted ocean service, there is to be a self-contained emergency source of electric power.

(b) The emergency sources of electrical power, associated transforming equipment, if any, transitional source of emergency power, emergency switchboard and emergency lighting switchboard are to be located above the uppermost continuous deck and are to be readily accessible from the open deck. They are not to be located forward of the collision bulkhead, except where permitted by the Society in exceptional circumstances.

(c) The locations of the emergency source of electrical power, associated transforming equipment, if any, the transitional source of emergency power, the emergency switchboard and the emergency lighting switchboard in relation to the main source of electrical power, associated transforming equipment, if any, and the main switchboard are to be such as to ensure to the satisfaction of the Society that a fire or other casualty in the space containing the main source of electrical power, associated transforming equipment, if any, and the main switchboard, or in any machinery space of category A will not interfere with the supply, control and distribution of emergency electrical power. As far as practicable the spaces containing the emergency source of electrical power, associated transforming equipment, if any, the transitional source of emergency electrical power and the emergency switch-board are not to be contiguous to the boundaries of machinery spaces of category A or those spaces containing the main source of electrical power, associated transforming equipment, if any, and the main switchboard. Where this is not practicable, the contiguous boundaries are to be Class A60.

(d) 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.

(e) Alternative to Emergency Source of Power

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 systems, 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 4.11.4(f), the requirements of 4.11.4(a), 4.11.4(b) and 4.11.4(d) may be considered satisfied without an additional emergency source of electrical power, provided that:

(i) There is at least one generating set, meeting the requirements of 4.11.4(n) and each of sufficient capacity to meet the requirements of 4.11.4(f), in each of at least two non-contiguous spaces;

(ii) The arrangements required by 4.11.4(e)(i) above in each such space are equivalent to those required by 4.11.4(g)(i), 4.11.4(*i*), (j), (k), (l), (m), and 4.11.5 so that a source of electrical power is available at all times to the services required by 4.11.4, and

(iii) The generator sets referred to in 4.11.4(e)(i) and their self-contained systems are installed in accordance with 4.11.4(b).

(f) The electrical power available is to be sufficient to supply all those services that are essential for safety in an emergency, due regard being paid to such services as may have to be operated simultaneously. The emergency source of electrical power is to be capable, having regard to starting currents and the transitory nature of certain loads, of supplying simultaneously at least the following services for the periods specified hereinafter, if they depend upon an electrical source for their operation:

(i) For a Period of 12 Hours, Emergency Lighting:

(1) At the stowage positions of life-saving appliances;

(2) At all escape routes such as alleyways, stairways, exits from accommodation and service spaces, embarkation points, etc.;

(3) In the public spaces, if any;

(4) In the machinery spaces and main emergency generating spaces, including their control positions;

(5) In control stations;

(6) At the stowage positions for fireman's outfits, and

(7) At the steering gear.

(ii) For a Period of 12 Hours:

(1) The navigation lights and other lights required by the International Regulation for Preventing Collisions at Sea in force;

(2) Electrical internal communication equipment for announcements during evacuation;

(3) Fire-detection and general alarm system and manual fire alarms, and

(4) Remote control devices of fire-extinguishing systems, if electrical.

(5) The navigational equipment as required by Chapter 13 of the IMO International Code of Safety for High-Speed Craft. Where such provision is unreasonable or impracticable, the Administration may waive this requirement for craft of less than 5,000 GT.

(iii) For a Period of 4 Hours of Intermittent Operation:

(1) The daylight signaling lamps, if they have no independent supply from their own accumulator battery, and

(2) The craft's whistle, if electrically driven.

(iv) For a Period of 12 Hours:

(1) Navigational equipment;

(2) Essential electrically powered instruments and controls for propulsion machinery, if alternate sources of power are not available for such device;

(3) One of fire pumps required by 6.2.3(b) of this Part if dependent upon the emergency generator for its source of power;

(4) The sprinkler 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; and

(6) Craft radio facilities and other loads as set out in 14.13.2 of the IMO International Code of Safety for High-Speed Craft.

(v) For a Period of 10 Minutes:

Power drives for directional controls devices including those required to direct thrust forward and astern.

(vi) Craft on Short Duration Voyages

In a craft engaged regularly in voyages of short duration where an adequate standard of safety is attained, a lesser period than the 12 hour period specified in 4.11.4(f)(i), 4.11.4(f)(ii) ,and 4.11.4(f)(iv)(3) but not less than 5 hours may be accepted.

(g) The emergency source of electrical power may be either a generator or an accumulator battery, which is to comply with the following:

(i) Where the emergency source of electrical power is a generator, it is to be:

(1) driven by a suitable prime-mover with an independent supply of fuel, having a flashpoint (closed cup test) of not less than 43°C;

(2) started automatically upon failure of the main source of electrical power supply unless a transitional source of emergency electrical power in accordance with 4.11.4(g) (i)(3) of this Part is provided; where the emergency generator is automatically started, it is to be automatically connected to the emergency switchboard; those services referred to in 4.11.4(h) of this Part are then to be connected automatically to the emergency generator; and

(3) provided with a transitional source of emergency electrical power as specified in 4.11.4(h) of this Part unless an emergency generator is provided capable both of supplying the services mentioned in 4.11.4(h) of this Part and of being automatically started and supplying the required load as quickly as is safe and practicable subject to a maximum of 45 seconds.

(ii) Where the emergency source of electrical power is 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; and

(3) immediately supplying at least those services specified in 4.11.4(h) of this Part.

(iii) Where electrical power is necessary to restore propulsion, the capacity is to be sufficient to restore propulsion to the craft in conjunction with other machinery, as appropriate, from a dead craft condition within 30 minutes after blackout.

(h) The transitional source of emergency electrical power where required by 4.11.4(g)(i)(3) above is to consist of an accumulator battery suitably located for use in an emergency which is to operate without recharging while maintaining the voltage of the battery throughout the discharge period within 12% above or below its nominal voltage and be of sufficient capacity and is to be so arranged as to supply automatically in the event of failure of either the main or the emergency source of electrical power for half an hour at least the following services if they depend upon an electrical source for their operation:

(i) For a Period of 30 Minutes:

The loads specified in 4.11.4(f)(i), 4.11.4(f)(ii), and 4.11.4(f)(iii) and

(ii) 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 should have sufficient capacity to operate each door at least three times (i.e., closed-open-closed) against an adverse list of 15°, and

(2) Power to the control, indication and alarm circuits for the watertight doors for half an hour. For the transitional phase of loads as per 4.11.4(h)(i) above, such loads may not be connected to the transitional source of power provided that:

a) The services are fitted with an independent supply for the period specified from an accumulator battery suitably located for use in an emergency.

b) The emergency lighting, in respect of the machinery space and accommodation and service spaces are provided by permanently fixed, individual, automatically charged, relay operated accumulator lamps.

(i) The emergency switchboard is to be installed as near as is practicable to the emergency source of electrical power.

(j) 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.

(k) No accumulator battery fitted in accordance with this Regulation is to be installed in the same space as the emergency switchboard. An indicator is to be mounted in a suitable place on the main switchboard or in the machinery control room to indicate when the batteries constituting either the emergency source of electrical power or the transitional source of electrical power referred to 4.11.4 (g) (ii) or 4.11.4 (h) above are being discharged.

(l) The emergency switchboard is to be supplied during normal operation from the main switchboard by an interconnector feeder which is to be adequately protected at the main switchboard against overload and short circuit and which is to be disconnected automatically at the emergency switchboard upon failure of the main source of electrical power. Where the system is arranged for feedback operation, the interconnector feeder is also to be protected at the emergency switchboard at least against short circuit.

(m) In order to ensure ready availability of the emergency source of electrical power, arrangements are to be made where necessary to disconnect automatically non-emergency circuits from the emergency switchboard to ensure that electrical power is to be available automatically to the emergency circuits.

(n) 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 full rated power when the craft is upright and when inclined at any angle of list up to 22.5° or when inclined up to 10° either in the fore or aft direction, or is in any combination of angles within those limits.

(o) Provision is to be made for the periodic testing of the complete emergency system and is to include the testing of automatic starting arrangements.

4.11.5 Starting Arrangements for Emergency Generating Sets

(a) Emergency generating sets are to be capable of being readily started in their cold condition at a temperature of 0°C. If this is impracticable, or if lower temperatures are likely to be encountered, provision acceptable to the Society is to be made for the maintenance of heating arrangements, to ensure ready starting of the generating sets.

(b) Each emergency generating set arranged to be automatically started is to be equipped with starting devices approved by the Society 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. In addition, a second source of energy is to be provided for an additional three starts within 30 minutes unless manual starting can be demonstrated to be effective.

(c) The stored energy is to be maintained at all times, as follows:

(i) electrical and hydraulic starting systems are to be maintained from the emergency switchboard;

(ii) compressed air starting systems may be maintained by the main or auxiliary compressed air receivers through a suitable non-return valve or by an emergency air compressor which, if electrically driven, is supplied from the emergency switchboard;

(iii) all of these 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.

(d) Where automatic starting is not required, manual starting is permissible, such as manual cranking, inertia starters, manually charged hydraulic accumulators, or power charge cartridges, where they can be demonstrated as being effective.

(e) When manual starting is not practicable, the requirements of 4.11.5 (b) and 4.11.5 (c) above are to be complied with except that starting may be manually initiated.

4.11.6 Use of Emergency Generator in Port

(a) To prevent the emergency generator or its prime mover from becoming overloaded when used in port, arrangements are to be provided to shed sufficient non-emergency loads to ensure its continued safe operations.

(b) The prime mover is to be arranged with fuel oil filters and lubrication oil filters, monitoring equipment and protection devices as requested for the prime mover for main power generation and for unattended operation.

(c) The fuel oil supply tank to the prime mover is to be provided with a low level alarm, arranged at a level ensuring sufficient fuel oil capacity for the emergency services for the period of time as required in 4.11.3 and 4.11.4.

(d) The prime mover is to be designed and built for continuous operation and is to be subjected to a planned maintenance scheme ensuring that it is always available and capable of fulfilling its role in the event of an emergency at sea.

(e) Fire detectors are to be installed in the location where the emergency generator set and emergency switchboard are installed.

(f) Means are to be provided to readily change over to emergency operation.

(g) Control, monitoring and supply circuits for the purpose of the use of the emergency generator in port are to be so arranged and protected that any electrical fault will not influence the operation of the main and emergency services. When necessary for safe operation, the emergency switchboard is to be fitted with switches to isolate the circuits.

(h) Instructions are to be provided on board to ensure that, even when the vessel is underway, all control devices (e.g. valves, switches) are in a correct position for the independent emergency operation of the emergency generator set and emergency switchboard.These instructions are also to contain information on the required fuel oil tank level, position of harbour/sea mode switch, if fitted, ventilation openings, etc.

4.11.7 Craft of less than 500 GT having electrical plants of 75 kW and above

(a) General

This requirement is intended for craft less than 500 GT having electrical plants of an aggregate capacity of 75 kW and above. The emergency source of electrical power is to be self-contained and readily available. 4.11.4(b), 4.11.4(c), 4.11.4(g) through 4.11.4(o) and 1.1 of Part V of CR high speed craft rules are also applicable. Where the source of electrical power is a battery, see 4.6 for the arrangement. For emergency lighting, a relay-controlled, battery-operated lantern is acceptable.

(b) Capacity

The emergency source of electrical power is to be capable of supplying simultaneously at least the following services for the period as specified herein:

(c) For a Period of 6 Hours, Emergency Lighting:

(i) At the stowage positions of life-saving appliances;

(ii) At all escape routes such as alleyways, stairways, exits from accommodation and service spaces, embarkation points, etc.;

(iii) In the public spaces, if any;

(iv) In the machinery spaces and main emergency generating spaces, including their control positions;

(v) In control stations;

(vi) At the stowage positions for fireman's outfits, and

(vii) At the steering gear.

(d) For a Period of 6 Hours:

(i) The navigation lights and other lights required by the International Regulation for Preventing Collisions at Sea in force;

(ii) Craft radio facilities and other loads as set out in 14.13.2 of the IMO International Code of Safety for High-Speed Craft.

(iii) Electrical internal communication equipment for announcements during evacuation.

4.12 Additional Requirements for Electric Propulsion Equipment

4.12.1 Electric Propulsion Equipment are to be in accordnace with the requirements of Chapter 13 of Part VII of the Rules for Steel Ships.

4.13 High Voltage Installations with Voltages above 1 kV up to 15 kV

4.13.1 High Voltage Installations are to be in accordnace with the requirements of Chapter 14 of Part VII of the Rules for Steel Ships.

4.14 Semiconductor Equipment

4.14.1 Semiconductor Equipment are to be in accordnace with the requirements of Chapter 15 of Part VII of the Rules for Steel Ships.

4.15 Tests after Installation on Board

4.15.1 Tests after Installation on Board are to be in accordnace with the requirements of Chapter 16 of Part VII of the Rules for Steel Ships.

4.16 Spare Parts

4.16.1 Spare Parts are to be in accordnace with the requirements of Chapter 17 of Part VII of the Rules for Steel Ships.

4.17 Uninterruptible Power System

4.17.1 Uninterruptible power systems are to be in accordnace with the requirements of Chapter 18 of Part VII of the Rules for Steel Ships.

4.18 Electrical Plants of Less Than 75 kW

4.18.1 General

Electrical plants having an aggregate capacity of less than 75 kW are to comply with the following requirements and the requirements in Chapter 4 of this Part as applicable – except 4.1.3, 4.2.2 (c), 4.2.2 (a), 4.11.2, 4.11.3, 4.11.4 ~ 4.11.7, 4.2.3 (j), 4.2.3 (m), 4.2.4, 4.2.5 (a) ~ 4.2.5 (l), 4.2.1 (n), 4.8 and 4.14 of this Part and 7.1.3, 5.1.2 and 5.2.6 of Part VII of the Rules for Steel Ships.

4.18.2 Standard Details

Standard wiring practices and details, including such items as cable supports, earthing details, bulkhead and deck penetrations, cable joints and sealing, cable splicing, watertight and explosion-proof connections to equipment, earthing and bonding connections, etc., as applicable, are to be indicated on the submitted plans or may be submitted in a booklet format.

4.18.3 Calculations of Short-circuit Currents

In the absence of precise data, the following short circuit currents at the machine terminals are to be assumed:

(a) Direct Current System

Ten times the full load current for generators normally connected (including spare) for each generator capable of being simultaneously connected. Six times full load current for motors simultaneously in service.

(b) Alternating Current System

Ten times the full load current for generators normally connected (including spare) for each generator capable of being simultaneously connected-symmetrical rms. Three times full load current of motors simultaneously in service.

4.18.4 Lightning Protection

For lightning protection systems, see 4.2.6 (g) of this Chapter.

4.18.5 Temperature Ratings

In the requirements contained in 4.18 of this Chapter, an ambient temperature of 40°C has been assumed for all locations. Where the ambient temperature is in excess of this value, the total temperature specified is not to be exceeded. Where equipment has been rated on ambient temperature less than that contemplated, consideration will be given to the use of such equipment, provided the total temperature for which the equipment is rated will not be exceeded.

4.18.6 Generators

Craft using electricity for propulsion auxiliaries or preservation of cargo are to be provided with at least two generators. These generators are not to be driven by the same engine. The capacity of the generating sets is to be sufficient to carry the necessary load essential for the propulsion and safety of the craft and preservation of the cargo (if applicable) with any one generator set in reserve. Craft having only one generator are to be provided with a battery source to supply sufficient lighting for safety.

4.18.7 Emergency Source of Power

(a) Capacity

The emergency source of electrical power is to have adequate capacity to provide emergency lighting for a period of at least 6 hours.

(b) Sources

The emergency power source may be any of the following:

(i) An automatically connected or manually controlled storage battery; or

(ii) An automatically or manually started generator; or

(iii) Relay-controlled, battery-operated lanterns.

(c) Battery Sources

Where the source of electrical power is a battery connected to a charging device with an output of more than 2 kW, the battery is to be located as near as practicable

4.18.8 Cable Construction

Cables are to have copper conductors constructed in accordance with a recognized standard and are to be of the stranded type, except sizes not exceeding 1.5 mm^2 (16 AWG) may have solid conductors.

4.18.9 Switchboards, Distribution Boards and Panels

(a) Installation

Switchboards, distribution boxes panels and panels are to be installed in dry accessible, and well ventilated areas. Not less than 610 mm clearance is to be provided in front of switchboards, distribution boxes panels and panels. When located at the helm or other area adjacent to or part of an open cockpit or weather deck, they are to be protected by a watertight enclosure.

(b) Instrumentation

A voltmeter, ammeter, frequency meter, and voltage regulator are to be provided for each generator installed. Control equipment and measuring instruments are to be provided as necessary to insure satisfactory operation of the generator or generators.

4.18.10 Navigation Running Lights

Mast head, port, starboard, and stem lights when required are to be controlled by a running light indicator panel. A fused-feeder disconnect switch is to be provided; the rating of the fuses is to be at least twice thatof the largest branch fuse and greater than the maximum panel load.

4.19 Specialized Craft and Services

4.19.1 Installations in Special-Category Spaces

(a) Application

In addition to the foregoing requirements in this Section, the following requirements are applicable for installations in special-category spaces. Special category spaces are those enclosed spaces intended for the carriage of motor vehicles with fuel in their tanks for their own propulsion, into and from which such vehicles can be driven, and to which passengers have access, including spaces intended for the carriage of cargo vehicles.

(b) Ventilation System

(i) Arrangement

The ventilating system for special-category spaces is to be independent from other ventilation systems and is to be capable of being controlled from a position outside the space.

(ii) Capacity

An effective power ventilation system of sufficient capacity to give at least 10 air changes per hour while navigating and 20 air changes per hour at the quayside during vehicle loading and unload operations is to be provided.

(iii) Fans

Exhaust fans are to be of non-sparking construction.

(iv) Material and Arrangement of Ducts

Ventilation ducts, including dampers, are to be of steel. Ducts serving spaces capable of being sealed are to be separated for such space.

(v) Exhaust Inlet and Outlet

Inlet for exhaust ducts are to be located within 450 mm above the vehicle deck. The outlet is to be sited in a safe position, having regard to the source of ignition near the outlet.

(vi) Emergency Shutdown

Arrangements are to be provided to permit a rapid shutdown and effective closure of the ventilation system in case of fire, taking into account the weather and sea conditions. See also 4.19.1(b)(i).

(vii) Operating Compartment Indication

Means are to be provided on the operating compartment or other appropriate locations to indicate any loss of the ventilating capacity.

(c) Location and Type of Equipment

(i) Certified Safe Type Equipment

Except as provided for in 4.19.1 (c) (ii) below, electrical equipment and wiring within the enclosed vehicle spaces referred to in 4.19.1 (b) (i). are to be increased-safety, explosion-proof or intrinsically-safe type.

(ii) Arrangements

Except for a distance within 450 mm above the platform that does not have openings of sufficient size permitting penetrations of petroleum gases downward, electrical equipment of a type so enclosed and protected as to prevent the escape of sparks, e.g., protection degree of IP55 of equivalent.

(iii) Equipment in Ducts from Vehicle Space

Electrical equipment and wiring installed within an exhaust duct are to be increased-safety, explosion-proof or intrinsically-safe type.

4.20 Craft less than 24 meters in Length

4.20.1 General

Electrical systems are to comply with a recognized standard acceptable to the Society. Examples of acceptable standards are given below:

(a) ISO 10133 Small Craft – Electrical Systems – Extra-low-voltage DC installations

(b) ISO 13297 Small Craft – Electrical Systems – Alternating current installations

(c) ABYC, Section E-11 (AC and DC)AC and DC Electrical Systems on Boats

4.20.2 Interior Communication Systems and Manually Operated Alarms

Interior communication and Alarms systems complying with 4.2.5 are required except as modified below:

(a) Craft which do not have below deck spaces are not required to have interior communication systems.

(b) Craft which have below deck spaces which are not normally occupied while in operations are not required to have interior communication systems.

(c) Alternatives to the requirements of 4.2.5 will be considered provided they are shown to be no less effective than the requirements of that Section.

4.20.3 Battery Starting Systems

Craft are to comply with 3.6.2 of Part IV of the Rules for Steel Ships. Alternatively where the propulsion engines can be started manually, only one battery (battery bank) will be required.

Chapter 5

Automatic or Remote Control and Monitoring systems

5.1 General Requirements

Automatic or remote control and monitoring systems are to be in accordnace with the requirements of Part VIII of the Rules for the construction and classification of steel ships.

Chapter 6

Fire Detection and Extinction

6.1 All Craft

6.1.1 General

(a) Classification requirements

The following are the minimum classification requirements for high-speed cargo craft which do not proceed, in the course of their voyage, more than 8 hours, at operational speed, from a place of refuge.

Cargo craft which proceed more than 8 hours from a place of refuge are to comply with the applicable requirements of the Rules for Steel Ships.

Application of the requirements for fire detection and extinction is to be in accordance with Fig. IV 6-1 below.

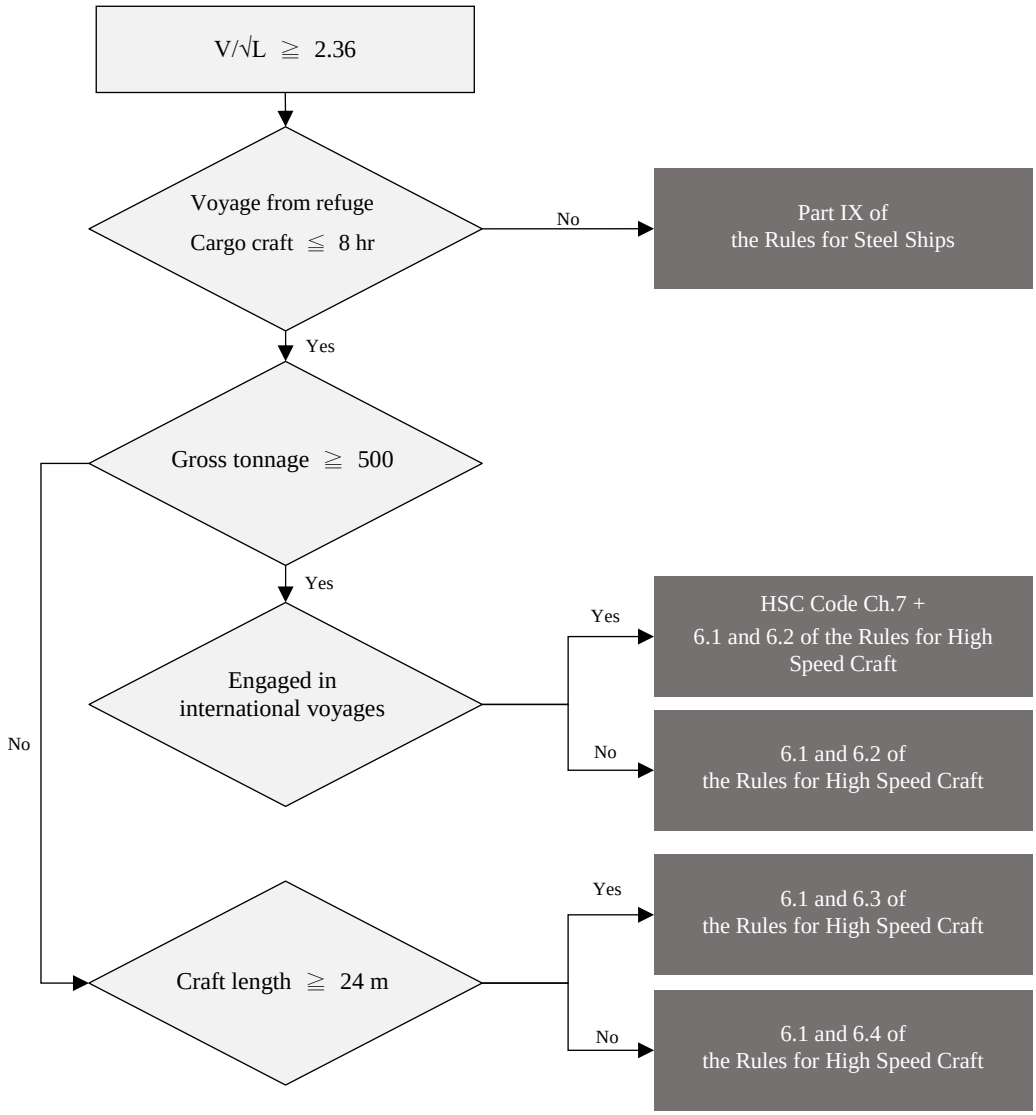


Fig. IV 6-1
Application of the Requirements for Different Types of Craft

(b) Governmental authority

Attention is directed to the appropriate governmental authority. In each case, there may be additional requirements depending on the gross tonnage, length, type and intended service of the craft, as well as other particulars and details. Consideration will be given to fire extinguishing systems which comply with the published requirements of the governmental authority of the country in which the craft is to be registered.

(c) Automated propulsion machinery spaces

Where automatic controls for propulsion machinery spaces are installed and it is intended that the propulsion machinery spaces are either not continuously manned at sea or only one person is required on watch, the requirements of Chapter 5 of this Part are to be met.

(d) Plans and specifications

The plans together with supporting data and particulars listed as follows are to be submitted for review. The Society reserves its right to ask for supplementary copies, if deemed necessary in particular cases.

(i) Arrangement and details of control station for emergency closing of openings and stopping machinery

(ii) Details and location of firefighter's outfits

(iii) Details of fire extinguishing appliances

(iv) Fire control plans (see 6.1.1(e) below)

(v) Plans of the following systems:

(1) Fire main system

(2) Foam extinguishing system

(3) Fire detection systems

(4) Fixed gas extinguishing system

(5) Fixed water spraying system

(vi) Other fire extinguishing arrangements

For craft of 500 gross tonnage and over, the most severe service condition for the operation of the emergency fire pump (e.g., lightest draft as shown in Trim and Stability Booklet, etc.)

For craft of 500 gross tonnage and over, calculations and pump data demonstrating that the emergency fire pump system can meet the operational requirements specified in 6.2.3(b)(iii) and 6.2.3(b)(vi) of this Chapter with the proposed pump location and piping arrangements (e.g., adequate suction lift, discharge pressure, capacity, etc.) at the most severe service condition

(e) Fire control plans

(i) Required information

Fire control plans are to be general arrangement plans showing for each deck the provision, location, controls and particulars, as applicable, of fixed fire detection, alarm and extinguishing systems, portable fire fighting appliances and equipment, controls for shutdowns of the ventilation system, fuel oil pumps and valves, along with details of the means provided for the closing of openings, and locations of accesses to critical spaces (such as fire control stations, Category A machinery spaces, etc.). For craft where structural fire protection is required by the Rules, locations and type of fire retarding bulkheads are to be specified on the plan.

(ii) Plan location

The fire control plans are to be conspicuously posted in the craft for the guidance of the crew.

(f) Additional fixed fire fighting systems

Where a fixed fire extinguishing system not required by Sections 6.2, 6.3 or 6.4 is installed, such system is to meet the applicable requirements of 6.2.6 of this Chapter and is to be submitted for approval.

6.1.2 Fire pumps, fire main, hydrants and hoses

(a) Materials

Materials readily rendered ineffective by heat are not to be used for fire mains unless adequately protected. In order to be considered not "readily rendered ineffective by heat", a component is to be certified as having passed an applicable, recognized fire test, or the material is to have a melting temperature higher than the test temperature specified in an applicable fire test.

For cargo craft less than 500 gross tonnage constructed of aluminum and FRP, pipes, valves and fittings which are required to be "not readily rendered ineffective by heat" may be accepted provided the solidus melting point of the material is greater than or equal to that of the material forming the bottom shell plating.

(b) Fire pumps

(i) Number of pumps

All craft are to have at least two fire pumps. Refer to 6.2.3 of this Chapter for craft of 500 gross tonnage or over, or 6.3.1(a) of this Chapter for craft under 500 gross tonnage. Refer to 6.4.2 of this Chapter for craft under 24 m in length.

(ii) Type of pumps

Sanitary, ballast, bilge or general service pumps may be accepted as fire pumps, provided that they are not normally used for pumping oil. If the pumps are subject to occasional duty for the transfer or pumping of fuel oil, changeover arrangements that prevent operation for firefighting when configured for fuel transfer are to be fitted.

(iii) Pressure

Power-driven fire pumps are to have sufficient pressure to produce 12 m jet throw through any two adjacent hydrants located in accordance with 6.1.2(d)(i) below. Also refer to 6.2.3(a) or 6.3.1(a) of this Chapter.

(iv) Relief valves

In conjunction with all fire pumps, relief valves are to be provided if the pumps are capable of developing a pressure exceeding the design pressure of the water service pipes, hydrants and hoses. These valves are to be so placed and adjusted as to prevent excessive pressure in any part of the fire main system. In general, the relief valve is to be set to relieve at no greater than 1.7 bar in excess of the pump pressure necessary to maintain the requirements of 6.1.2(b)(iii) above.

(c) Fire main

(i) Size

Refer to 6.2.2 of this Chapter for craft of 500 gross tonnage and over. For craft under 500 gross tonnage, the diameter of the fire main and water service pipes is to be sufficient for the effective distribution of the maximum required discharge from the pump(s). Refer to 6.3.1, 6.4.2(b) and Table IV 6-5 of this Chapter.

(ii) Cocks or valve

A valve is to be fitted to serve each fire hose so that any fire hose may be removed while the fire pumps are at work.

(iii) Cold weather protection

Fire main systems are to be provided with drains, circulation loops or other means for cold weather protection.

(d) Hydrants

(i) Number and position of hydrants

The number and position of the hydrants are to be such that at least two jets of water not emanating from the same hydrant, one of which is to be from a single length of hose, may reach any part of the craft normally accessible to the passengers or crew while the craft is being navigated. In addition, the arrangements are to be such that at least two jets of water can reach any part of any cargo space when empty.

(ii) Materials

Materials readily rendered ineffective by heat are not be used for fire protection systems unless adequately protected. See 6.1.2(a) above.

(iii) Installation

The pipes and hydrants are to be so placed that the fire hoses may be easily coupled to them. In craft where deck cargo may be carried, the positions of the hydrants are to be such that they are always readily accessible and the pipes are to be arranged to avoid risk of damage by such cargo.

(e) Hoses

(i) General

Fire hoses are to be of a type certified by a competent independent testing laboratory as being constructed of nonperishable material to a recognized standard. The hoses are to be sufficient in length to project a jet of water to any of the spaces in which they may be required to be used.

Fire hoses are to have a length of at least 10 m, but not more than:

- 15 m in machinery spaces;

- 20 m in other spaces and open decks; and

- 25 m for open deck on craft with a maximum breath in excess of 30 m

Each hose is to have a nozzle and the necessary couplings. Fire hoses, together with any necessary fittings and tools, are to be kept ready for use in conspicuous positions near the hydrants.

(ii) Diameter

For craft less than 500 gross tonnage, hoses are not to have a diameter greater than 38 mm. Hoses for craft under 20 m in length may be of a good commercial grade having a diameter of not less than 16 mm, and are to be have a minimum test pressure of 10.3 bar and a minimum burst pressure of 31.0 bar.

(iii) Number of fire hoses

In craft of 1,000 gross tonnage and upwards, the number of fire hoses to be provided is to be at least one for each 30 m length of the craft and one spare, but in no case less than five in all. This number does not include any hoses required in any engine or boiler room. In craft of less than 1,000 gross tonnage, the number of fire hoses to be provided is to be at least one for each 30 m length of the craft and one spare. However, the number of hoses is to be in no case less than three.

Unless one hose and nozzle is provided for each hydrant in the craft, there are to be complete interchangeability of hose couplings and nozzles.

(f) Nozzles

(i) Size

Standard nozzle sizes are to be 12 mm, 16 mm and 19 mm, or as near thereto as possible. Larger diameter nozzles may be permitted subject to compliance with 6.1.2(b)(iii) above. For accommodation and service spaces, a nozzle size greater than 12 mm need not be used. For machinery spaces and exterior locations, the nozzle size is to be such as to obtain the maximum discharge possible from two jets at the pressure mentioned in 6.1.2(b)(iii) above from the smallest pump; however, a nozzle size greater than 19 mm need not be used.

(ii) Type

All nozzles are to be of an approved dual-purpose type (i.e., spray and jet type) incorporating a shut-off. Fire hose nozzles of plastic type material such as polycarbonate may be accepted subject to review of their capacity and serviceability as marine use fire hose nozzles.

6.1.3 Means for closing of openings, stopping of machinery and oil containment

(a) Ventilation fans and openings

Means are to be provided for stopping ventilation fans serving machinery and cargo spaces, and for closing all doorways, ventilators and other openings to such spaces. These means are to be capable of being operated from outside such spaces in case of fire. See 2.1.13(a) of Part VII of the Rules for Steel Ships.

(b) Other auxiliaries

Machinery driving forced- and induced-draft fans, oil-fuel transfer pumps, oil-fuel unit pumps and other similar fuel pumps, fired equipment such as an incinerator, lubricating oil service pumps, thermal oil circulating pumps and oil separators (purifiers) are to be fitted with remote shutdowns situated outside of the spaces concerned so that they may be stopped in the event of a fire arising in the space. This need not apply to oily water separators. See 2.1.13(b) of Part VII of the Rules for Steel Ships.

In addition to the remote shutdowns required above, a means to shut down the equipment is to be provided within the space itself.

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(c) Oil tank suction pipes

Except for small independent tanks having a capacity of less than 500 liters, every oil-suction pipe from a storage, settling, daily service tank or lube oil tank situated above the double bottom is to be fitted with a valve capable of being closed in the event of a fire from outside of the space where such tanks are located. In the special case of deep tanks situated in any shaft or pipe tunnel, control may be effected by means of an additional valve on the pipe line outside of the tunnel. See 3.3 of this Part.

Where inadvertent valve closure could result in damage to the running machinery due to lack of lubricating oil, a valve is to be fitted on the lubricating oil tank, but remote control of the valve from outside of the space is not required.

6.1.4 Helicopter facilities

(a) Application

For each helicopter deck on board a craft designated for helicopter operations, fire fighting system and equipment complying with 6.1.4(b)(ii) and 6.1.4(b)(iii) below as applicable, are to be provided. Helicopter deck (helideck) is a purpose-built helicopter landing area, on a craft including all structure, fire fighting appliances and other equipment necessary for the safe operation of helicopters, but not those areas for occasional or emergency helicopter operations (e.g., circle H marked on hatch covers for drop-off/ pickup of pilot). Helicopter facility is a helideck including any refueling and hangar facility.

(b) Provisions for helicopter deck

(i) Hoses and nozzles

At least two combination solid stream and water spray nozzles and hoses sufficient in length to reach any part of the helicopter deck are to be provided.

(ii) Portable extinguishers

The helicopter deck is to be protected by at least two dry powder extinguishers of a total capacity of not less than 45 kg.

(iii) Back-up system

A back-up fire fighting system is to be provided consisting of CO_2 extinguishers of a total capacity of not less than 18 kg or equivalent, one of these extinguishers being equipped so as to enable it to reach the engine area of any helicopter using the helicopter deck. The back-up system is to be located so that the equipment would not be vulnerable to the same damage as the dry powder extinguisher required by 6.1.4(b)(ii) above.

(iv) Fixed foam system

A suitable fixed foam fire extinguishing system, consisting of monitors or hose streams or both, is to be installed to protect the helicopter landing area in all weather conditions in which helicopters can operate. The system is to be capable of delivering foam solution at a discharge rate in accordance with Table II 12A-4 in the Rules for Steel Ships for at least 5 minutes. The operation of the foam system is not to interfere with the simultaneous operation of the fire main.

The foam agent is to meet the performance standards for Level B foam in the International Civil Aviation Organization's Airport Services Manual (Part 1 Chapter 8, Paragraph 8.1.5, Table 8-1) or other recognized standard and be suitable for use with sea water.

(v) Fireman's outfits

In addition to the fireman's outfits required in 6.2.8 of this Chapter, 2 additional sets of fireman's outfits are to be provided and stored near the helicopter deck.

(vi) Other equipment

The following equipment is to be provided near the helicopter deck and is to be stored in a manner that provides for immediate use and protection from the elements:

- Adjustable wrench
- Fire resistant blanket
- Bolt cutters with arm length of 60 cm or more
- Grab hook or salving hook
- Heavy duty hack saw, complete with six spare blades
- Ladder
- Lifeline of 5 mm diameter × 15 m length
- Side cutting pliers
- Set of assorted screw drivers
- Harness knife complete with sheath

(c) Provisions for enclosed helicopter facilities

Hangars, refueling and maintenance facilities are to be treated as machinery space of category A with regard to structural fire protection, fixed fire-extinguishing system and fire detection system requirements. See 6.2.6 of this Chapter and 6.1.6 below.

(d) Operation manual

Each helicopter facility is to have an operation manual, including a description and a checklist of safety precautions, procedures and equipment requirements. This manual may be part of the craft's emergency response procedures.

6.1.5 Portable extinguishers

Portable extinguishers are to be provided in the quantities and locations indicated in Table IV 6-1 and Table IV 6-2 below.

Table IV 6-1
Classification of Portable and Semi-Portable Extinguishers

Extinguisher Type[1]		Water (*l*)	Foam (*l*)	Carbon dioxide (kg)	Dry chemical (kg)	Wet chemical (*l*)
A-II	Hand Portable	9	9	-	5	9
B-II	Hand Portable	-	9	5	5	-
B-III	Semi-Portable	-	45	15.8	9	-
B-IV	Semi-Portable	-	76	22.5	22.5	-
B-V	Semi-Portable	-	152	45[2]	22.5[2]	-
C-II	Hand Portable	-	-	5	5	-
C-III	Semi-Portable	-	-	15.8	9	-
C-IV	Semi-Portable	-	-	22.5	13.5	-
F-II or K-II	Hand Portable	-	-	-	-	9

Notes:

(1) Fire extinguishers are designated by type as follows:
- A: for fires in combustible materials such as wood;

- B: for fires in flammable liquids and greases;
- C: for fires in electrical equipment.

(2) For outside use, the amount is to be double.

Table IV 6-2
Portable and Semi-Portable Extinguishers

Space	Extinguisher type	Arrangement[5]
Control Stations		
Wheelhouse	C-II	2 in vicinity of exit[4]
Radio room	C-II	1 in vicinity of exit[4]
Accommodations		
Sleeping accommodations	A-II	1 in each sleeping accommodation space Where occupied by more than four persons.)
Corridors	A-II	1 in each main corridor not more than 46 m apart (May be located in stairways.)
Service Spaces		
Galleys	B-II or C-II	1 for each 230 m^2 or fraction thereof for hazards involved.
Storerooms	A-II	1 for each 230 m^2 or fraction thereof located in vicinity of exits, either inside or outside of spaces[4]
Workshops	A-II	1 outside the space in vicinity of exit[4]
Machinery Spaces		
Diesel engines or gas turbine	B-II and B-III	1 for each 746 kW, but not less than 2 nor more than 6[1] 1 required[3]
Electric motors or generators of the open type	C-II	1 for each motor or generator unit[2]

Notes:

(1) When installation is on weather deck or open to atmosphere at all times, 1 type B-II extinguisher for every three engines is allowable.

(2) Small electrical appliances, such as fans, etc., are not to be counted or used as basis for determining number of extinguishers required.

(3) Not required on craft of less than 500 gross tonnage.

(4) Vicinity is intended to mean within 1 m.

(5) For craft of 1,000 gross tonnage and above, at least five extinguishers are to be provided for accommodation spaces, service spaces, spaces where the craft's radio, main navigation equipment or emergency source of power is located, and locations where the fire recording or fire control equipment is located.

6.1.6 Fixed fire detection and alarm systems

(a) General

Where required, fixed fire detection and alarm systems are to comply with Regulations 7.7.1 and 7.7.2 of the International Code of Safety for High-Speed Craft and Chapter 9 of the International Code for Fire Safety Systems.

(b) Machinery space

A Fixed Fire Detection and Alarm System complying with 6.1.6(a) above are to be provided for any machinery space containing an diesel engine, gas turbine, oil filling station, or switchboards of aggregate capacity exceeding 750 kW.

(c) Accommodation and service spaces

A fixed fire detection and alarm system complying with 6.1.6(a) above is to be provided for all accommodation and service spaces.

6.1.7 Paint and flammable liquid lockers

Paint and flammable liquid lockers or any similar service spaces used for the storage of flammable liquids (such as solvents, adhesives, lubricants etc.) are to be protected by a fire extinguishing arrangement enabling the crew to extinguish a fire without entering the space. Unless required or permitted otherwise by the flag Administration, one of the following systems is to be provided:

(a) Lockers of 4 m^2 or more floor area and lockers with access to accommodation spaces

Paint lockers and flammable liquid lockers of floor area 4 m^2 or more and also such lockers of any floor area with access to accommodation spaces are to be provided with one of the fixed fire extinguishing systems specified below:

(i) CO_2 system, designed for 40 % of the gross volume of the space.

(ii) Dry powder system, designed for at least 0.5 kg/m^3.

(iii) Water spraying system, designed for 5 $liters/m^2$/minute. The water spraying system may be connected to the craft's fire main system, in which case, the fire pump capacity is to be sufficient for simultaneous operation of the fire main system, as required in 6.2.3(a) of this Chapter, and the water spray system. Precautions are to be taken to prevent the nozzles from being clogged by impurities in the water or corrosion of piping, nozzles, valves and pump.

(iv) Systems or arrangements other than those referenced above may be also considered, provided they are not less effective.

(b) Lockers of less than 4 m^2 floor area having no access to accommodation spaces

For paint lockers and flammable liquid lockers of floor area less than 4 m^2 having no access to accommodation spaces, portable fire extinguisher(s) sized in accordance with 6.1.7(a)(i) and which can be discharged through a port in the boundary of the lockers may be accepted. The required portable fire extinguishers are to be stowed adjacent to the port. Alternatively, a port or hose connection may be provided for this purpose to facilitate the use of water from the fire main.

The required portable fire extinguisher are to be stowed adjacent to the port. Alternatively, a port or hose connection may be provided to facilitate the use of fire main water.

6.1.8 Spaces containing dangerous goods

Craft intending to carry dangerous goods are to comply with the applicable requirements of Chapter 7 Part D of the International Code of Safety for High-Speed Craft.

6.2 Craft of 500 Gross Tonnage and Over

6.2.1 Fire safety measures

The applicable requirements of 4.1 of Part III of the Rules are to be complied with.

6.2.2 Size of fire main

The diameter of the fire main and water service pipes is to be sufficient for the effective distribution of the maximum required discharge from two fire pumps operating simultaneously, except that the diameter need only be sufficient for the discharge of 140 m^3/hr.

6.2.3 Main and emergency fire pumps

(a) Main fire pumps

(i) Number of pumps

For craft of 1,000 gross tonnage and above, the pumps are to be independently power-driven. For craft less than 1,000 gross tonnage, only one of the pumps need be independently power-driven and one of the pumps may be attached to the propulsion unit.

(ii) Total pump capacity

The fire pumps required by 6.2.3(a)(i) above are to be capable of delivering for firefighting purposes a quantity of water, at the appropriate pressure prescribed, not less than four-thirds of the quantity required under 3.2.2(b) of this Part to be dealt with by each of the independent bilge pumps when employed on bilge pumping, using in all cases L = length of craft, as defined in 1.1.2 of Part III of the Rules, except that the total required capacity of the fire pumps need not exceed 180 m^3/hr.

(iii) Individual pump capacity

Each of the fire pumps required by 6.2.3(a)(i) above is to have a capacity of not less than 40% of the total required capacity, but not less than 25 m^3/hr, and in any event is to be capable of delivering at least the two required jets of water. These pumps are to be capable of supplying the water under the required conditions. Where more pumps than required are installed, their capacity will be subject to special consideration.

(iv) Pressure

For craft 1,000 gross tonnage and over with the two power-driven pumps simultaneously delivering through the nozzles specified in 6.1.2(f) the quantity of water specified in 6.1.2(c)(i) through any adjacent hydrants, a pressure of 2.5 bar is to be maintained at all hydrants.

For craft less than 1,000 gross tonnage, the power-driven fire pumps are to have sufficient pressure to produce 12 m jet throw through any two adjacent hydrants located in accordance with 6.1.2(c)(i).

(v) Arrangement

Unless an emergency fire pump complying with 6.2.3(b) below is provided, the two main fire pumps, including their power source, fuel supply, electric cables, and lighting and ventilation for the spaces in which they are located, are to be in separate compartments so that a fire in any one compartment will not render both main pumps inoperable. Only one common boundary is allowed between the compartments, in which case, the single common boundary is to be at least to A-0 standard.

No direct access is allowed between the compartments except that where this is impracticable, an access meeting the requirements in 6.2.3(a)(vi) below may be considered.

(vi) Alternative arrangement

Where it is impracticable to do otherwise, a direct access between the compartments containing the main fire pumps may be considered, provided:

(1) A watertight door capable of being operated locally from both sides of the bulkhead, and from a safe and accessible location outside of these spaces is provided. The means for the latter operation is expected to be available in the event of fire in these spaces; or

(2) An air lock consisting of two gastight steel doors. The doors are to be self-closing without any hold back arrangements.

(3) In addition to the arrangements specified in 6.2.3(a)(vi)(1) or 6.2.3(a)(vi)(2) above, a second protected means of access is to be provided to the space containing the fire pumps.

(vii) Isolation

Isolating valves and other arrangements, as necessary, are to be provided so that if a fire pump and its associated piping within its compartment are rendered inoperable, the fire main can be pressurized with a fire pump located in another compartment.

(b) Emergency fire pumps

(i) When Required

If a fire in any one compartment could put all main pumps out of action (see 6.2.3(a)(ii)), an independently power-driven and self-priming emergency fire pump complying with this paragraph is to be provided.

(ii) Arrangement

An emergency fire pump system, including power source, fuel supply, electric cables, and lighting, as well as lighting and ventilation for the emergency fire pump space, is to be in a separate compartment than the main fire pumps so that a fire in any one compartment will not render both the main and the emergency firepumps inoperable.

No direct access is permitted between the main machinery space and the spaces containing the emergency fire pump and its source of power. Where this is impracticable, access between the space containing the emergency fire pump and the main machinery space, in accordance with 6.2.3(a)(vi), may be considered

The space containing the emergency fire pump is not to be contiguous to the boundaries of machinery spaces of Category A or the spaces containing the main fire pumps. Where this is impracticable, the common bulkhead between the two spaces is to be constructed to A-60 standard. The insulation is to extend at least 450 mm outside of the area of the joint bulkheads and decks.

(iii) Capacity

The emergency fire pump is to be capable of supplying at least two jets of water required by 6.1.2(c)(i), using the available hydrants, hoses and nozzles, and is to have a capacity of at least 40% of the total capacity of the fire pumps required by 6.2.3(a)(ii) or 25 m^3/hr, whichever is greater.

When the pump is delivering the quantity of water, as above, the pressure at the hydrant is to be not less than the pressure given in 6.2.3(a)(iv).

In addition, the emergency fire pump is also to be capable of simultaneously supplying the amount of water needed for any fixed extinguishing system protecting the space containing the main pumps.

(iv) Starting

Diesel engines larger than 15 kW are to be provided with power starting systems having a capacity sufficient for at least six starts within 30 minutes, including at least two within the first ten minutes. For engines of 15 kW and smaller, manual means of starting is sufficient.

Any diesel engine driving an emergency fire pump is to be capable of readily being started in its cold condition down to a temperature of 0°C. If this is impracticable or if lower temperatures are likely to be encountered, consideration is to be given to the provision and maintenance of heating arrangements.

(v) Fuel Supply

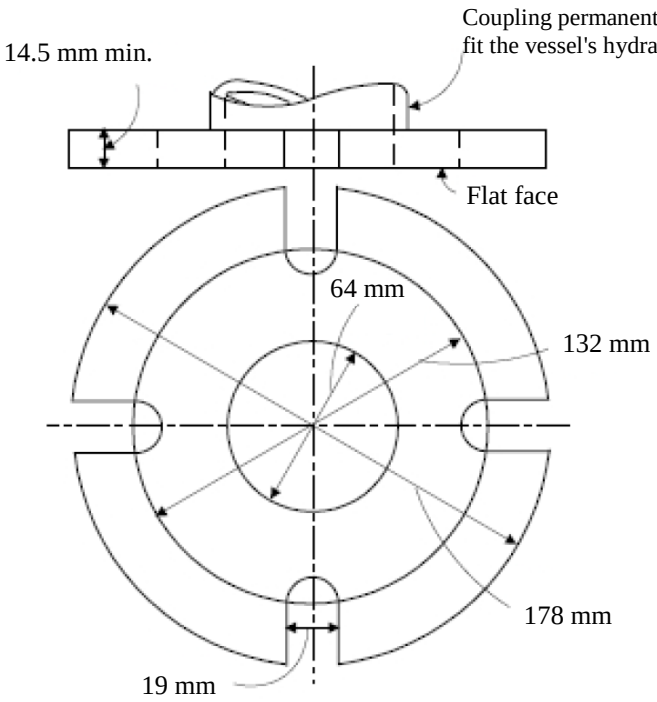
Any service fuel tank is to contain sufficient fuel to enable the pump to run on full load for at least three hours and sufficient reserves of fuel are to be available outside of the main machinery space to enable the pump to be run on full load for an additional 15 hours.

(vi) Suction

The total suction head and the net positive suction head of the pump is to be such that the requirements of 6.2.3(b) of this Chapter.3 and 6.2.3(a)(iv) will be satisfied under all conditions of list, trim, roll and pitch likely to be encountered in service. The sea valve is to be operable from a position near the pump or locked in the open position (provided possible flooding can be detected).

6.2.4 International shore connection

At least one international shore connection, as shown in Fig. IV 6-2 below, is to be provided and kept aboard the craft with gasket, bolts and eight washers. Facilities are to be available enabling such a connection to be used on either side of the craft.



Bolt: 4, each of 16 mm dia., 50 mm in length
Flange surface: Flat face
Material: Any suited for 10 bar service
Gasket: Any suited for 10 bar service

Fig. IV 6-2
International Shore Connection

6.2.5 Machinery spaces

Category A machinery spaces are to be protected by a fixed fire extinguishing system complying with 6.2.6 below.

(a) Fixed local application firefighting systems

For cargo craft of 2,000 gross tonnage and above, the machinery spaces of category A above 500 m^3 in volume, in addition to the fixed fire extinguishing system required in 6.2.6 below, are to be protected by an approved type of fixed water-based or equivalent local application firefighting system complying with the provisions of the IMO Guidelines for the Approval of Fixed Water-based Local Application Firefighting System for Use in Category A Machinery Spaces, MSC/Circ. 1387. In the case of periodically unattended machinery spaces, the fire fighting system is to have both automatic and manual release capabilities. In case of continuously manned machinery spaces, the fire fighting system is only required to have a manual release capability. The fixed local fire fighting systems are to protect areas such as the following without the necessity of engine shutdown, personnel evacuation or sealing the spaces:

(i) The fire hazard portion of internal combustion machinery;

(ii) The fire hazard portions of incinerators; and

(iii) Boiler front

(iv) Purifiers for heated fuel oil. See 3.3.1(b) of this Part.

Activation of any local application system shall give a visual and distinct audible alarm in the protected space and at continuously manned stations. The alarm is to indicate the specific system activated. The system alarm requirements described within this paragraph are in addition to, and not a substitute for, the detection and

fire alarm system required elsewhere in 6.2 and 6.3 of this Chapter. A bridge alarm is to be provided with a visual notification when the system has been deactivated or placed in manual mode.

6.2.6 Fixed fire extinguishing systems

(a) Gas smothering

(i) Storage

Where the gas smothering medium is stored outside of the protected space, the storeroom is to be situated in a safe and readily accessible position and is to be effectively ventilated by a ventilation system independent of all other spaces.

Spaces for storage of cylinders or tanks for extinguishing gas are not to be used for other purposes. These spaces are not to be located forward of the forward collision bulkhead, when fitted. Access to these spaces is to be possible from the open deck. Spaces situated below the deck are to be located no more than one deck below the open deck.

Spaces where entrance from the open deck is not provided or which are located below deck are to be fitted with mechanical ventilation. The exhaust duct (suction) is to be lead to the bottom of the space. Such spaces are to be ventilated with at least six air changes per hour.

Fire-extinguishing media protecting the cargo holds (see 6.2.13 below) may be stored in a room located forward of the cargo holds, but aft of the collision bulkhead, provided that both the local manual release mechanism and remote control(s) for the release of the media are fitted, and the latter is of robust construction or so protected as to remain operable in case of fire in the protected spaces. The remote controls are to be placed in the accommodation area in order to facilitate their ready accessibility by the crew. The capability to release different quantities of fire-extinguishing media into different cargo holds so protected is to be included in the remote release arrangement..

Where the CO_2 system discharge piping is also used for the sample extraction smoke detection system piping, see Chapter 10 of the International Code for Fire Safety Systems (FSS Code), as amended), for the location of the indicating unit.

(ii) Design

Containers and associated pressure components are to be designed based upon an ambient temperature of 55°C.

For CO_2 fire extinguishing systems, the wall thickness of steel piping is to be suitable for the pressure and not less than the thickness identified in Table IV 6-3. Column A is for piping from storage containers to distribution station, and column B is for piping from distribution station to nozzles. For other fixed gas fire extinguishing systems, calculations showing compliance with 3.1.5 of this Part are to be submitted for approval.

Where the fire-extinguishing medium is used as the power source for the pre-discharge alarm, the piping to the alarm is to comply with Column B of Table IV 6-3.

Table IV 6-3
Minimum Steel Pipe Wall Thickness for CO_2 Medium Distribution Piping

Nominal size, mm	OD mm	A mm	B mm
15	21.3	2.8	2.6
20	26.9	2.8	2.6
25	33.7	4.0	3.2
32	42.4	4.0	3.2
40	48.3	4.0	3.2
50	60.3	4.5	3.6
65	76.1	5.0	3.6
80	88.9	5.5	4.0
90	101.6	6.3	4.0
100	114.3	7.1	4.5
125	139.7	8.0	5.0
150	168.3	8.8	5.6

Notes:

(1) The above minimum thicknesses are derived from those thicknesses available in ISO 4200 Series 1 (OD), JIS (N.P.S.), or ASTM (N.P.S.). Diameter and thickness according to other recognized standards will be accepted.

(2) For threaded pipes, where approved, the thickness is to be measured to the bottom of the thread.

(3) The internal surface of pipes outside of the engine room is to be galvanized.

(4) For larger diameters the minimum wall thickness will be subject to special consideration by the Society.

(5) In general, the minimum thickness is the nominal wall thickness and no allowance need be made for negative tolerance or reduction in thickness due to bending.

The pressure rating of pipe connections such as flanges from the distribution aftermost valve to discharge nozzles is to be not less than the maximum pressure developed during the discharge of CO_2 into protected spaces.

The relief valve of a CO_2 fire extinguishing system is to discharge outside of the CO_2 container storage compartment. In addition, in piping sections where valve arrangements introduce sections of closed piping, such sections are to be fitted with a pressure relief valve and the outlet of the valve is to be led to open deck.

Gray cast iron piping components are not to be used for fixed gas fire extinguishing systems. All discharge piping, fittings and nozzles in the protected spaces are to be constructed of materials having a melting temperature which exceeds 925°C. The piping and associated equipment are to be adequately supported.

Threaded joints in CO_2 systems are to be allowed only inside protected spaces and in CO_2 cylinder rooms.

(iii) Alarm

Means are to be provided for automatically giving audible and visual warning of the release of fire extinguishing gas into any space to which personnel normally have access. The audible alarms are to be located so as to be audible throughout the protected space with all machinery operating, and the alarms are to be distinguished from other audible alarms by adjustment of sound pressure or sound patterns. The alarm is to operate for at least a 20 second period before the gas is released. Alarms may be pneumatically (by the extinguishing medium or by air) or electrically operated.

(1) Electric
If electrically operated, the alarms are to be supplied with power from the main and an emergency source of electrical power.

(2) Pneumatic

If pneumatically operated by air, the air supply is to be dry and clean and the supply reservoir is to be automatically kept charged at all times and is to be fitted with a low pressure alarm. The air supply may be taken from the starting air receivers. Any stop valve fitted in the air supply line is to be locked or sealed in the open position. Any electrical components associated with the pneumatic system are to be powered from the main and an emergency source of electrical power.

(3) Uninterruptible power supply
For fire extinguishing systems that protect the machinery space containing the main source of power, instead of the power supply arrangements required above for electrically operated alarms and electrical components associated with pneumatic alarms, an uninterruptible power supply which is supplied with power from the emergency switchboard is to be provided.

(iv) Controls

Except as otherwise permitted herein, two independent manual control arrangements are to be provided, one of them being positioned at the storage location and the other in a readily accessible position outside the protected space.

(v) Air reservoirs

The volume of starting air receivers converted to free air volume is to be added to the gross volume of the machinery space when calculating the necessary quantity of the extinguishing medium. Alternatively, a discharge pipe from the safety relief valves or other pressure relief devices may be fitted and led directly to the open air.

(b) Carbon dioxide systems

Fixed carbon dioxide fire extinguishing system is to be in accordance with the requirements of 7.7.3.3.2-7.7.3.3.16 and 7.7.3.4 of the International Code of Safety for High-Speed Craft and Chapter 5 of the International Code for Fire Safety Systems.

Note: Attention is to be paid that positive means is to be provided to ensure correct sequential operation of the controls of carbon dioxide system as specified in 7.7.3.4.5 of HSC Code. See FSS Code Chapter 5, 2.2.2.1 and MSC.1/Circ. 1456.

(c) Clean agent fire extinguishing systems

Fixed gas fire-extinguishing systems equivalent to those specified in 6.2.6(a) through 6.2.6(b) above are to be submitted for approval, based on the guidelines specified in the IMO MSC/Circ. 848 as amended by MSC/Circ. 1267 and this subsection.

Fire extinguishing systems using Halon 1211, 1301, and 2402 and perfluorocarbons are prohibited. The use of a fire-extinguishing medium, which either by itself or under expected conditions of use gives off toxic gases, liquids and other substances in such quantities as to endanger persons, is not permitted.

(i) Fire suppression agent

The agent is to be recognized as a fire extinguishing medium by NFPA Standard 2001 or other recognized national standard. The minimum extinguishing concentration for net volume total flooding of the protected space at the lowest expected operating temperature, but not greater than 0°C (32°F), is to be determined by an acceptable cup burner test. The minimum design concentration is to be at least 30% above the minimum extinguishing concentration and is to be verified by full-scale test (see 6.2.6(c)(ii) below).

The fire extinguishing agent is to be acceptable for use in occupied spaces by U.S. EPA or other recognized national organization. The concentrations for cardiac sensitization NOAEL (No Observed Adverse Effect Level), LOAEL (Lowest Observed Adverse Effect Level) and ALC (Approximate Lethal Concentration) are to be submitted.

(ii) Fire tests

The system is to pass the fire tests in the Appendix of the IMO MSC/Circ. 848 as amended by MSC/Circ. 1267. The testing is to include the system components.

The system is to pass an additional fire test (number 1 in the Appendix of MSC/Circ. 848) with the agent storage cylinder at the lowest expected operating temperature, but not greater than 0°C.

(iii) System components

The system is to be suitable for use in a marine environment. Major components (valves, nozzles, etc.) are to be made of brass or stainless steel, piping is to be corrosion resistant (stainless steel or galvanized) and the material is to have a melting point of not less than 927°C.

The system and its components are to be designed, manufactured and installed in accordance with recognized national standards.

Containers and associated pressure components are to be designed based upon an ambient temperature of 55°C.

Minimum wall thickness for distribution piping is to be in accordance with Table IV 6-3 (Columns A or B, as applicable).

(iv) System installation

(1) Storage

As far as practicable, the fire suppression agent is to be stored outside the protected space in a dedicated storeroom. The storeroom is to be in accordance with 6.2.6(a)(i), except that when mechanical ventilation is provided, the location of the exhaust duct (suction) is dependent on the density of the agent relative to air.

When allowed by the flag Administration, the fire suppression agent may be stored inside the protected space. In addition to the related instructions from the flag Administration, the installation is to be in accordance with paragraph 11 of IMO MSC/Circ. 848 as amended by MSC/Circ. 1267.

In the case of new installation in existing units, the storage of the fire suppression agent within a low fire risk space with a net volume at least 2 times greater than the net volume of the protected space may be specially considered, based on the type of agent and the possible hazards for the personnel within the space.

(2) Alarm

An audible and visual predischarge alarm in accordance with 6.2.6(a)(iii) and paragraph 6 of IMO MSC/Circ. 848 as amended by MSC/Circ. 1267 is to be provided inside the protected space in which personnel normally work or to which they have access.

(3) Controls

Except as otherwise permitted herein two independent manual control arrangements are to be provided, one of them being positioned at the storage location and the other in a readily accessible position outside of the protected space.

Automatic actuation is not permitted when the protected space is normally manned or interferes with the safety navigation of the craft. If the protected space is normally unmanned and may be entered occasionally for brief periods such as for repairs, maintenance or other purpose, automatic actuation may be allowed in addition to manual actuation, provided that the following conditions are met:

a) The egress from the protected space is horizontal. Exit doors from the spaces are to be outward-swinging self-closing doors (i.e., opening in the direction of escape routes) which can be opened from the inside, including when the doors are locked from the outside.

b) Notices that the space is protected by an automatic activation system are prominently posted at the entrance to the space.

c) A switch is provided near the entrance to disable the automatic release feature of the system.

The switch is to have an indicator of its status such as red pilot light to indicate when the switch is activated (automatic release feature disabled). A sign is to be posted near the switch indicating that the automatic release feature is to be disabled when the space is occupied and that the automatic actuation is to be enabled when leaving the space. The sign is to also indicate that the manual release of the system remains enabled and the space is to be vacated immediately when the release alarm sounds.

d) When the automatic release feature is disabled, all other controls, alarms, etc., are to remain activated.

e) An indicator at the control console is provided to indicate when the automatic release feature has been disabled.

f) The medium release warning alarm is to operate for the length of time needed to evacuate the space, but in no case less than 30 seconds for space exceeding 170 m^3 and 20 seconds for spaces 170 m^3 or less before the medium is released.

g) The automatic release of a clean agent fire extinguishing system is to be approved by the craft's flag Administration.

(4) Nozzles
The nozzle type, maximum nozzle spacing, maximum height and minimum nozzle pressure are to be within the limits to provide fire extinction as tested and verified in the appropriate fire test (see 6.2.6(c)(ii) above.).

(d) Foam

(i) Fixed high expansion foam systems

In addition to the applicable requirements of the Rules, fixed, high expansion foam systems are to be in accordance with Chapter 6.2.1 and Chapter 6.2.2 of the International Code for Fire Safety Systems.

Fixed foam fire-extinguishing systems using inside air are to be designed, constructed and tested in accordance with the requirements identified in MSC.1/Circ. 1271, Guidelines for the Approval of High-Expansion Foam Systems Using Inside Air for the Protection of Machinery Spaces and Cargo Pump-Rooms.

Foam concentrates are to be of an approved type.*

Note: *Reference is made to the International Maritime Organization MSC/Circular 670 "Guidelines for the Performance and Testing Criteria, and Surveys of High-Expansion Foam Concentrates for Fixed Fire-Extinguishing Systems."

(ii) Fixed low expansion foam systems

Low expansion foam systems may be fitted in addition to the required fixed fire extinguishing system. In addition to the applicable requirements of the Rules, fixed low expansion foam systems are to be in accordance with Chapter 6.2.1 and Chapter 6.2.3 of the International Code for Fire Safety Systems. Foam concentrates are to be of an approved type.**

Note: **Reference is made to the International Maritime Organization MSC/Circular 582 "Guidelines for the Performance and Testing Criteria, and Surveys of Low-Expansion Foam Concentrates for Fixed Fire-Extinguishing Systems."

(e) Fixed Water Spraying Systems

In addition to the requirements of the Rules, fixed water spraying systems are to be in accordance with Chapter 7 of the International Code for Fire Safety Systems.

6.2.7 Fireman's outfit

At least two complete fireman's outfits are to be carried onboard the craft.

Each outfit is to consist of an approved breathing apparatus, a lifeline, a safety lamp, an axe, nonconducting boots and gloves, a rigid helmet and protective clothing.

2 spare charges are to be provided for each required breathing apparatus. All air cylinders for breathing apparatus are to be interchangeable.

A minimum of two two-way portable radiotelephone apparatus for each fire party for fire-fighter's communication are to be carried on board. Those two-way portable radiotelephone apparatus are to be of an explosion-proof type or intrinsically safe.

The fireman's outfits and equipment are to be stored so as to be easily accessible and ready for use and are to be stored in widely separate positions.

6.2.8 Emergency escape breathing devices (EEBDs)

(a) Accommodation spaces

All ships are to carry at least two emergency escape breathing devices and one spare device within accommodation spaces.

(b) Machinery spaces

On all craft, within the machinery spaces, emergency escape breathing devices are to be situated ready for use at easily visible places, which can be reached quickly and easily at any time in the event of fire. The location of emergency escape breathing devices is to take into account the layout of the machinery space and the number of persons normally working in the spaces. (See the Guidelines for the performance, location, use and care of emergency escape breathing devices, MSC/Circ. 849 and 1081). The number and locations of EEBDs are to be indicated in the fire control plan required in 6.1.1(e) of this Chapter.

A summary of the MSC/Circ. 1081 requirements are shown in Table IV 6-4 below. This applies to machinery spaces where crew are normally employed or may be present on a routine basis.

Table IV 6-4
Minimum Number of Required EEBDs

A In machinery spaces for category A containing internal combustion machinery used for main propulsion(1) :	
(a)	1 EEBD in the engine control room, if located within the machinery space
(b)	1 EEBD in workshop areas. If there is, however, a direct access to an escape way from the workshop, an EEBD is not required; and
(c)	1 EEBD on each deck or platform level near the escape ladder constituting the second means of escape from the machinery space (the other means being an enclosed escape trunk or watertight door at the lower level of the space).
B In machinery spaces of category A other than those containing internal combustion machinery used for main propulsion,	
1 EEBD should, as a minimum, be provided on each deck or platform level near the escape ladder constituting the second means of escape from the space (the other means being an enclosed escape trunk or watertight door at the lower level of the space).	
C In other machinery spaces	
The number and location of EEBDs are to be determined by the Flag Administration.	

Notes:

(1) Alternatively, a different number or location may be determined by the Flag Administration taking into consideration the layout and dimensions or the normal manning of the space.

6.2.9 Portable fire extinguishers

Spare charges are to be provided for 100% of the first 10 extinguishers and 50% of the remaining fire extinguishers capable of being recharged on board. Not more than 60 total spare charges are required. Instructions for recharging are to be carried on board.

For fire extinguishers which cannot be recharged on board, additional portable fire extinguishers of the same quantity, type, capacity and number, as determined above, are to be provided in lieu of spare charges.

6.2.10 Portable foam applicator units

Each category A machinery space is to be provided with at least one portable foam applicator unit.

(a) Specification

A portable foam applicator unit is to consist of a foam nozzle/branch pipe, either of a self-inducing type or in combination with a separate inductor, capable of being connected to the fire main by a fire hose, together with a portable tank containing at least 20 *l* of foam concentrate and at least one spare tank of foam concentrate of the same capacity.

(b) System performance

(i) The nozzle/branch pipe and inductor is to be capable of producing effective foam suitable for extinguishing an oil fire, at a foam solution flow rate of at least 200 *l*/min at the nominal pressure in the fire main.

(ii) The foam concentrate shall be approved by the Society based on guidelines in the Guidelines for the Performance and Testing Criteria and Surveys of Low-expansion Foam Concentrates for Fixed Fire-extinguishing Systems (MSC/Circ.582/Corr.1).

(iii) The values of the foam expansion and drainage time of the foam produced by the portable foam applicator unit is not to differ more than ±10% of that determined in 6.2.10(b)(ii) above.

(iv) The portable foam applicator unit is to be designed to withstand clogging, ambient temperature changes, vibration, humidity, shock, impact and corrosion normally encountered on ships.

6.2.11 Sample extraction smoke detection systems

Any required fixed sample extraction smoke detection system is to meet the requirements in Chapter 10 of the International Code for Fire Safety Systems.

6.2.12 Fixed fire extinguishing arrangements in way of cargo spaces

(a) Cargo craft of 2,000 gross tonnage and over

Except for cargo spaces covered by 6.2.13 and 6.2.14 below, cargo spaces of cargo craft of 2000 gross tonnage and above are to be provided with approved fixed fire extinguishing systems.

(b) Exceptions

A fixed system need not be fitted in the case of cargo holds fitted with steel hatch covers, and where all ventilators and other openings leading to the holds can be effectively closed, and the craft is constructed and intended solely for carrying ore, coal, grain, unseasoned timber or noncombustible cargoes.

(c) Controls

As an alternative to providing the controls required by 6.2.6(a)(iv) above, a single manual means may be provided at the storage location.

6.2.13 Ro-Ro cargo spaces

(a) Fire detection

An approved automatic fire detection and fire alarm system complying with 6.1.6 of this Chapter and the following is to be provided. Manual call points are to be provided to activate the fire alarm from the navigation bridge and the passageways having entrances to the ro-ro spaces. The fire alarm indicator/control panel is to be located on the bridge or at the fire control station, if provided. When the indicator/control panel is located at the fire control station, an additional alarm is to be provided on the navigation bridge.

(b) Fire extinguishing arrangements

Ro-ro cargo spaces capable of being sealed are to be fitted with an approved fixed gas fire extinguishing system. If a carbon dioxide system is fitted, the quantity of gas available is to be at least sufficient to give a minimum volume of free gas equal to 45% of the gross volume of the largest such cargo space which is capable of being sealed, and the arrangements are to be such as to ensure that at least two thirds of the gas required for the relevant spaces is introduced within 10 minutes.

In lieu of the above, a fixed high expansion foam system or water spray system may be fitted subject to special consideration. Ro-ro spaces not capable of being sealed are to be fitted with a fixed pressure waterspraying system. The water-spraying system, drainage and pumping arrangements will be subject to special consideration.

As an alternative to providing the controls required by 6.2.6(a)(iv) above, a single manual means may be provided at the storage location.

(c) Portable fire extinguishers

At least one approved portable extinguisher is to be located at each cargo space access.

(d) Ro-Ro spaces carrying motor vehicles with fuel in their tanks

(i) Each ro-ro cargo space intended for the carriage of motor vehicles with fuel in their tanks for their own propulsion is to meet the requirements of 4.19.1(c) of this Part.

(ii) Gravity drainage systems are not to be led to machinery spaces or other spaces where sources of ignition are present.

(iii) In addition, each space is to be provided with at least three water fog applicators and one portable foam applicator unit complying with the provisions of 6.2.10 above, provided that at least two such units are available on the craft for use in such ro-ro cargo spaces.

(iv) Portable fire extinguishers suitable for fighting oil fires are to be provided at each vehicle deck level in all spaces where vehicles are carried. Extinguishers are to be located not more than 20 m apart on both sides of the craft. Portable extinguishers required under 6.2.13(c) above may be credited in meeting this requirement.

6.2.14 Cargo spaces carrying vehicles with fuel in their tanks (other than Ro-Ro Spaces)

Cargo spaces, other than ro-ro spaces, intended for the carriage of motor vehicles with fuel in their tanks for their own propulsion are to comply with 6.2.13 above with the following exceptions:

(a) A sample extraction smoke detection system complying with the provisions of 6.2.11 above may be permitted in lieu of 6.2.13(a) above , and

(b) The provisions of 6.2.13(d)(iii) and 6.2.13(d)(iv) above may be omitted

6.2.15 Release of smoke from machinery space

Suitable arrangements are to be made to permit the release of smoke, in the event of fire, from the machinery space of Category A. The normal ventilation may be acceptable for this purpose. The means of control is to be provided for permitting the release of smoke and such control is to be located outside the space concerned so that they will not be rendered inaccessible in the event of fire in the space they serve. See also 2.1.14(a) of Part VII of the Rules for Steel Ships.

6.3 Craft under 500 Gross Tonnage

6.3.1 Fire pumps

(a) Number of pumps

All craft are to have at least 2 fire pumps. Only 1 of the pumps need be independently power-driven, and one of the pumps may be attached to the propulsion unit.

(b) Capacity

The capacity of each power-driven fire pump is to be in accordance with the Table IV 6-5. Hand pumps, where permitted, are to have a minimum capacity of 1.1 m^3/hr.

Table IV 6-5
Fire Pump Minimum Capacity for Craft less than 500 Gross Tonnage

Craft Length	Minimum Capacity
24 m ≤ L < 30.5 m	11.0 m^3/hr
30.5 m ≤ L < 61 m	14.3 m^3/hr
L > 61 m	Capacity to be in accordance with 6.2.3(a)

6.3.2 Fixed fire extinguishing systems

(a) Fixed systems

For all craft, fixed fire extinguishing systems are to be fitted in the machinery spaces when propulsion and auxiliary engines with a total aggregate power of 750 kW or greater are installed (see 1.2.1 of this Part) and in any machinery space in which an oil fuel unit for heated fuel oil is installed, regardless of the total aggregate power. Also see 6.2.6 of this Chapter.

(b) Carbon dioxide systems

Where a fixed carbon dioxide fire extinguishing system is installed, the system is to comply with the requirements of 6.2.6(a) and 6.2.6(b) of this Chapter, except that storage arrangements may be in accordance with the following.

(i) Storage

Generally, the cylinders are to be located outside of the protected space in a room which is situated in a safe and readily accessible location. The access doors to the storage space are to open outwards. The storage room is to be gastight and effectively ventilated. The ventilation system is to be independent of the protected space. Any entrance to the storage room is to be independent of the protected space, except that where this is impracticable due to space limitations, the following requirements may be considered:

(1) The door between the storage location and the protected space is to be self-closing with no hold-back arrangements.

(2) The space where cylinders are stored is to be adequately ventilated by a system which is independent of the protected space.

(3) Means are to be provided to prevent unauthorized release of gas, such as containment behind a break glass.

(4) There is to be provision to vent the bottles to the atmosphere in order to prevent a hazard to personnel occupying the storage area.

(5) An additional entrance to the storage location, independent of the protected space, is provided.

6.3.3 Portable extinguishers

Machinery spaces are to be provided with portable fire extinguishers, in accordance with the applicable requirements in Table IV 6-2.

6.3.4 Axe

One fire axe is to be provided on each craft.

6.4 Craft less than 24 meters in Length

6.4.1 General

Craft less than 24 meters in length are to comply with the following and the requirements of 6.1.1 and 6.1.7 of this Chapter.

6.4.2 Fire pumps, fire main, hydrants, and hoses

(a) Number of pumps

All craft are to have at least two fire pumps. Only one of the pumps need be independently power-driven, and one of the pumps may be attached to the propulsion unit. For craft less than 24 m in length, one power-driven pump, which may be an attached unit, and one hand operated fire pump may be provided.

(b) Pump capacity and pressure

Power driven pumps are to have a capacity of at least 5.5 m^3/hr. Hand pumps, where permitted are to have a minimum capacity of at least 1.1 m^3/hr. The pumps are to have sufficient pressure such that they are capable of directing an effective stream of water to any part of the craft through any single hydrant.

(c) Materials

Piping for the fire main is to meet the requirements of 3.1.4 of this Part.

(d) Hydrants

The number and position of the hydrants are to be such that at least one jet of water may reach any part of the craft with a single hose.

(e) Hoses and nozzles

Hoses may be of a good commercial grade having a diameter of not less than 16 mm and are to have a minimum test pressure of 10.3 bar and a minimum burst pressure of 31.0 bar.

One fire hose with the couplings and nozzle is to be provided for each hydrant and for each portable hand pump. Additionally, at least one spare hose is to be kept onboard.

Nozzles are to be the dual-purpose type (with spray and jet capability) and may be of commercial grade with a rating at least equal to the hose.

6.4.3 Portable fire extinguishers

Portable extinguishers are to be provided in the quantities and locations indicated in Table IV 6-6. See Table IV 6-1 for classification.

Table IV 6-6
Portable and Semi-Portable Extinguishers

Space	Extinguisher type	Arrangement
Control Stations		
Wheelhouse	C-II	1 in vicinity of exit(3)
Accommodations		
Sleeping accommodations	A-II	1 in each sleeping accommodation space Where occupied by more than 4 persons.)
Corridors	A-II	1 in each main corridor (May be located in stairways.)
Service Spaces		
Galley	B-II or C-II	1 for each galley
Storerooms	A-II	1 for each located in vicinity of exits, either inside or outside of spaces(3)
Workshops	A-II	1 outside the space in vicinity of exit(3)
Machinery Spaces/Machinery Compartments		
Diesel engines or gas turbine in an engine room(5)	B-II	1 for each 746 kW, but not less than 2 nor more than 6(1)(4)
Diesel engines or gas turbine in an engine compartment(6)	B-II	1 for each engine propulsion engine, but not less than 2
Outboard engines	B-II	1 required
Electric motors or generators of the open type	C-II	1 for each motor or generator unit(2)

Notes:

(1) When installation is on weather deck or open to atmosphere at all times, 1 B-II type extinguisher for every 3 engines is allowable.

(2) Small electrical appliances, such as fans, etc., are not to be counted or used as bases for determining number of extinguishers required.

(3) Vicinity means within 1 m.

(4) For engine rooms, at least one fire extinguisher is to be located outside the machinery spaces in vicinity of the entrance to the space.

(5) An engine room is defined as an enclosed space which contains the propulsion or generating machinery fitted with a door and having sufficient size so that a person can safely enter the space with all equipment in operation.

(6) An engine compartment is defined as an enclosed space which contains the propulsion or generating machinery of sufficient size for the equipment only and is typically not accessed while the craft is in operation.

6.4.4 Machinery spaces

Engine Rooms (as defined in Table IV 6-6, Note (5)) and Engine Compartments (as defined in Table IV 6-6, Note (6)), with propulsion and auxiliary engines having a total aggregate power of 750 kW or greater are installed are to be fitted with a fixed fire extinguishing system complying with 6.2.6 of this Chapter.

Automatic release may be approved for small, unattended engine rooms fitted with a Medium Release Warning System complying with 6.2.6(a)(iii) of this Chapter. Also, warning signs are to be provided, indicating that the space is protected by an automatic fire extinguishing system.

The storage containers may be located inside the protected space, provided the controls for the release of the medium are located in a readily accessible location outside protected space. Furthermore, the point where the controls enter the protected space to the location of the storage containers is as short as practical.

Engine Rooms (as defined in Table IV 6-6, Note (5)) and Engine Compartments (as defined in Table IV 6-6, Note (6)) are to be fitted with a fire detection system complying with 6.1.6 of this Chapter.

6.4.5 Accommodation and service spaces

A fire detection and alarm system complying with 6.1.6 of this Chapter is to be provided for accommodation and service spaces where the sum of the length of the spaces is greater than 5 meters or where sleeping accommodations are provided, regardless of length of the spaces.

6.4.6 Fixed fire extinguishing systems

In addition to 6.2.6 of this Chapter, other extinguishing systems may be approved, provided they are shown to be no less effective than approved gas systems.

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RULES FOR THE CONSTRUCTION AND CLASSIFICATION OF HIGH-SPEED CRAFT 2021

PART V —SPECIALIZED CRAFT AND SERVICES

August 2020

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PART V SPECIALIZED CRAFT AND SERVICES

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Chapter 1

Craft Intended to Carry Passengers

1.1 General

1.1.1 Application

These requirements are intended to apply to a craft of Category A or Category B of the International Code for Safety for High-Speed Craft, carrying more than 12 passengers on an international voyage.

1.1.2 Classification

In accordance with 1.3 and 1.4 of Part I, either the classification of ✠ **CR100 HSC-PA** or ✠ **CR100 HSC-PB** is to be assigned to craft designed and specifically fitted for the carriage of passengers and built to the applicable requirements of this section and other relevant sections of these Rules. In addition, the craft is to have a Safety Certificate for High-Speed Craft from the Administration of registry or its agent evidencing the craft compliance with the requirements of the International Code for Safety for High-Speed Craft (IMO HSC Code).

1.1.3 Scope

This section is intended to cover the additional hull construction, accommodation arrangement, machinery and safety equipment required to class a craft as a passenger craft. These requirements are applicable to those features that are permanent in nature and can be verified by plan review, calculation, physical survey or any other means. These Rules do not address the requirements for Life Saving Appliances and Arrangements (Chapter 8), Navigational Equipment (Chapter 13), Radio Communications (Chapter 14), and Operational Requirements (Chapter 18) found in the International Code for Safety for High-Speed Craft, which are not a condition for classification.

For a passenger craft intended for international voyage which is beyond the scope of the International Code for Safety for High-Speed Craft, the arrangements and scantlings are to comply with the requirements of Part VII of the Rules for Steel Ships.

For a craft not engaged in international voyage, if the requirements of the Rules are not fully applicable, the relevant drawings and documents are to be submitted to the Society for evaluation of approved alternative requirements, equipment or methods. The alternatives may be accepted by this Society for special consideration.

1.1.4 Safety Certificate for High-Speed Craft

Where authorized by the Administration of country signatory to the International Convention for the Safety of Life at Sea, 1974 as amended, and upon request of the owners of a classed craft or one intended to be classed, CR will review the plans, data, etc., and survey the craft for compliance with the requirements of the International Code for Safety for High-Speed Craft and issue a Safety Certificate for High-Speed Craft, prescribed in the Convention on behalf of the Administration.

1.1.5 Definitions

(a) General

For definitions of terms used in this section and not shown below, reference is to be made to the definitions in the various Chapters in the International Code of Safety for High-Speed Craft. (Abbreviated: IMO HSC Code).

(b) Administration

Administration means the Government of the State whose flag the craft is entitled to fly.

(c) Category A Craft

Any high-speed passenger craft carrying not more than 450 passengers and operating on a route where it has been demonstrated to the satisfaction of the flag and port States 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 : a) the time to prevent persons in survival craft from exposure causing hypothermia in the worst intended conditions, b) the time appropriate with respect to environmental conditions and geographical features of the route, or c) 4 hours.

(d) Category B Craft

Any high-speed passenger craft, other than a category A craft, with machinery and safety systems arranged such that, in the event of damage disabling any essential machinery and safety systems in one compartment, the craft retains the capability to navigate safely.

(e) Crew Accommodations

Crew accommodations are those spaces allocated for the use of the crew, and include cabins, sick bays, offices, lavatories, lounges and similar spaces.

(f) Passenger

A passenger is every person other than, a) the master and members of the crew or other persons employed or engaged in any capacity on board a craft on the business of that craft and b) a child under one year of age.

(g) Public Space

Public spaces are those spaces allocated for the passengers and include bars, kiosks, smoke rooms, main seating areas, lounges, dining rooms, recreation rooms, lobbies, lavatories and similar permanently enclosed spaces allocated for passengers.

1.2 Stability

1.2.1 Intact Stability

The intact stability for passenger craft, in the displacement mode, in the transient mode and in the non- displacement mode are to comply with 3.1.2(a) of Part III of the Rules. The submission of evidence showing approval by an Administration will be acceptable. Alternatively, upon request the review will be performed by CR for compliance with the applicable requirements of the IMO HSC Code.

1.2.2 Subdivision and Damage Stability

When the craft is issued a Safety Certificate for High-Speed Craft by the Administration or its agent other than CR, such certificate will be accepted as evidence of compliance with the subdivision and stability requirements of Chapter 2.6 of the IMO HSC Code. On all other passenger craft, when authorized by an Administration and requested by the Owner, CR will review the data on the subdivision and stability for compliance with the IMO HSC Code on behalf of the Administration.

1.2.3 Inclining Experiment and Stability Information

When the craft is issued a Safety Certificate for High-Speed Craft by the Administration or its agent other than CR, such certificate will be accepted as evidence of compliance with the requirement for an inclining experiment and stability information of Chapter 2.7 of the IMO HSC Code. On all other passenger craft, when authorized by an Administration and requested by the Owner, CR will review the inclining experiment and stability information for compliance with the IMO HSC Code on behalf of the Administration.

1.3 Construction

1.3.1 General

The scantlings and arrangements of the hull structure are to be in accordance with the applicable requirements of Part III.

1.3.2 Accommodation Space Design

Passenger and crew accommodation spaces are to be designed and arranged so that the occupants are protected from unfavorable environmental conditions, and the risk of injury to occupants during normal and emergency conditions is minimized. Spaces accessible to passengers are not to contain controls, electrical equipment, high-temperature parts and pipelines, rotating assemblies, or other items from which injury to passengers could result, unless such items are adequately shielded, isolated, or otherwise protected.

The design and location of public spaces and crew accommodation may be in accordance with the requirements in Appendix 1 of this Part, "Guidelines for Accommodation Design of Passenger Craft" unless the flag Administration has specific requirements in this respect.

1.4 Bilge System

1.4.1 General

The bilge system is to comply with 3.2 of Part IV except as modified below. Suitable arrangements are to be provided for the drainage and discharge of water which may be discharged by the fixed sprinkler system in 1.5.2 of this Chapter.

1.4.2 Bilge Pumps

(a) Number of Fixed Bilge Pumps

(i) Monohull Craft

Each category B monohull craft is to be provided with three power bilge pumps connected to the bilge main. Each category A craft is to be provided with at least two power bilge pumps connected to the bilge main. One of the pumps in either case may be driven by the propulsion machinery.

(ii) Multihull Craft

On multihull craft, each hull is to be provided with at least two bilge pumps.

(b) Arrangement for Fixed Bilge Pumps

The bilge system is to be arranged such that at least one power bilge pump will be available for use in all flooding conditions which the craft is required to withstand as follows:

(i) One of the bilge pumps is to be an emergency pump of a reliable submersible type connected to an emergency source of power; or

(ii) The bilge pumps and their sources of power are to be distributed throughout the length craft so that at least one pump in an undamaged compartment will be available.

(c) Submersible Bilge Pumps

As an alternative to 1.4.2(a) and 1.4.2(b) of this Chapter, an arrangement utilizing submersible pumps may be utilized. See 3.2.2(a)(iii) of Part IV.

1.4.3 Manifold, Cocks and Valves

Manifolds, 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 pipe connection to the bilge main is not to make the bilge system inoperable. 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 the specified flooding conditions. In that case, only the valves necessary for the operation of the emergency system need be capable of being operated from above the bulkhead deck.

All cocks and valves referred to above which can be operated from above the bulkhead deck are to have their controls at their place of operation clearly marked and are to be provided with means to indicate whether they are open or closed.

1.5 Fire Protection

1.5.1 General

The requirements in Part IV, Chapter 6 applicable for cargo craft of 500 gross tons and above are to be applied for all passenger craft, regardless of the gross tonnage. The following requirements also apply.

1.5.2 Fixed Sprinkler Systems

Public spaces, service spaces, storage rooms other than those containing flammable liquids, and similar spaces are to be protected by a fixed sprinkler system based on the standards developed by the Organization*. Manually operated sprinkler systems are to be divided into sections of appropriate size, and the valves for each section, the means to start the sprinkler pump(s) and alarms are to be operable from two spaces separated as widely as possible, one of which is to be a continuously manned control station. In category B craft, no section of the system is to serve more than one of the zones required in 1.5.4(a)(ii)(1) of this Chapter.

Plans of the system are to be displayed at each operating station.

Suitable alternatives may be accepted in lieu of a fixed sprinkler system provided the alternative is acceptable to the Administration.

* Refer to the Standards for fixed sprinkler systems for high-speed craft, adopted by the Organization by resolution MSC.44(65), as may be amended, and the associated interpretations of MSC/Circ.912.

1.5.3 Fireman’s Outfits

(a) Category A Craft

The fireman’s outfits, are not required for Category A Craft.

(b) Category B Craft

In addition to the two fireman's outfits required, there are to be two more fireman’s outfits for every 80 m, or part thereof, of the aggregate of the lengths of all passenger spaces and service spaces on the deck which includes such spaces. If there is more than one such deck, the deck which has the largest aggregate of such lengths is to be used for determining the number of additional fireman’s outfits to be carried. Each fireman’s outfit is to consist of the items stipulated in 7.10 of the HSC Code. Also, one water fog applicator is to be provided for each pair of breathing apparatus. The water fog applicator is to be stored adjacent to the breathing apparatuses.

1.5.4 Fire Safety Measures

(a) General

The requirements specified in 4.1.2 of Part III are applicable. In addition, the arrangement of spaces is to be as follows:

(i) Category A Craft

For Category A craft, a single public space is acceptable.

(ii) Category B Craft

For Category B craft, public spaces are to be divided into zones according to the following:

(1) Passenger spaces are to be divided into at least two zones and the mean length of each zone is to be less than 40 m.

(2) For the occupants of each zone there should be an alternative safe area to which it is possible to escape in case of fire. The alternative safe area is to be separated from other passenger zones by smoke-tight divisions of non-combustible materials or fire-restricting materials extending from deck to deck. The alternative safe area can be another passenger zone provided the additional number of passengers may be accommodated in an emergency.

(3) The alternative safe area is to be located adjacent to the passenger zone it is intended to serve. There should be at least two exits from each passenger zone, located as far away from each other as possible, leading to the alternative safe area. Escape routes should be provided to enable all passengers and crew to be safely evacuated from the alternative safe area.

(iii) Control stations, stowage positions of life-saving appliances, escape routes and places of embarkation into survival craft are not to be located adjacent to any area of major or of moderate fire hazard.

1.6 Electrical Installations

1.6.1 Emergency Source of Power

The emergency source of electrical power is to comply with 4.11.3 of Part IV.

1.7 Ro-Ro Craft

1.7.1 General

Craft which are intended for carrying motor vehicles in addition to passengers are to comply with the following requirements.

1.7.2 Definition of Spaces

(a) Open Ro-Ro Spaces

Open ro-ro spaces are spaces intended for the carriage of motor vehicles with fuel in their tanks for their own propulsion, to which passengers have access, that are either open at both ends or open at one end and provided with permanent openings distributed in the side plating or deckhead or from above, having a total area of at leat 10% of the total are of the space sides.

(b) Special Category Spaces

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 clear height for vehicles does not exceed 10 m.

1.7.3 Electrical Equipment and Ventilation

Electrical equipment and ventilation for special category spaces are to be in accordance with 4.19.1 of Part IV.

1.7.4 Fire Detection and Fire Alarm System

The fire detection and fire alarms system for special category spaces and ro-ro spaces are to be complied with 7.8.3 of the HSC Code.

1.7.5 Fire Extinguishing System

Each special category space is to be fitted with an approved manually-operated fixed pressure water spraying system. Other types of fire extinguishing systems may be considered provided that they have been shown by full-scale test in conditions simulating a flowing petrol fire in a special category space to be not less effective in controlling fires likely to occur in such a space.

1.7.6 Fire Extinguishing Equipment

Each special category space is to be provided with the following fire extinguishing equipment.

At least three water fog applicators.

One portable foam applicator unit consisting of an air-foam nozzle of an inductor type capable of being connected to the fire main by a fire hose, together with a portable tank containing 20 liters of foam-making liquid and one spare tank.

The nozzle is to be capable of producing effective foam suitable for extinguishing an oil fire at the rate of at least 1.5 m^3/min. Each craft having special category spaces is be provided with at least two portable foam applicator units as a minimum.

Portable fire extinguishers located so that no point in the space is more than 15 m from an extinguisher, provided that at least one portable extinguisher is located at each access to the space.

1.7.7 Scuppers, Bilge Pumping and Drainage

In order to prevent a serious loss of stability which could result due to large quantities of water accumulating on the vehicle deck(s) from operation of the fixed water spraying system in 1.7.6 of this Chapter, scuppers are to be fitted to directly discharge the water overboard. Alternatively, pumping and drainage arrangements may be provided additional to the requirements in 1.4 of this Chapter.

Appendix 1

Guidelines for Accommodation Design of Passenger Craft

Note: This Appendix is prepared to give guidelines to users of these Rules to design, build and operate craft intended to carry passengers on International voyages. It should be noted that any interpretations to the International Code of Safety for High-Speed Craft in this respect issued by the flag Administration govern the guidelines in this Appendix.

A1.1 General

For passenger craft, superimposed vertical accelerations above 1.0 g at the longitudinal center of gravity should be avoided unless special precautions are taken with respect to passenger safety.

A1.2 Design Acceleration Levels

Passenger craft are to be designed for the collision load with respect to the safety in, and escape from, the public spaces, crew accommodation and escape routes, including in way of life-saving appliances, and emergency source of power. The size and type of craft together with speed, displacement and building material are to be taken into consideration when the collision load is determined. The collision design condition is to be based on a head on collision at operational speed with a vertical rock with maximum 2 m height above the waterline. Unless any specific data of collision energy are available in the process of design, the following may be used for assessment of collision deceleration. Where the deceleration of the craft is determined by carrying out a collision load analysis of the craft in accordance with these assumptions, that value may be used as g_{coll}.

(a) Monohulls

$$g_{coll} = \frac{0.1224P}{\Delta}$$

where

g_{coll} = collision deceleration — g's

P = $460\sqrt[3]{EC_H(MC_L)^2}$ — kN

but not less than $9000MC_L\sqrt{C_H(d_c+2)}$ — kN

M = 0.95 for mild steel
= 1.3 for higher tensile steel
= 1.0 for aluminum alloy
= 0.8 for fiber reinforced plastic

$C_L = \frac{165 + L_c}{245} + (\frac{L_c}{80})^{0.4}$

$C_H = \frac{d_c + 2 + f(D_c / 2)}{2D_c}$

L_c = 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.

D_c = depth of the craft measured at the middle of L from the underside of the keel to the top of the effective hull girder, in meters

d_c = buoyancy tank clearance to skirt tip (m, (negative)) for air-cushion vehicles; lifted clearance from keel to water surface (m, (negative)) for hydrofoils; and draft of the craft measured at the middle of L from the underside of the keel to the design load waterline, in m, for all other craft.

f = 0 when $(d_c + 2) < D_c$

f = 1 when $(d_c + 2) \geq D_c$

E = kinetic energy of the craft

= $0.132\Delta V^2$ kN-m

Δ = average craft displacement taken as the mean of the lightweight and the maximum operational displacement tonnes
V = operational speed of the craft knots
g = 9.81

(b) Catamarans and Surface Effect Craft

Catamarans and Surface Effect Craft may use the same equation as given in A1.2(a) of this Appendix for g_{coll} with the following exceptions:

f = 0 when $T + 2 < D_c - H_T$
= 1 when $D_c - H_T \leq (T+2) < D_c$
= 2 when $D_c \leq (T+2)$

T = lifted clearance from the keel to the water surface, taken as negative m
H_T = minimum height from tunnel or wet deck bottom to the top of the effective hull girder m

(c) Air Cushion Vehicles

Air cushion vehicles may use the same equation as given in A1.2(a) of this Appendix for g_{coll} with the following exceptions:

f = 0 when $H_T > 2$
= 1 when $H_T \leq 2$

H_T is as defined in A1.2(b) of this Appendix.

(d) Hydrofoils

Hydrofoils may use the same equation as given in A1.2(a) of this Appendix for gcoll. However, g_{coll} is not to be taken less than (kF/Δ) where:

F = failure load of bow foil assembly applied at the operational waterline kN

k and Δ are as defined in A1.2(a) of this Appendix.

A1.3 Accommodation Design

(a) Location of Public Spaces

Public spaces are not to be located within a distance of $0.0132V^2/g_{coll}$ meters of the extreme forward end of the top of the effective hull girder of the craft, where the terms V and g_{coll} are as defined in A1.2(a) of this Appendix. For the purpose of this requirement, g_{coll} is not to be taken as greater than 12, and need not be taken as less

(b) Accommodation Requirements

Accommodations are to be as required by Table V A1-1 of this Appendix, and are to be designed to a recognized standard.

(c) Foundations

Calculations are to be submitted indicating that foundations for large masses such as main engines, auxiliary engines, lift fans, transmissions and electrical equipment can withstand the collision design acceleration, g_{coll}, as given in A1.2(a) of this Appendix, without fracturing.

Table V A1-1
Accommodation Requirements

		g_{coll}		
		< 3	$3 \leq g_{coll} \leq 12$	> 12
Seat	Seatback Requirements	Low or high seatback	High seatback with protective deformation and padding	High seatback with protective deformation and padding
	Seating Direction	No restrictions	Forward or backward	Forward or backward
	Sofas	Sofas allowed	Not allowed as seats	Not allowed
	Seat Belts	Not required	Lap belt required in seats with no protective structure forward	Three point belt or belt with shoulder harness in forward facing seats
Tables		No restrictions	Protective features and dynamic testing required	Not allowed
Projecting objects		Padding required	Padding required	Padding required and is to be specially approved.
Kiosks, bars, etc.		No restrictions	Only on aft side of bulkheads or specially approved	Specially approved
Baggage		No restrictions	Protection required forward	Protection required forward and is to be specially approved
Large masses		To be restrained and positioned	To be restrained and positioned	To be restrained and positioned and to be specially approved

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